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MONETARY POLICY TRANSMISSION MECHANISM AND TVP-VAR MODEL

Methodological article

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Abstract

The transmission of monetary policy to the economy is a subject of major importance for central banks because, by using these measures, central banks can achieve their purpose of ensuring price stability without neglecting the objective of sustainable economic growth. In order to analyze the evolution of the monetary policy transmission mechanism in Romania, a time varying structural vector auto regression model is estimated, by using a Markov Chain Monte Carlo algorithm for the posterior evolution. The conclusions of the empirical study are: both systematic and non-systematic monetary policy have changed during the investigated period of time, the systematic response of the interest rate to shocks in inflation and unemployment being faster over the recent period. Also, non-policy shocks seem more important than interest rate shocks in explaining inflation and unemployment evolution.

Introduction

The purpose of this paper is to provide an example about how can the systematic and non-systematic part of the monetary policy be estimated and interpreted by using a time varying methodology. In order to ensure the econometric framework, time varying parameters are needed with the purpose of measuring policy changes. And also a model of the economy with multiple equations is needed in order to understand how changes in policy are affecting the rest of the economy.

Based on the last two statements, a time varying structural vector auto regression model is used and the source of time variation derives from drifting coefficients. The estimation of the model - the posterior of the parameters of interest - requires numerical methods; therefore the model described in the paper is an efficient Markov Chain Monte Carlo algorithm.

The section *Description of the model* offers some insight on the arguments for the usage of Bayesian methods, but also some general information about the variables used for estimation and data transformation. Same section provides information about setting the priors, the importance of the order of the variables and the simulation process itself. The results of both non-systematic and systematic monetary policy actions are described in *Results of the estimation* section. Conclusions and ideas for further research are presented in the final section of the paper.

Description of the model

The model used for estimation purpose is a multivariate time series model with time varying coefficients. These drifting coefficients are used to capture time variation in the lag structure of the model.

Arguments for using this model

The posterior distribution of the parameters of interest, such as the unobservable states and the hyper-parameters are evaluated based on Bayesian methods.

One reason for using these methods is given by the existence of unobservable components. Moreover, Bayesian inference is used instead of classical maximum likelihood estimator because of the following drawback of this method: difficulties in dealing with high dimensionality and nonlinearity. It is possible that the likelihood to have multiple peaks some of them being in unreasonable areas of the parameter space.

Also, due to these peaks, the likelihood might reach high values and might become fewer representatives for the model's fit. This drawback is removed by the Bayesian setting, with the help of uninformative priors' usage.

Moreover, even though it might be possible to write down the likelihood, it is very difficult to maximize it over such a high dimensional space. Bayesian methods are those that deal efficiently with the issues related to high dimension of the parameters space and the non-linearity of the model. A particular variant of Markov Chain Monte Carlo methods is Gibbs sampling, which is used for posterior numerical evaluation of the parameters and consists of drawing from conditional posteriors with lower dimension than joint posterior of the whole parameter set.

Another reason for using Bayesian setting is that the estimates are based on the entire available set of data, therefore smoothed estimates are delivered [5][1]. The objective of the paper is to investigate the true evolution of the unobservable states over time and smoothed estimates are more efficient in achieving this goal than filtered ones.

General information about the data and the methodology

A small, monthly model for the economy of Romania is estimated, with the sample running from 1999:M6 to

2013:M6. Three variables are included in the model: harmonized index of consumer prices, unemployment rate and money market interest rate, in this order. The first two variables represent the non-policy block and the short term interest rate represents the policy block. A short description of the variables can be found in appendix A. Two lags are used for estimation purposes and the simulation is based on 3,000 iterations, out of which first 1,000 are discarded in order to ensure convergence.

The model is formed out the following equations [5]:

a) The measurement equation:

$$Y(t) = B_0(t) + B_1(t) * Y(t-1) + \dots + B_p(t) * Y(t-2) + u(t), with\, u(t) \sim N(0,\Omega) \quad (1)$$

b) The transition equation:

$$B(t) = B(t-1) + error, where\, B(t) = [B_0(t), B_1(t), B_2(t)] \quad (2)$$

Where:

- $Y(t) is\ an\ n \times 1\ vector\ of\ observed\ endogeous\ variables$
- $B_0(t)\ is\ an\ n \times 1\ vector\ of\ time\ varying\ coefficients\ that\ multiply\ constant\ terms$
- $B_1(t), \dots, B_p(t)\ are\ n \times n\ matrices\ of\ time\ varying\ coefficients$
- $u(t) are\ unobservable\ shocks\ with\ variance\ covariance\ matrix\ \Omega$
- $p\ is\ the\ number\ of\ lags\ in\ the\ VAR\ model$

Before starting estimating the model, several transformations are applied to the data. First of all, time series are checked for *seasonal adjustment* in Demetra+ software, by using TRAMO/SEATS method with RSA4 specification, which means that series as kept in level or in logarithm and the adjustment is done for working days, Easter and outliers by using an automatic model identification [6][4] (Demetra+ automatically identifies and estimates the best Arima model).

Series are checked for the existence of unit roots and level of integration, by using Augmented Dickey Fuller (ADF) test and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test. ADF test assesses the null hypothesis of a *unit root* in univariate time series. If the probability computed by the test is larger than the significance level of five percent, the null hypothesis is accepted, series are integrated and they need to be differentiated in order to become stationary. Same results are returned when using KPSS test. The difference is that KPSS test assesses the null hypothesis that a univariate time series is trend stationary against the alternative that it is a nonstationary unit-root process. Both tests are used in the analysis to ensure better evidence regarding the existence of unit roots [6].

Based on the results displayed by the two above mentioned tests, harmonized index of consumer prices and unemployment rate are differentiated once in order to become stationary and money market interest rate is left in level. It worth mentioning that harmonized index of consumer prices is used in logarithm.

Priors and ordering

The initial states for the coefficients, for the covariances and for the hyper-parameters are independent of each other. The priors for the hyper-parameters are assumed to be distributed as independent inverse-Wishart. The priors for the initial states of the time varying coefficients are assumed to be normally distributed. These assumptions imply normal priors for the coefficients conditional on the hyper-parameters. What needs to be also mentioned is that the order of the variables matters. This is due to the lower triangular structure imposed on the error term in the measurement equation.

The first 40 observations are used to calibrate the prior distributions. The priors take the following forms [5]:

$$B_0 \sim N(\widehat{B_{OLS}}, 4 * V(\widehat{B_{OLS}})) \quad (3)$$

$$Q \sim IW(k_Q^2 * 40 * V(\widehat{B_{OLS}}), 40) \quad (4)$$

$$\Omega \sim IW(I, p+1) \quad (5)$$

Where:

- Q *is the covariance matrix of* $B(t)$
- Ω *is the covariance matrix of the VAR covariance*

The following triangular reduction of Ω is considered:

$$A * \Omega * A^t = \sum * \sum^t => \widetilde{\Omega} = \tilde{A}^{-1} * \widetilde{\sum} * \widetilde{\sum^t} * \tilde{A}^{-1t} \quad (6)$$

Where:

- A *is a lower triangular matrix*
- $\sum$ *is a diagonal matrix*

The order of the variables in the measurement equation matters due to the lower triangular structure imposed on the matrix A. The identifying assumption for the monetary policy shock is that monetary policy shocks do not affect inflation and unemployment contemporaneously and the response is lagged. For this reason, interest rate is ordered last in the model. This is an identification condition, essential for identifying monetary policy shocks. With regard to the simultaneous interaction between inflation and unemployment, it is modelled in a lower triangular form with inflation first.

Simulation method

The model is estimated by simulating the distribution of the parameters of interest given the data and for this purpose, Gibbs sampling is being used. As a first step, the priors are being set. $B_i, i = 1..p$ are estimated afterward, using Kalman Filter methodology and backward recursions or Kalman Smoother. Having $B_i, i = 1..p$ computed, the error from the transition equation can be computed and based on the error, Q matrix. Also, starting from $B_i, i = 1..p$ and using the measurement equation, Ω matrix can be drawn. Computations are kept for each iteration that is not dropped and then used for generating impulse response functions for each time period [5][2][3][7].

As mentioned before:

$$Q \sim IW(k_Q^2 * 40 * V(\widehat{B_{OLS}}), 40) \quad (7)$$

The value of k_Q used for estimation is $k_Q = 0.01$. Posterior inference can be affected by the choice of k_Q, but k_Q does not parameterize time variation, just prior beliefs about the amount of time variation. In large samples, posterior mean converges to the maximum likelihood estimator. In general, the posterior mean is a combination of the prior and the likelihood information and the weights are given by the relative size of the degrees of freedom of the prior and the sample size. The choice of k_Q affects the prior, but parameterizes time variation only when the prior degrees of freedom are driven to infinity.

Results of the estimation

The results of the model come from both non-systematic and systematic monetary policy actions. Non-systematic policy actions are related to monetary policy interest rate and systematic policy actions are related to the block of variables consisting of inflation and unemployment rate.

Non-systematic monetary policy

The measure of non-systematic policy actions is given by the identified monetary policy shocks. The changes in the effect of non-systematic policy are presented in Figure 1. The response of inflation, unemployment and interest rate itself after a shock in interest rate is plotted in this figure. Three points in time are investigated: 2006: M1 (after the adoption of inflation targeting monetary policy strategy), 2009:M6 (during the latest economic crisis) and 2012:M10 (in order to form an image on the current economic situation).

After an increase in the level of interest rate, inflation decreases in each one of the three moments of time, which is according to the theoretical view and it is a proof of the existence of the interest rate channel. After several periods of time, the response of inflation dissipates, which confirms the theory regarding the long term neutrality of money. Even though there is not much difference, it can be noted though, that the response is good after the adoption of inflation targeting monetary policy strategy (in 2006), decreases during the crisis (in 2009) and then slightly increases towards 2012.

Unemployment rate increases also after an increase in the level of interest rate and it stabilizes afterwards. The difference between responses at the tree points in time is not easily distinguishable. A small difference can observed: the impact on the unemployment rate decreases faster in time during the period of crisis.

Systematic monetary policy

The responses of the interest rate to shocks in inflation and unemployment are measures of the systematic monetary policy. These responses can be seen in Figure 2 and Figure 3. It can be noticed that the reaction of both variables is lagged and there is no contemporaneous impact. After an increase in unemployment rate, the interest rate decreases in order to stimulate the economy, the investors' decisions and the employment rate. The greatest response was observed during the crisis, which means that the monetary policy strategy was a stimulating one. After a shock to inflation, the response of the monetary policy interest rate follows the natural course after approximately two-three months. It increases in order to lower the level of investments and the level of consumption with the purpose of decreasing inflation. The fastest reaction can be noticed in 2006 after adopting inflation targeting strategy.

Conclusions and further research

Several observations can be made after estimating the TVP-VAR model with time varying coefficients and homoschedastic variance-covariance matrix on a sample database consisting of: inflation, unemployment and interest rate time series for Romanian economy. Three moments in time were chosen for the investigation: 2006: M1 (after the adoption of inflation targeting monetary policy strategy), 2009:M6 (during the latest economic crisis) and 2012:M10 (in order to form an image of the current economic situation). Regarding non-systematic monetary policy, even though there is not much difference between the three functions, it can be noted though, that the response is according to the theoretical view after the adoption of inflation targeting monetary policy strategy (in 2006), decreases during the crisis (in 2009) and then slightly increases towards 2012. Unemployment rate increases also after an increase in the level of interest rate and it stabilizes afterwards. The difference between responses at the tree points in time is not easily distinguishable.

On the other hand, after an increase in unemployment rate, the interest rate decreases in order to stimulate the economy and the greatest response is observed during the crisis, which means that the monetary policy strategy was a stimulating one. After a shock to inflation, the response of the monetary policy interest rate follows the natural course after approximately two-three months, the fastest reaction being noticed in 2006 after adopting inflation targeting strategy. Therefore, it can be concluded that the systematic monetary policy was focused on lowering inflation in 2006 and changed in time by focusing on unemployment rate evolution.

Further research might include the estimation of a TVP-VAR model with both time varying coefficients and multivariate stochastic volatility. A Markov switching regime model could be also estimated.

References

[1] Boivin, J., & Giannoni, M., (2002). Assesing Changes in the Monetary Transmission Mechanism: a VAR Approach. *FRBNY Economic Policy Review / May 2002*.

[2] Koop, G., & Korobilis, D., (2009). Manual to accompany MATLAB package for Bayesian VAR models,
http://personal.strath.ac.uk/gary.koop/KoKo_Manual.pdf.

[3] Koop, G., & Korobilis, D., (2009). Bayesian Multiariate Time Series Methods for Empirical Macroeconomics:
http://personal.strath.ac.uk/gary.koop/kk3.pdf

[4] National Bank of Poland, (2012). Demetra+ User Manual.

[5] Primiceri, G., (2004). Time Varying Structural Vector Autoregressions and Monetary Policy. *Review of Economic Studies*, No 72.

[6] Roşoiu, A., & Roşoiu, I., (2013). Monetary Policy Transmission Mechanism In Emerging Countries. *CrossCultural Management Journal*, No 28.

[7]http://personal.strath.ac.uk/gary.koop/bayes_matlab_code_by_koop_and_korobilis.html

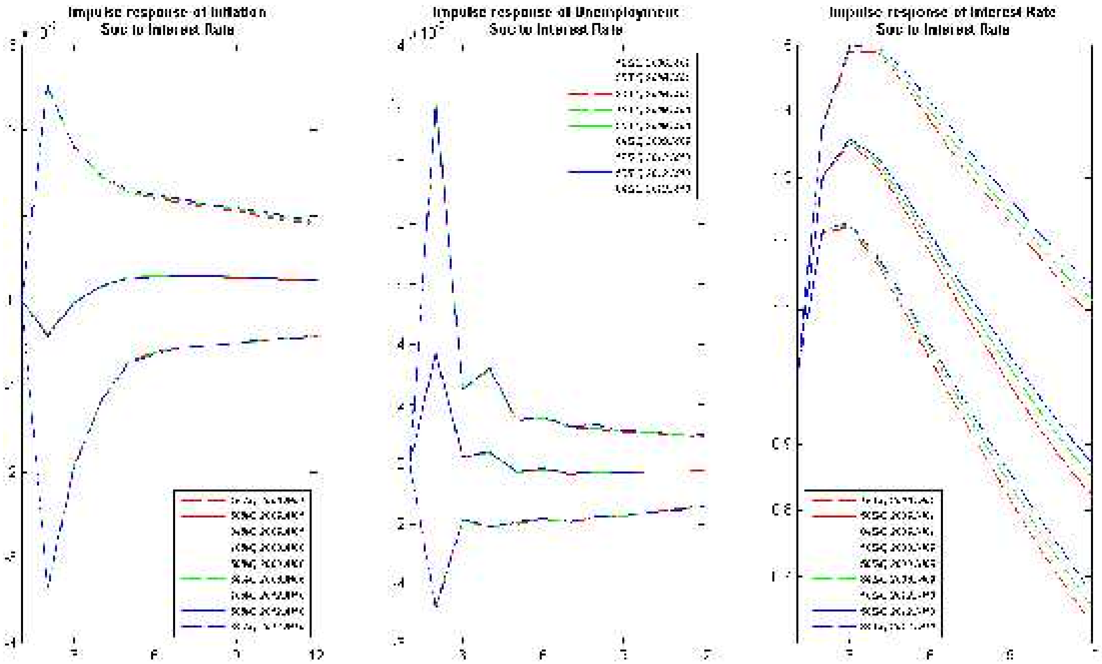

Figure No. 1 Impulse response after a shock to Interest Rate on a period of 12 months

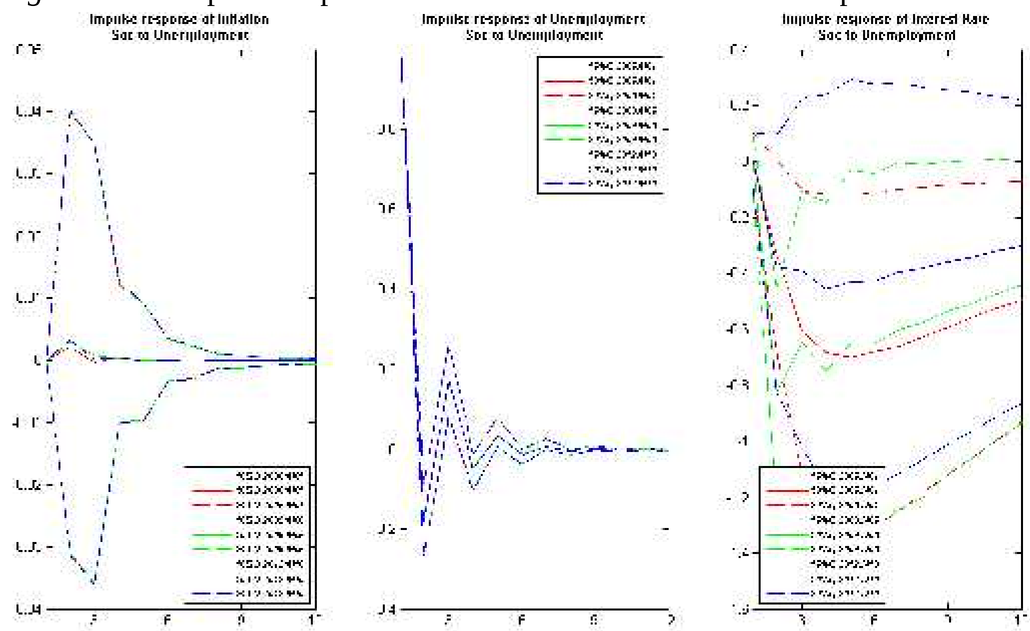

Figure No. 2 Impulse response after a shock to Unemployment Rate on a period of 12 months

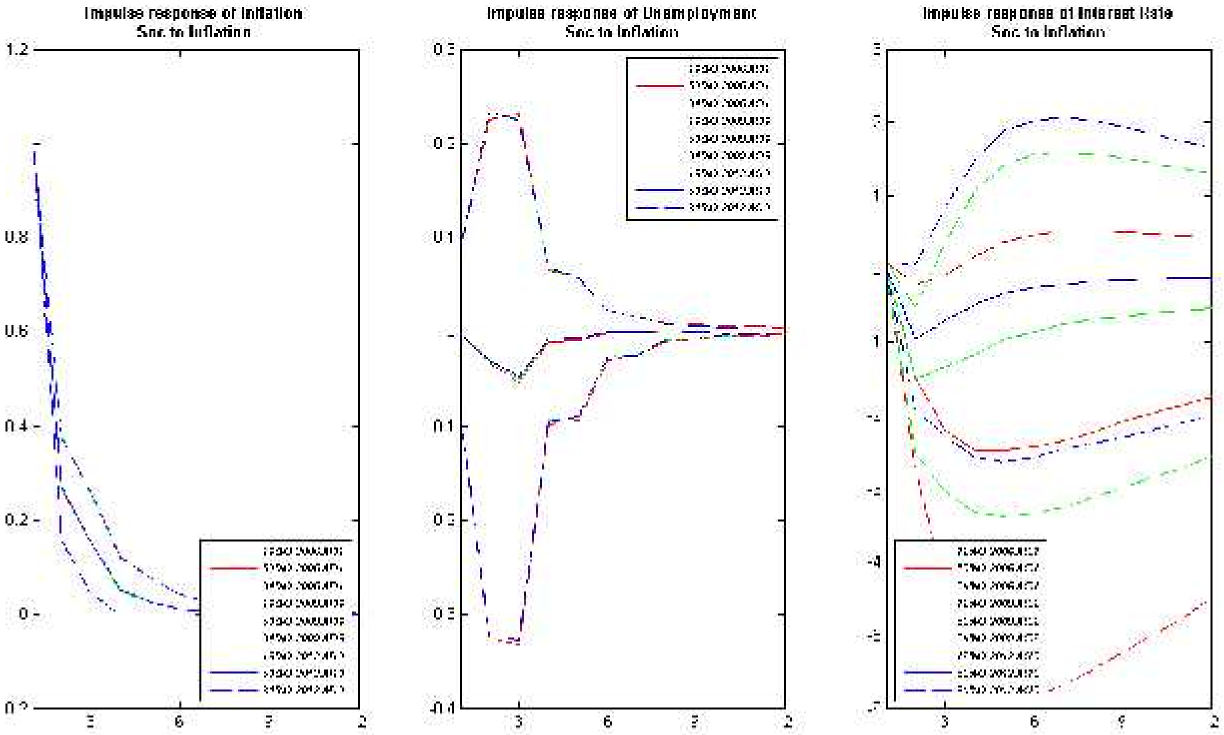

Figure No. 3 Impulse response after a shock to Inflation Rate on a period of 12 months

Appendix A: Data (sources and description)

Endogenous variables for Romania:

- HCPI is the harmonized consumer price index.
- UR is the unemployment rate.
- IR is the short term interest rate.

Data for all endogenous variables were taken from Eurostat.