FORECASTING INFLATION AND ITS DETERMINANTS

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Abstract: VAR modeling in inflation forecasting has been widely used, and rather successful, even if there have been several critiques of its exactness or accuracy. This paper is structured into two sections. The first one accomplishes a general presentation of VAR modeling in forecasting inflation, and the second is focused on the results of this econometric approach for inflation in Romania. Even if we considered methodologies containing inflation measured using CPI, CORE1 and CORE2, testing will only be performed for the CPI Inflation. Data used in mainly provided by statistics issued by the Romanian National Bank, and computing is accomplished using Mathematica 5.0.

Key words: inflation, VAR models, forecast, Romania

VAR models in Forecasting Inflation

Forecasts of real macroeconomic statistics have been successfully produced by vector autoregressive (VAR) models.

Even though, this type of models are still used by a large number of monetary institutions, including national banks in the process of forecasting short-term inflation and in isolating essential determinants for the inflationary process. Romania, and the Romanian National Bank represent examples in this respect. The NBR is interested in both forecasting and determination on monetary and non-monetary elements responsible for the inflation in Romania. This represents an important issue due to the fact that, in Romania, for instance inflation seems to have become a process with long duration and high significance in connection to the EMU accession process.

VAR modeling has its theoretical genesis in the time series analysis of Wold Taio, Box and Jenkins. They basically modeled the moving average and autoregressive components of a time series, which can then be used to predict future movements in the variables. The most widely used model was the Box and Jenkins autoregressive integrated moving average (ARIMA) models. Much of the appeal of VAR stems from Sims (1980) critique of structural models. He basically questioned the theoretical validity of the restrictions imposed on the structural models of the time. Sims favored a theoretical approach to modeling based on vector autoregressions, in which the data generation process determines the model.

Given the objective of price stability, the ability to predict the process of price adjustments is essential. From a policy perspective, an understanding of the interactions and transmission process between the main macroeconomic variables and prices serves to guide the process of policy formulation and implementation. In understanding and predicting inflation it is necessary to understand the importance of shocks and the underlying process. Critical elements of these are the persistent components such as expectations, indexation and the structural factors such as the openness of the economy, as well as the production function. This paper explores these interrelations and attempts to provide an alternative means of forecasting inflation by employing a Vector Autoregressive (VAR) model. In so doing it attempts to elucidate some aspects of the transmission process. The initial relative success of this approach led to the development of large scale models, the most noted of which were the MIT, Penn State and the Federal Reserve models. During the late seventies, however, these models were criticized by Lucas as being highly inappropriate for policy analysis as they violated the 'policy invariance' property. More recently, Sims(1980) in a seminal critique argued that the restrictions applied to structural models in the estimation procedure were 'incredible' and could not be properly tested.

A VAR model uses historical data to predict future values. An unrestricted VAR *(UVAR)* model can be written

$$x = \mu + \beta(L)X + \varepsilon \tag{1}$$

where x is a *kxl* vector of variables, μ is a *kx1* vector of constant terms, β (L) is a polynomial of degree m in the lag operator (L), and e is a *kxl* vector of error terms. In practice, a k-variable model is often simply k separate equations for which the coefficients can be estimated by ordinary least squares. The price equation in the *VAR* considered below is

$$p_t = \mu_p + \sum_{v=1}^{k}\sum_{j-1}^{m}\beta_{j,v}x_{v,t-j} + \varepsilon_t \tag{2}$$

where p is the inflation rate, t indexes time, v indexes the particular variable, j indexes the lag number, and μ_p and the $\beta_{j,v}$ are coefficients. Note that even for a relatively small VAR model such as the one used in this paper, with the number of variables k=5 and the lag length m=6, the price equation contains 31 coefficients to be estimated. It is often believed desirable to limit the number of estimated coefficients.

In order to limit the number of estimated parameters, this paper's strategy is to reduce many lag lengths in an adjusted VAP (AVAP) model. For each equation, set two lag lengths -- one for the dependent variable and another for all independent variables -- in order to optimize some statistical criterion. The particular criterion used in this paper is the Schwarz Criterion (SC), which typically gives a parsimonious specification.' It is defined as

$$SC = T\,ln\,\delta^2 + N\,ln T \tag{3}$$

where T is the number of observations, N is the number of estimated coefficients, and δ^2 is the estimated residual variance. By minimizing the Schwarz Criterion one is trading off the lower residual variance from adding an additional coefficient against a penalty term that rises with the number of estimated coefficients. The strategy for selecting lag lengths is to specify a maximum lag length, assume that all independent variables in each equation have the same lag length, and compute the

Schwarz value for all possible lag length combinations. Of special interest is the price equation for the AVAP model, which is

$$p_t = \mu_p + \sum_{v=1}^{k}\sum_{j-1}^{m}\beta_{j,v}x_{v,t-j} + \varepsilon_t + \sum_{v=p}\sum_{j=1}^{m}\beta_{j,v}x_{v,t-j} \qquad (5)$$

where the number of lags m, of the dependent variable is three and the number of lags q of each independent variable is one.

Because many variables do affect inflation, and are in turn affected by inflation, it is possible to identify a small selection of economic variables, movements in which appear to have been highly correlated with inflation in the past and as such may then be useful in forecasting future inflation. The VAR approach provides a convenient means of accomplishing this, as it relies on the causal and feedback relation amongst variables.

Inflation in Romania

The two essential hypothesis of this research are: 1. inflation is a persistent phenomena in Romania, more than in every other CEEC candidate to the adoption of the Euro; 2. the accession to the Euro-Area has no opt-out clause for the most recent EU member states, and thus, neither for Romania. The two hypotheses are of crucial importance to both Romania and the Euro-Area as a dynamic monetary entity – inflation can cause serious economic and monetary damages to all involved parties while the Euro adoption is a simple matter of time.

Thus, this study is of major interest to both the EU (and the Euro-Area) and the Romanian authorities. This could offer a better perspective concerning Romania's real compliance to the real and nominal convergence criteria, and at the same time, it could offer viable and scientific solutions to Romanian authorities in their search of an optimal monetary policy set of actions when facing the entrance in the ERM III.

Inflation has become a serious and severe matter especially when considered in the context of the monetary integration process. CEEC's performance during transition time, but also as functioning market economies, have been measured using inflation as central indicator. In most recent evolutions, Romania has proved to be unsuccessful in implementing a solid disinflation process (gradual disinflation - a targeted depreciation rate of the exchange rate as a nominal anchor). For 2007, the National Bank of Romania, has admitted, before the end of the year, that the inflation target has been missed reaching 6,57%.

Table no. 1. Inflationary variations in Romania

Annual variation (%)			dec. 06/ sep. 07(pp)
	sep. 07	dec. 07	
CPI	6,03	6,57	↑0,54
Volatile Prices	10,57	12,56	↑1,99
Administrated Prices	7,28	4,97	↓2,31
CORE2	4,60	5,83	↑1,23

Source: National Bank of Romania

Therefore, Romania is an interesting case for studying a more general question: Why do countries choose different targets for disinflation? Like most similar literature, previous studies on disinflation in Romania estimate a vector autoregressive model to illuminate the links among inflation and other macroeconomic variables (see Moore, 2001; Gueorguiev, 2004).

From a methodological point of view, the measurement of inflation is difficult. The aim of this research project is to point-out the influence of some different elements from the classic ones. An upward bias in the consumer price index driven by four effects such as quality effect, substitution effect, new goods effect, outlet effect (Boskin et al. 1996, 1998; Gordon 2000).

The quality effect stems from changes in the quality of a good that may lead to price increases that are misconceived as price inflation. The substitution effect relates to changes in consumption patterns: In response to relative price increases, consumers may switch to similar but cheaper products. The new consumption pattern is not always reflected in updated weights for the consumer price index.

The new goods effect arises when new goods are included in the CPI consumption basket only with a delay. Finally, the outlet effect stems from the difficulties faced by official price collectors in reflecting consumers' moves towards shopping at cheap outlets such as hypermarkets.

The econometric analysis also wishes to study the possibility to predict inflation and its determinants. In this respect, a distribution of price modifications shall be accomplished on main groups of products and VAR bi-variant models shall be built in order to determine the economic variables determining inflation and finally being able to predict it. (Christoffersen and Wescott 1999). Most studies start from the assumption that price changes for the main components of the consumption basket are normally distributed. According to Ball and Mankiw (1995), Pujol and Griffiths (1996), the asymmetry coefficient or the high variability of prices' movement may lead to an inclination towards inflation due to the asymmetric behavior towards prices' change. Distribution is also significant in predicting inflation evolution. In order to determine prices' distribution and inflation determinants in Romania, we shall use price sub-groups from the CPI for the last 5 years, adjusted and standardized. The Jarque-Bera test will help in establishing the existence of a normal distribution or not. In order to determine the inflation determinants, we shall test the Granger causality and we shall built bi-variant VAR models using inflation series (measured using the CPI, CORE1[22], CORE2[23] and CORE3[24]).

The analysis from the monetary point of view includes an evaluation of the Balassa Samuelson effect and of elements such as the exchange rate, the interest rate, the balance of payment etc

Research can be sustained in this area by contacts, information exchange and documentation within the National Bank of Romania who has already supported actions in this respect. I have been part of a research program and conference organized by the National Bank of Romania with the best 8 young economist investigating the issues around Romania's present and perspective convergence to the Euro-Area and the Euro adoption process.

The importance of asymmetrical shocks which could lead to an upward bias in inflation rates must not be neglected. Three types of possible shocks deserve particular consideration: terms of trade shocks, agricultural shocks, and adjustments of

[22] CORE1 = CPI – administrated prices

[23] CORE2 = CORE1 – prices for season products

[24] CORE3 = trimmed mean 23 percent

administered prices. They might prove to be responsible for part of the inflationary process, but at the same time, they might also carry on a chain of asymmetrical shocks further on to the Euro- Area once Romania becomes a member and the issues surrounding inflation have not yet been solved.

The present econometric analysis studies the possibility to predict inflation using VAR models. In this respect, we studied price modification on categories of goods and services and bivariate VAR models in order to identify the variables that determine inflation and based on which inflation can be forecast, according to procedures used by Christoffersen and Wescott (1999).

Most analyses reffering to inflation leave from the hypothesis that the modification of the prices of the most important components of the consumer's basket are normally distributed.

This is important from at least two points of view. First, as Ball and Mankiw (1995) and Pujol and Griffiths (1996) argued, the asymmetry coefficient or the high variability of the prices' movement may lead to an inclination towards inflation due to unequal behavior towards price change. Second, it facilitates forecast. In order to compute the distribution in price changes from 55 month (June 2002 – December 2006) – 1925 observations. Each price change has been standardized by deducting the monthly average inflation for each month and dividing the difference with the corresponding standard deviation.

The Jaque-Bera test confirms (at 1% relevance level) the inexistence of a normal distribution. The obtained distributions have a positive asymmetry coefficient and a high kurtosis excess.

In order to establish determinants of inflation, we tested for Granger causality and VAR models using the inflation series measured using the CPI, CORE1, CORE2, CORE3. Based on the results, VAR multivariate models were used in for CPI inflation measure.

The used series are: - price indices, administrated prices' indices, indices of industrial production, the average gross wage, the average net wage (2004=100), the unemployment rate, the PPI, monetary aggregates M2, M1, the net internal actives of the banking system, the real interest rate, the real assets value, the nominal exchange rate (lei/EUR), the result of the public budget as percent of the budget income. All the series have been used in log (excepting interest rate the real assets' value, the exchange rate and the budget result). The causality bivariate Granger test results (probabilities associated to the F-static test) between the CPI measured inflation and the macroeconomic variables are presented in the table below.

Table no. 2. Results of the Granger test

Lags	1	2	3	4	5	6	7	8
Indicators								
Administrated price	**0.007**	**0.015**	**0.029**	0.067	0.090	0.072	0.064	0.001
Industrial out-put	0.431	0.403	0.524	0.775	0.709	0.711	0.821	0.884
Gross wage	0.213	0.445	0.560	0.544	0.477	0.697	0.802	0.804
Net wage	0.236	0.153	0.116	0.146	0.131	0.258	0.367	0.411
ULC	0.217	0.501	0.644	0.506	0.636	0.808	0.867	0.507
Interest rate	0.535	0.524	**0.017**	**0.023**	**0.008**	**0.022**	**0.020**	**0.037**
PPI	**0.014**	**0.017**	**0.037**	**0.035**	**0.000**	**0.000**	**0.000**	**0.001**

Lags	1	2	3	4	5	6	7	8
M2	0.263	0.543	0.524	0.084	**0.009**	**0.004**	**0.008**	**0.006**
M1	0.203	0.552	0.677	0.471	**0.022**	**0.035**	**0.022**	**0.005**
Net internal assets	0.662	0.814	0.3	0.293	0.218	0.123	0.147	0.154
Real interest rate	0.548	0.636	0.397	0.622	0.670	0.437	0.575	0.478
State titles	0.442	0.730	0.841	0.709	0.666	0.671	0.848	0.930
BUBOR real	0.348	0.697	0.821	0.370	0.463	0.484	0.474	0.620
Nominal exchange rate	0.348	0.389	0.111	0.140	0.185	0.058	**0.018**	**0.039**
Budget result	**0.015**	**0.017**	0.043	0.081	0.149	0.192	0.159	0.077

According to probabilities associated to a 5% relevance level, the evolutions of inflation is preceded by the evolution of : administrated prices, unemployment rate, industrial production price index, M1, M2, the exchange rate, and the budget result. In building the VAR models, in determining the lag, the probability resulted from the Granger test were taken into account.

According to the results obtained in the impulse-response functions, inflation is influenced by: the index of administrated prices, unemployment rate, M1, M2, internal net actives of the banking system, exchange rate.

In order to asses the inflation prognosis, we use a VAR multivariate model with 4 variable lags: inflation (CPI), M2, real interest rate, the exchange rate and the budget result.

According to the diagnosis through sum of errors and the sum of the square errors, the Jarque-Bera test rejects the hypothesis of a normal distribution. The dynamic relations between inflation and unemployment and administrated prices are correct – an increase in unemployment determines an increase in inflation, and an increase in administrated prices determines a decrease in inflation.

Also, due to the correlation between M1, M2 and the net internal actives of the banking system, the VAR model only retained the M2 variable.

Conclusions

VAR model appear in consequence as a solid instrument in modeling and forecasting inflation. The Romanian case is a special one in respect of this matter – the inflationary phenomenon – and has to be studied accordingly. The present analysis is only a small step indeterming inflation factors and fors-eeing their influence. Econometric results obtained in simulations on the designed models are significant and in strict accordance to the economic reality and theory. Actual development and inflation evolution stages in Romania require a deeper analysis of monetary and non-monetary determinants of inflation and share them account for. In this respect, further research is to be continued. The initial hypothesis remains and even becomes a conclusion – inflation is and seems to remain (at least on a short run) a persistent phenomenon with causes that can be traced beyond the monetary instruments.

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