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One of the most difficult issues that monetary authorities in many developing economies have to deal with is the management of a stable price environment. Inflation can create uncertainty, a low level of investment, and raise costs in general, thus lowering rates of growth. As a result, there exists a widespread need for understanding inflationary dynamics in any country of interest, especially in developing countries, subject to more significant and volatile price changes. This paper develops a VEC model for the Romanian economy, using CPI index and other macroeconomic data, in order to capture the transmission mechanism of inflation.

Keywords: inflation forecasting, monetary policy, developing countries, Romania, VAR model

JEL codes: E52, C32

Introduction

The primary focus of monetary policy has traditionally been the maintenance of a low and stable rate of aggregate price inflation as defined by commonly accepted measures such as the consumer price index. The underlying justification for this objective is the widespread consensus supported by numerous economic studies, that inflation is costly as it undermines real, wealth enhancing economic activity. This consensus is probably stronger today than it ever has been in the past.

The interest in empirical studies of monetary policy has increased in the last decade, possibly for the following two reasons. First, financial markets have been deregulated and monetary of the monetary policy process in a country with an inflation target may look something like the following. Official central bank inflation forecasts are presented to the public rather infrequently (e.g. in quarterly "inflation reports" as in Romania, Sweden or the U.K.). On these occasions attempts are made to measure and justify the overall stance of monetary policy, considering not only the development of inflation, but also other variables such as interest rates, the nominal exchange rate, indexes of "monetary conditions" (weighted averages of exchange and interest rates), and the "output gap" (the difference between actual and so-called potential GDP).

Forecasts of inflation will represent a key ingredient in designing policies which are geared toward the achievement of price stability. Moreover, such forecasts should be optimal in the sense that they make use of all relevant indicators and weight them correctly according to their reliability as predictors of future price developments.

Literature review

Previously, forecasting and policy analyses have been conducted using structural macroeconomic models developed along the lines of the Cowles Commission approach. These structural models, using hypothesized theoretical relations, show the main linkages in the economy. In the ’40s and ’50s, this was the traditional approach to econometric modeling of the monetary transmission mechanism, based on the quantitative evaluation of the impact of monetary policy on macroeconomic variables. The Cowless Comission methodology was based on the following three stages: specification and identification of the theoretical model, estimation of relevant parameters and simulation of the effects of monetary policy.

These models thus rely on economic theory, to determine the number of variables and their influence on the inflation. Under the Cowles Commission approach, if a particular structural form or parameterization that is derived from economic theory fails to be identified by the data; the parameter space is then transformed such that each point uniquely represents distinct behavioral patterns.

Two famous critiques were given by Lucas[270] in 1976 and Sims in 1980. Lucas notes that Cowless Comission models do not take into account expectations explicitly and expectational parameters are not stable across different policy regimes, so traditional macro-models are useless for the purpose of policy simulation. Additionally, his critique is related to the fact that this type of model „did not represent the data...did not represent theory ... were ineffective for practical purposes of forecasting and policy evaluation”[271].

Sims’[272] critique is parallel to that of Lucas’, but concentrate on the status of exogeneity arbitrarily attributed to some variables to achieve identification within structural Cowles Commission models. He argues however that “having achieved identification in this way, the equations of the model are not products of distinct exercises in economic theory.”[273] The fact is that in structural models, to achieve identification, restrictions are often imposed which have no theoretical justification. Further, and more importantly, Sims asserts that such restrictions are not necessary for the intended use of macromodels (i.e. forecasting and policy analysis). He argues that economic interpretation and investigation may not be possible without incorporating nonstatistical a priori information.

Since the seminal work of Sims, structural-VAR and cointegrated VAR’s have been applied to economic data to forecast macro time series, study the sources of economic fluctuations, test economic theories. Additionally, the failure of the Cowless Comission approach lead to a series of methods of empirical research such as VAR approach or RBC approach.

The statistical and econometrical modeling has proven itself one of the main ways through which the inflationist phenomenon is analyzed with the purpose of bringing forth the main factors which determine the level and dynamics of inflation, the economic literature dedicated to this inflationist phenomenon in Romania being extremely rich. Some studies deepen the phenomenon analysis from the perspective of the monetary theories, others take into consideration a multitude of factors, forecasting the dynamics of the prices within some models of general equilibrium; a small number study inflation through the institutional factor and/or in correlation with the dynamics of the work market.[274] In some models the shocks on the side of the offer are taken into

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[270] Lucas, R., *Econometric Policy Evaluation: A Critique,* Carnegie-Rochester Conference Series on Public Policy, 1, 1976, p.36.

[271] Pesaran, M. H., Smith, R., *Estimating long-run relationships from dynamic heterogeneous panels*, Journal of Econometrics, Elsevier, 1995, vol. 68(1), p. 95.

[272] Sims, C., A., *Macroeconomics and Reality,* Econometrica, issue 1, vol. 48,1980, p. 2.

[273] Idem, p. 2.

[274]Ciutacu, C., Ciumara, M., *Inflaţia în România. Modelarea fenomenului inflaţionist*, Editura Expert, Bucureşti, 2004, p. 23.

consideration, some authors have included the world price of petrol as explanatory variable of inflation.[275]

In the models built on the basis of monetary theory of inflation, the authors include as variable the monetary supply (considered in the large sense through the M2 component), the output (represented either by the gross domestic product, or the industrial production) and the opportunity post, usually through the introduction the monetary exchange, all these start from the affirmation made by M. Friedman which argues that the inflation is exclusively tied to the currency demand, namely "the excessive growth of the monetary mass is the main and the only cause of inflation."[276]

One of the most well-known models referring to the inflation in Romania is the Dobrescu model, that was developed throughout 1996-2000 and which includes between the main relations, also the ones referring to the forecasting of certain prices (expressed through the deflator of the gross domestic product, the consumer prices index and the gross capital formation prices index). For this model, the inflation calculation is done through the consumer product prices index. This was determined based on different econometrical relations in the 3 versions of the model. In the first version, this was determined by having as explanatory variable the deflator of the gross domestic product; in the model versions from 1997 and 1998, the previous level of the dependent variable was added as explanatory variable, and in the last versions the deflator of the gross domestic product and the monetary offer was used as explanatory variable.[277]*The inflation calculation through the consumer product prices index finds its theoretical support in the monetary theory of Friedman and others, if the explanatory variable included in the model is the monetary one.*

In what follows some models of inflation will be presented with scientific support in the monetary theory from different perspectives. Nina Budina and her collaborators build a model of inflation forecasting for Romania, starting from the function of real demand of currency from the Cagan formulation.[278] They reached the conclusion that in the analyzed period (1992-2000) as well as in the periods of price liberalization, the inflation was a monetary phenomenon. The monthly modifications of the inflation rate are explained in the study through the correction of errors mechanism in which the imbalance between the currency demand and supply plays an essential part, the changes of the exchange rate and of the controlled prices through administrative regulation being considered as having transitory effects on the evolution of the monthly rate of inflation.[279]

Cezar Boțel in his article "Cauzele inflației în România" analyzed the inflation in Romania by utilizing the technique of the structural autoregressive vector (SARV) and the cointegration technique. The results of his analysis have been obtained as the form of the response function to shock, of the decomposition of the variable and the tests for the detection of the Granger causality. The most important conclusion made based on this study is that the higher inflation in Romania is the result of the late reformation of the banking and real sectors, compared with other countries which are in transition.[280]

Florin Ovidiu Bîlbîie used the Granger cauzality tests, the variation decomposition and the econometrical models based on the techniques of the non-structural and unrestrictioned autoregressive vectors in order to point out the relevant indicators that influence the inflation. The obtained results show that the most significant indicators that influence the inflation are the

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[275] Pelinescu, Elena, Dospinescu, A., *Modelarea ratei inflației*, Revista Oeconomica, 2006, nr. 1, p. 126-127.
[276] Friedman, M., Friedman, Rose, *Liber să alegi*, Editura All, Bucureşti, 1998, p.219.
[277] Dobrescu, E., *Tranzacția în România. Abordări econometrice,* Editura Economică, Bucureşti, 2002, p.81.
[278] Budina, Nina, Maliszewski, W. , De Menil, G., Ţurlea, Geomina, *Money, Inflation and Output in Romania, 1992-2000*, Working Paper, 2002-15, DELTA, octombrie 2002, p. 10.
[279] Idem, p. 20.
[280] Boţel, C., *Cauzele inflației în România, iunie 1997-august 2001. Analiză bazată pe vectorul autoregresiv structural*, Caiete de studii, nr. 11, iunie 2002, p. 45.

exchange rate and the real nongovernmental credit, followed by the monetary aggregates and the interest rate practiced by the commercial banks.[281]

David Moore, IMF expert, studied the empirical relationship between the inflation rate, the unitary cost of the work force and the exchange rate utilizing a model of autoregressive vector (ARV). The conclusion that the author had reached is that in Romania, the inflation was determined mainly by the wage increase in the context of a low productivity, the channel of transmission used was the financial lack of discipline and the low budgetary constraint.[282]

Starting from another ARV model, Elena Pelinescu, in her article "Modelarea inflației în România", reaches the conclusion that the factors whose modification influences inflation the most are the exchange rate and monetary supply.[283] Using the models based on the method of the smallest squares or the conintegration techniques of the un-restrictioned autoregressive vector (UARV), Mugur Isărescu, Cornel Târhoacă and Lucian Croitoru, argued in their study the influence of certain factors on inflation, such as monetary supply, the dynamic of industrial production, the unemployment rate, the exchange rate, the real interest, lastly, underlining a strong negative correlation between inflation and unemployment.

In the study "Țintirea directă a inflației: o nouă strategie politică monetară. Cazul României" a wide rage of different econometrical models are presented that have as purpose the realization of a forecast by the specialists of the National Bank of Romania in the context of a regime of aiming at the inflation. The authors consider that the forecast of inflation in Romania through econometrical models "is premature, given the frailty of the connections between the variables with characteristics of *leading indicators* and the inflation (measured through IPC, CORE1, CORE2). Together with the stabilization of the inflation on the palier of a single number and the consolidation of the macroeconomical equilibriums, the amelioration of these relations is predictable and, it follows, the possibility of utilizing the macroeconomic instrument for the realization of viable forecasts on medium turn."[284]

Methodology and data

Our model is based on monthly data for inflation rate (measured by CPI), unemployment rate (UR), broad money (BM2), real interest rate on deposits (IR), nominal exchange rate (EUR/RON– EREUR) for Romania between January 1997 and February 2010[285]. Unemployment rate represents the structural influences on inflation, broad money as well as real interest rate on deposits captures the monetary stance, nominal exchange rate is used in order to represent imported inflation. Data were computed in Eviews.

The data were tested for stationarity, using the ADF and the Phillips and Peron method. All series have one unit root I(1). The above mentioned tests confirmed that the first difference series were stationary. The Johansen cointegration without deterministic trend test was then conducted. The Unrestricted Cointegration Rank Test (Trace) indicated three cointegrating equations at 0,05 level.

Given the results, a VECM Vector Correction Model with 3 cointegrating equations was estimated. Restrictions were placed on the coefficients of each cointegrating relation as well as on the adjustment coefficients, using the normalized cointegrating coefficients and adjustment coefficients. The VEC Granger causality /block exogeneity Wald test showed that the variables

[281] Ciutacu, C., Ciumara, M., Op. Cit., p. 28.

[282] Bell, G., Cosse, S., Wang, T., Moore, D., Brown, W., *Romania: Selected Issues and Statistical Appendix*, International Monetary Fund – Country Report, ianuarie 2001, p. 11.

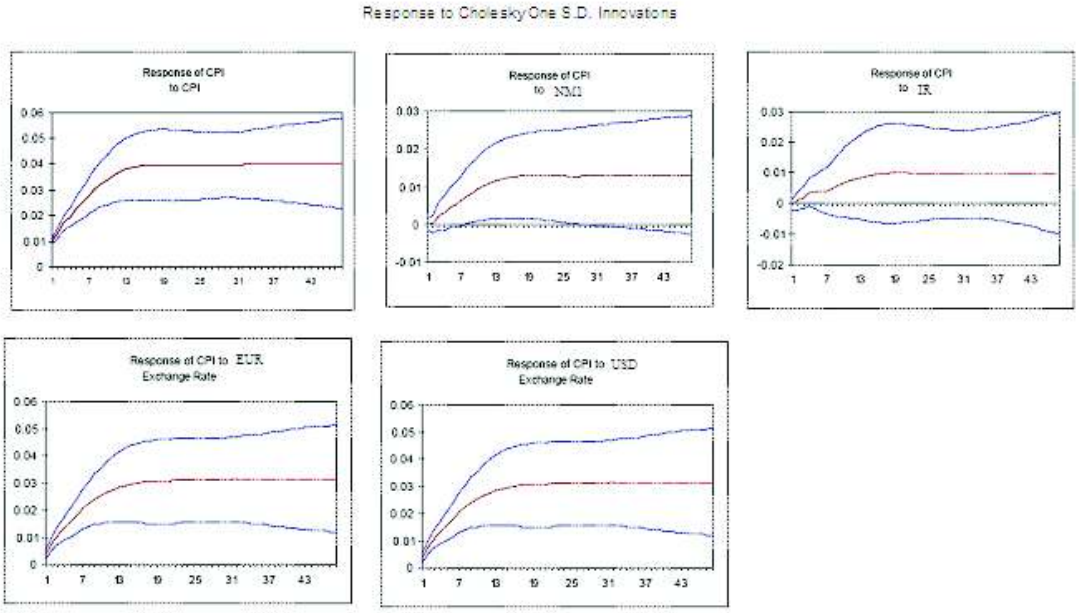
[283] Pelinescu, E., Dospinescu, A., *Modelarea ratei inflației*, Revista Oeconomica, 2006, nr. 1, p 140.

[284] Popa, Cristina (coord), *Ţintirea directă a inflaţiei: o nouă strategie politică monetară. Cazul României,* Caiete de studii, nr. 10, aprilie 2002, p. 34.

[285] BNR Monthly Bulletins, avaliable at http://www.bnr.ro/PublicationDocuments.aspx?icid=1182 accesed at 30.03.2009 and INSSE Tempo Online series available at https://statistici.insse.ro/shop/ accesed at 30.03.2009.

with significant impact on the evolution of CPI were EUR exchange rate, the interest rate and broad money M2. We conducted once again the Johansen cointegration without deterministic trend test. The Unrestricted Cointegration Rank Test (Trace) as well as the Unrestricted Cointegration Rank Test (Maximum eigenvalue) indicated two cointegrating equations at 0,05 level.
The VECM Vector Correction Model with two cointegrating equations, 6 lags and deterministic trend in CE, no trend in VEC proved to be the one that captures the best the behaviour of selected variables. The diagnostic tests for the VECM equation confirmed its coefficient stability, the Jarque-Bera test did not reject the null hypothesis of a normal distribution of the residuals (at 5 percent significance level) and the Portmanteau test as well as the correlogram of squared residuals did not show any autocorrelation or ARCH in the residuals.

Graph 1. Impulse response functions between CPI inflation rate and selected variables

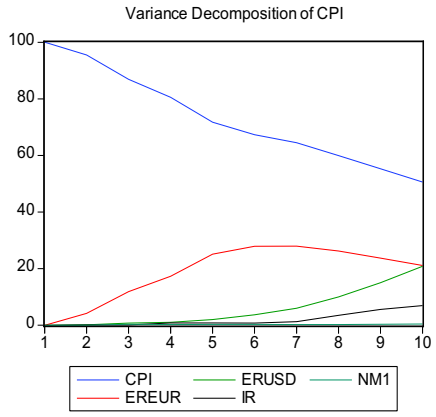


Source: authors' calculations

The dynamic property of the model is tested using variance decomposition and impulse response functions. Graph 1 shows the response of the inflation rate measured by CPI to a one unit shock to the exchange rate, narrow money, interest rate, net average wage. The x axis gives the time horizon or the duration of the shock whilst the y-axis gives the direction and intensity of the impulse or the percent variation in the dependent variable away from its base line level. This model confirms the existence of statistically significant links between the inflation rate and the selected macroeconomic variables. The reaction of CPI index is consistent with the macroeconomic data. The impulse responses meet a priori expectations in terms of the direction of impact. The graphs show that a positive shock to monetary variables or expansionary monetary policy, has a significant expansionary effect on inflation. The effect of a unit shock to base money on the cpi, occurs after approximately the first one to two months and reaching its peak between ten to twelve months.
Thereafter the cumulative effects of base money stabilize with the monthly CPI increasing by approximately one percent of its baseline level. The impact of the exchange rate is rather immediate and long lasting. A unit shock to the exchange rate causes the cpi in the first period to

deviate by approximately 0.5 percent from its base level. The inflation rate accelerates rather rapidly in the first ten to twelve months as the CPI tends to a new equilibrium level. Increases in the interest rates tend to have a contractionary effect on prices. The more significant impact however manifests itself after five months with the response function trending away from zero.

Graph 2. Variance decomposition – percent of CPI variance due to



Source: author's calculations

The variance decomposition is presented in Graph 2. The statistics indicate the percentage contribution of innovations in each of the variables in the system to the variance of the CPI. The results show that shocks to the CPI itself and the exchange rate accounts for most of the variability in the CPI over all horizons. Not much can be attributed to base money, although over longer horizons its relative contribution increases.

Conclusion

In the process of conducting monetary policy analysis, central bank economists are faced with a number of empirical questions. Does the nominal exchange rate help to predict inflation? Does the nominal exchange rate adjust in response to the difference between domestic and foreign inflation, to restore some equilibrium level of the real exchange rate? How useful are various measures of the output gap and of monetary conditions? How fast do changes in monetary policy affect output and inflation? These questions concern complex relations between variables which are all endogenously and simultaneously determined in the economic system. We do certainly not expect that there is any single model that can provide the best possible answers to all relevant questions in the analysis of monetary policy, or that it yields exactly the same answers when estimated for different time periods.

While many previously used inflation forecasting models depend on exogenous variables, the VAR approach endogenously determines all the variables which make up the system. Our VECM model has proven that that the basic transmission mechanism runs from base money (via interest rates which affect the relative return on financial assets) to the exchange rate and then to prices.

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