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One of the most difficult issues confronting 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 Lucas³⁹⁵ in 1976 and Sims in 1980. Lucas notes that Cowles Commission 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”³⁹⁶.

Sims³⁹⁷ 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.”³⁹⁸ 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 Cowles Commission approach lead to a series of methods of empirical research such as VAR approach or RBC approach.

One of the first significant studies regarding inflationary dynamics in developing countries was conducted on Chilean data by Harberger³⁹⁹. That early paper interestingly points out that analyzing nominal data in level form could result in spurious correlations in equations estimated for highly inflationary economies. In order to prevent this problem, percentage rates of change were utilized in a linear regression framework. The model developed is nowadays known as the "Harberger" framework, and incorporates real income, current and lagged values of the money supply, and the opportunity cost of holding cash balances⁴⁰⁰.

The success of this first model based on Chilean data generated a series of studies for other developing countries. However, following numerous applied econometric studies utilizing this approach, it became apparent that the model based on domestic variables alone often explained only partial characterizations of developing country inflationary processes⁴⁰¹. Bomberger and Makinen⁴⁰² provide a thorough examination of the Harberger model using quarterly data for Korea, Taiwan, and Vietnam. To overcome these shortcomings, Hanson⁴⁰³ proposes in 1985 a

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

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

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

398 Idem, p. 2.

399 Harberger, A., *The Dynamics of Inflation in Chile*, Chapter 2 in *Measurement in Economics: Studies in Mathematical Economics and Econometrics in Memory of Yehuda Grunfeld*, edited by Carl F. Christ, Stanford, CA: Stanford University Press, 1963.

400 Fullerton, Jr., Thomas M., Ikhida, Sylvanus I., *An Econometric Analysis of the Nigerian Consumer Price Index*, *Journal of Economics*, Volume 24, Number 2, 1998, p. 2.

401 Gerdes, William D., *The Dynamics of Inflation in Eastern and Southern Africa: 1969-1985*, *Tanzania Journal of Economics*, 1, 1989, p. 77.

402 Bomberger, W. A., Makinen, G. A., *Some Further Tests of the Harberger Inflation Model using Quarterly Data*, *Economic Development and Cultural Change*, 27, 1979, p. 635.

403 Hanson, J. A., *Inflation and Imported Input Prices in some Inflationary Latin American Economies*, *Journal of Development Economics*, 18, 1985, p. 400.

new model, extending the Harberger framework, incorporating an important missing component, import costs.

Hafer and Hein⁴⁰⁴ compared the accuracy of three different inflation forecasting methods. These included a univariate time series models, an interest rates model, and the median forecast based on the American Statistical Association - National Bureau of Economic Research survey. The authors studied the ex ante forecasts of quarterly inflation rates using the GNP deflator for the period 1970: I - 1984: II, and the general conclusion was that survey forecasts provide the most accurate inflation forecasts. In another article published in 1990, Hafer and Hein⁴⁰⁵ suggested that inflation forecasts derived from short term interest rates are as accurate as time series forecasts.

In 2003, Hahn⁴⁰⁶ investigated the pass-through of external shocks, i.e. oil price shocks, exchange rate shocks, and non-oil import price shocks to euro area inflation at different stages of distributions (import prices, producer prices and consumer prices). The analysis was based on VAR model that includes the distribution chain of pricing. According to their results the pass-through was largest and forecast for non-oil import price shocks, followed by exchange rate shocks and oil price shocks. The size and the speed of the pass through of these shocks declined along the distribution chain. External shocks explained a large fraction of the variance in all price indices.

Vector autoregressive (VAR) models have been much used in empirical studies of macroeconomic issues since they were launched for such purposes by Sims. They are now widely used in all kinds of empirical macroeconomic studies, from relatively atheoretical exercises such as data description and forecasting, to tests of fully specified economic models.

Earlier VAR studies have in many cases been concerned with measuring monetary policy and its macroeconomic effects. Gordon and Leeper⁴⁰⁷, Christiano, Eichenbaum, and Evans⁴⁰⁸, Leeper, Sims, and Zha⁴⁰⁹, and Bernanke and Mihov⁴¹⁰ for further references.

The model

Our model is based on monthly data for inflation rate (measured by CPI), net average wage (NAW), unemployment rate (UR), broad money (BM2), narrow money (NM1), real interest rate on deposits with the NBR(IR), nominal exchange rate (USD/RON and EUR/RON – ERUSD, EREUR) for Romania between January 1999 and January 2009⁴¹¹. Net average rate and unemployment rate represent the structural influences on inflation, broad and narrow money as well as real interest rate on deposits with the BNR 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 eight series have one unit root I(1); Consequently they have to be differenced once to become stationary. The above mentioned tests confirmed that the first difference series were stationary. The Johansen cointegration without deterministic trend test was then conducted. The Unrestricted

404 Hafer, R. W., Hein, S. E., [On the Accuracy of Time-Series, Interest Rate, and Survey Forecasts of Inflation](#), *Journal of Business*, University of Chicago Press, vol. 58(4),1985, p. 378.

405 Hafer, R. W., Hein, S. E., [Forecasting Inflation Using Interest-Rate and Time-Series Models: Some International Evidence](#), *Journal of Business*, University of Chicago Press, vol. 63(1),1990, p. 15.

406 Hahn, E., Pass-through of external shocks to euro area inflation. European Central Bank, working paper 243, 2003, available at <http://www.ecb.int>, accessed at 15.04.2009.

407 Gordon, D. B., Leeper, E. M. The Dynamic Impacts of Monetary Policy: An Exercise in Tentative Identification, *Journal of Political Economy*, 102, 1994, p. 1237.

408 Christiano, L. J., Eichenbaum, M., Evans, C., The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds, *Review of Economics and Statistics*, 53, 1996, p.24.

409 Leeper, E. M., Sims, C. A., Zha, T., What Does Monetary Policy Do? *Brookings Papers on Economic Activity*, 2/1996, p. 53.

410 Bernanke, B. S., Mihov, I., The Liquidity Effect and Long-Run Neutrality.,NBER Working Paper No. 6608, 1998

411 BNR Monthly Bulletins, available at <http://www.bnr.ro/PublicationDocuments.aspx?icid=1182> accessed at 30.03.2009 and INSSE Tempo Online series available at <https://statistici.insse.ro/shop/> accessed at 30.03.2009

Cointegration Rank Test (Trace) indicated three cointegrating equations and the Unrestricted Cointegration Rank Test (Maximum eigenvalue) indicated seven cointegrating equations at 0,05 level.

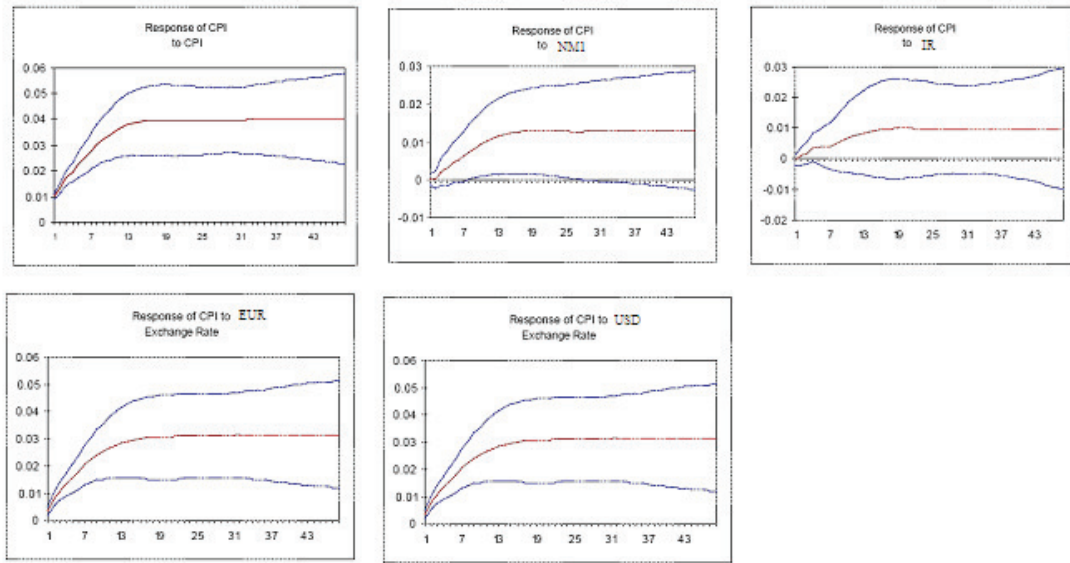
Given the results, a VECM Vector Correction Model with 3 cointegrating equations was estimated. Restrictions were placed on the coefficients of each cointegrating relation as well as on the adjustment coefficients, using the normalized cointegrating coefficients and adjustment coefficients. The VEC Granger causality /block exogeneity Wald test showed that the variables with significant impact on the evolution of CPI were the USD and EUR exchange rate, the interest rate and narrow money M1. 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.

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.

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

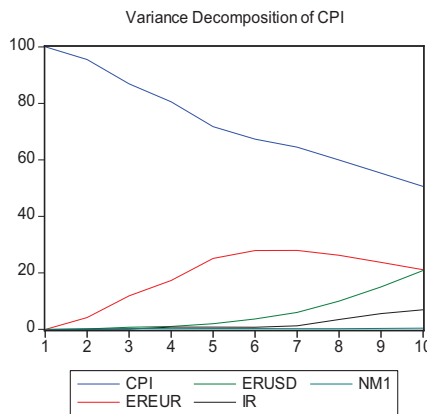
Response to Cholesky One S.D. Innovations



Source: author’s calculations

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 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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