CENTRAL BANKS FORECASTING MODELS AND POLICY ANALYSIS SYSTEMS IN A NEW ERA

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Forecasts have a great importance in the monetary policy formulation and implementation process. In this paper we aimed to close the gap between the research and practice in the matters related to forecasting and policy analysis systems applied by central banks. Particularly, we relied on the structure of the basic framework for policy analysis, their theoretical background and main processes which they imply. We focused on the FPSA developed by central banks from CEE countries, inclusively by the National Bank of Moldova, namely its construction for short-term and mid-term forecasts.

Key words: *models, inflation forecasting, mid-term forecasts, core model, near-term forecasting, DSGE models*

JEL Classification: E5, E61, E31

1. Introduction

Forecasting plays an important role in the process of formulation and implementation of the monetary policy. Before taking their decisions on monetary policy, the policy-makers need to know the stance of the current macroeconomic situation and its future developments. In other words, they need an appropriate forecasting framework for policy guidance, namely the tools that would help them to appreciate the economic implications of the monetary policy decisions and proper evaluation of the dynamics of the main macroeconomic indicators.

Under inflation targeting regime, the importance of a sustainable, rule-based monetary policy framework, characterized by a high degree of transparency and accountability, is of utmost importance, in order to ensure the proper communication of the monetary policy decisions.

The economic literature on the subject of forecasting approaches is wide, but is not specific about the structure and work mechanism of the forecasting and policy analysis systems implemented by the central banks from different countries.

In this paper we aimed to close the gap between the research and practice in the matters related to forecasting and policy analysis systems applied by central banks. Namely, the purpose of the study was to investigate the main processes and tools of the forecasting and policy analyzes systems implemented by the most central banks from CEE countries.

We showed that the structure of the forecasting models is designed to capture the basic business cycle dynamics and basic interrelations between a range of macroeconomic fundamentals. Their usage provides a better understanding of the main transmission mechanism channels, being as an organizing tool for policy reaction to various shocks (Tovar, 2008)

The study was structured as follows: in the second section was presented the theoretical framework of the forecasting and policy analysis systems, on which are based the macroeconomic models used by central banks, in the third section were analyzed the components of the forecasting process, namely the core model used for mid-term projections and the short-term forecasting methods. The las section concludes.

2. Conceptual framework of the forecasting and policy analysis system

The theoretical framework of the forecasting and policy analysis system is based on the Dynamic Stochastic General Equilibrium Models (DSGE), which is structured in three interconnected blocks: a demand block, a supply block and a monetary policy rule equation.

Following the above diagram, the demand block refers to the economic activity, which is expressed as a function of ex ante real interest rate $i - \pi^e$ and the expectations related to future activity Y^e. In this way, then the real interest rate is high, the individuals would rather save than consume or invest.. But then Y^e is high, people would tend to spent more, regarless of the level of the real interest rate. (Sbordone, A. et al, 2010)

The line which connects the demand and supply block shows that the output (Y) and future expectations of inflation, are the input factors for inflation determination (π).

The demand and supply blocks, through the output and inflation, determines the monetary policy block. From this blow we can see that the central bank sets the nominal interest rate as a function of inflation and real output.

Each aggregate equation of the block is derived from the microfoundations – the behavior of the main macroeconomic actors: households, economic agents and the government sector.

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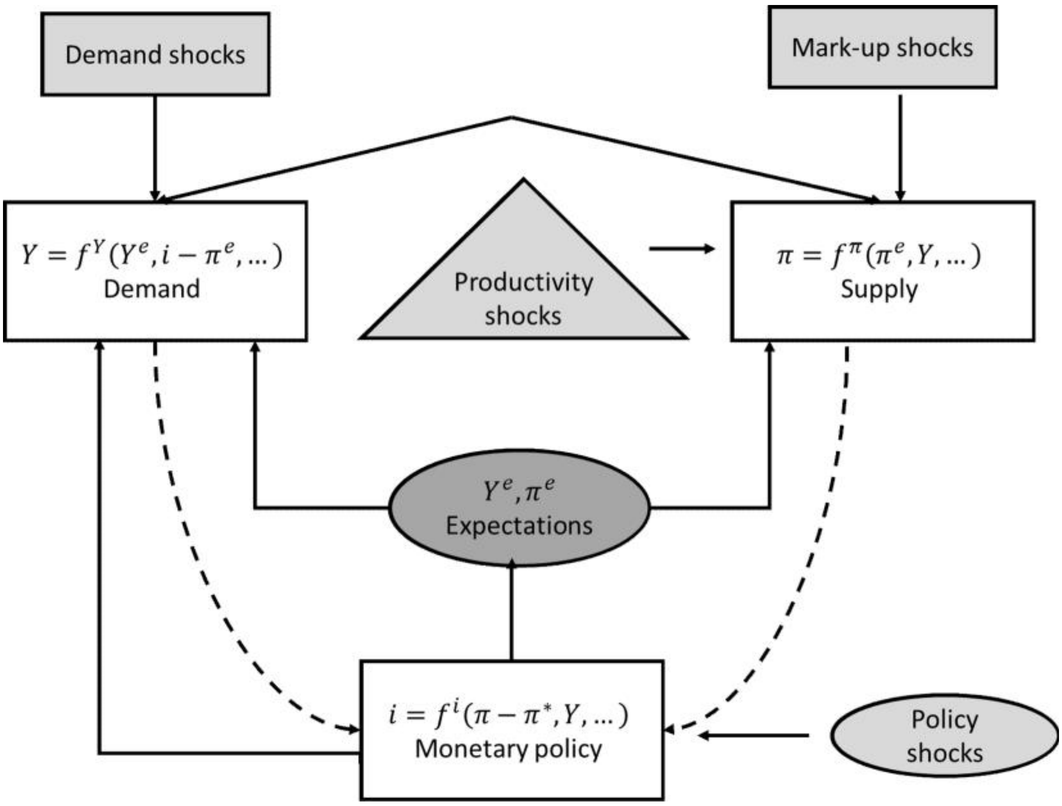

Fig. 1. The Simple version of the DSGE model

Source: authors

Households

Households are considered representative agents which seek to maximize a standard inter-temporal utility function of consumption, leisure and money.

$$U(C_t, N_t, \frac{M_t}{P_t}) \quad (1)$$

where

C – consumtion

N – hours of work

M/P – real balances, M – money and P – prices

The intertemporal budget constraint function is that spending and saving at time t is not greater than earning at time t.

$$C_t + \frac{M_t}{P_t} + \frac{B_t}{P_t} \leq \left(\frac{W_t}{P_t}\right) N_t + \frac{M_{t-1}}{P_t} + (1 + i_{t-1})\left(\frac{B_{t-1}}{P_t}\right) + \Pi_t \quad (2)$$

where

B – bonds

W- wage per hour

I – interest rate

π profits of the firm

The general solution of the model, also known as dynamic IS curve is the equation:

$$U'(C_t) = E_t\left[U'(C_{t+1})\frac{1+i_t}{1+®_{t+1}}\right] \quad (3)$$

Following the rationale of the above equation, exists a direct correlation between consumption and expected future inflation. Higher expected future inflation will increase consumption: $E_t\pi_{t+1}\uparrow \rightarrow U'(C_t)\downarrow \rightarrow C_t \uparrow$. A negative correlation can be observed between consumption and interest rates. An increase in interest rates will reduce consumption, $i_t\uparrow \rightarrow U'(C_t)\uparrow \rightarrow C_t\downarrow$.

Firms

To model the economic agents behaviour, the model starts with the constant returns to scale technology equation:

$c_{jt} = Z_t N_{jt}$ (4)

where

Z – aggregate productivity shock

The firms’ profit maximization function is as follows:

$$\max_{p_{jt}} E_t \sum_{i=0}^{\infty} \mu^i \Delta_{i,t+i} \left[\left(\frac{p_{jt}}{P_{t+i}} \right)^{1-¯} - ¨_{t+i} \left(\frac{p_{jt}}{P_{t+i}} \right)^{-¯} \right] C_{t+i} \quad (5)$$

Considering the p_t^* an optimal price, chosen by firms, then the First Order Condition rearanged using $\Delta_{i,t+i} = {}^i (C_{t+i} / C_t)^{-±}$, become:

$$\left(\frac{p_t^*}{P_t} \right) = \left(\frac{¯}{¯ - 1} \right) \frac{E_t \sum_{i=0}^{\infty} \mu^i \, {}^i C_{t+i}^{1-±} ¨_{t+i} \left(\frac{P_{t+i}}{P_t} \right)^{¯}}{E_t \sum_{i=0}^{\infty} \mu^i \, {}^i C_{t+i}^{1-±} \left(\frac{P_{t+i}}{P_t} \right)^{¯-1}} \quad (6)$$

$$P_t^{1-¯} = (1-\mu)(p_t^*)^{1-¯} + \mu P_{t-1}^{1-¯} \quad (7)$$

$(1-\mu)$ - proportion of firms able to change their price in a period t

μ - proportion of firms unable to change their price in a period t

From the equation above, after a series of transformation, the new Keynesian Phillips curve can be given by:

$$\hat{x}_t = \frac{\sim\mu}{(1-\mu)(1-\ \mu)} (®_t - \ E_t ®_{t+1}) \quad (8)$$

where

$© = \frac{(1-\mu)(1-\ \mu)}{\mu}$ - real marginal cost

$\hat{x}_t$ - output

Following this equation, if inflation is expected to rise in the future, firms set high prices now, reducing supply.

Monetary policy rule

The most common monetary policy rule is the Taylor rule, which is considered is able to provide a reasonable empirical description of many Central Banks’ behavior:

$$\hat{i}_t = ¢_® ®_t + ¢_x x_t + ¬_t \quad (9)$$

From above equation we can see that interest rate reacts to inflation and output gap with shocks.

3. The forecasting and policy analysis process

There are different kinds of forecasting systems implemented by the central banks. Usually each system is a kind of DSGE model, tailored to a specific features of the national economy.

Each forecasting and policy analysis process uses several models, which can be classified by the time horizon for which the forecast is made. In the first place, there are a ***core model***, around which are made all forecasts. The core models are used mainly for mid-term forecasts and are constructed following the basic structure of transmission mechanism of the monetary policy. This kinds of models allow a better understanding of the currents state of the national economy and potential prospects of its evolution in the medium-run.

To capture the short-run influences were designed the ***near-term forecasting approaches***. Usually they are a small time-series models without any construction restriction. To investigate the short-run dynamics, besides time-series models sometimes are analyzed simple relations between different indicators such as remittances, spending, evolution on the money market etc.

Before proceeding to the core estimation, are used the ***signal extraction models*** to determine the long-run trends and calculate the gaps of the variables. The gaps are needed for core model estimation, given the fact that core model framework is based on business cycle theory. To determine the variables gaps, widespread techniques for data filtering are Kalman and Hodrick-Prescott filters.

Usually the process of forecasting starts with the near-term forecasting to capture the short-term outlook of the national economy and global prospects. Then are determined the gaps of the variables to have insights related to evolutions along the current business cycle. Then are done the mid-term forecasts with the core model.

Sometimes, to have deeper insights in the data, are used the satellite models, small subsystems, which decompose variables from the core models in different subcomponents.

Below we will go into greater detail about approaches used by the National Bank of Moldova and other central banks in their forecasting and policy analysis process.

3.1 Nowcasting and near-term forecasting process

Given the fact that policy-makers need to monitor the macroeconomic developments without complete information, were developed approaches which helps to extract the necessary information. ***Nowcasting*** is a process, with which are made estimates during the reference period itself. (Bańbura, Giannone, and Reichlin, 2011) Mainly is used to GDP predictions, giving the fact that GDP statistical data are published quarterly, with a time lag. For nowcasting are used the state-space models. The estimates are performed by assuming that many economic variables co-move and exists a set of common variables that drives a set of observed variables. Examples of unobserved variables are risk premium in financial markets or output gap for inflation modelling. The unobserved component is estimated by employing the SS-model and Kalman filtration. This kind of models can use mixed frequencies for data (ex. monthly and quarterly).

Near-term forecasts perform short-term forecasts, which covers the period of up two quarters, which serve as entries for the core model. The need for short-term forecasts is given by the lack of complete macroeconomic information and the different frequencies with which data is published and the necessity to make appropriate expert judgements about the current state of the national economy. To make estimates are used mostly simple time series models, which construction rests on economic interactions among different fundamental variables. Their structure is very flexible, because they usually do not rests on a specific economy theory. Their aim is to derive a specific relationship among fundamental variables and to use these relationships for short-term forecasts. Very often for such forecasts are used the following techniques: VAR, BVAR, ARIMA, SARIMA etc.

3.2 Quarterly projection model and its properties

The Quarterly Projection Model (QPM) is the basic model applied generally in the countries with inflation targeting. The model is structural because each of its equations has an economic interpretation. The core forecasting model used by the National Bank of Moldova, was also based on the QPM framework.

The QPM model is a small open-economy gap model, structured in two separate blocks: long-run trends and cyclical fluctuation represented by gaps. Is based on a forward-looking transmission mechanism of monetary policy and focuses its predictions on interest rate reaction to future mid-term inflation deviations from target. The main components of the model are structured around the following parts: aggregate demand, aggregate supply, Uncovered Interest Rate Parity (UIP) and monetary policy rule.

Aggregate demand curve – reflects the dynamics of the cyclical part of the aggregate demand, output gap (output gap), taking into consideration the following factors: deviations of the monetary condition index (rmci) which comprises the real interest rate gap and the real exchange rate gap; persistence factor and namely the backward expectations of the output gap (y_gap_{t-1}) and the foreign output gap ($y\_gap^*_t$).

$$y\_gap_t = d_0\, y\_gap_{t-1} - rmci\_gap_{t-1} + d_1 y\_gap^*_t + \text{£}^{y\_gap}_t \quad (10)$$

Supply side or Phillips curve – the headline inflation is forecasted separately, by its components: core inflation, energy price inflation and inflation of regulated prices. In the core inflation equation enters the persistence factor, represented by forward looking and backward looking components, and behavioral components given by imported inflation, relative price movements and output gap.

Food inflation, is also influenced by the persistence factor, imported inflation and evolution of the business cycle.

Uncovered Interest Rate Parity (UIP) - the interest parity equation put into relation the evolution of the real exchange rate (z_t) with the real interest rate differential from home and abroad ($RR_t - RR^*_t$) from which is substracted the risk premium (ρ^*_t). The interest rate term is divided by 4 because the interest rates and the risk premium are measured at annual rates. (Berg et al., 2006)

$$z_t = z^e_{t+1}[RR_t - RR^*_t - \rho^*_t]/4 + \varepsilon^z_t \quad (11)$$

Monetary policy rule – the structure of the equation is based on the assumption that the central bank set its instruments in order to achieve a target level for inflation. In this way the short-term nominal interest rate (*rs*), set by central bank will depend on a persistence factor (rs_{t-1}), equilibrium level of the real interest rate (rr_eq), inflation expectations and the reaction to business cycle (output gap (y_gap_t) and expected inflation deviation from the target ($E\text{®}_{t+4} - \text{®}^{\text{target}}_{t+4}$)).

$$rs_t = \text{ª} rs_{t-1} + (1 - \text{ª})\left[rr\_eq_t + \text{®}_{t+4} + \text{©}(E\text{®}_{t+4} - \text{®}^{\text{target}}_{t+4}) + \text{¦} y\_gap_t\right] + \text{£}^i_t \quad (12)$$

The QPM model is based on the calibration techniques, the parameters of the model being set giving the special features of the economy, economic theory and behavior in shock responses.

5. Conclusions

Macroeconomic models used for forecasting in central bank, are a complex models designed to describe the interactions of key macroeconomic variables over different time horizons. In this paper we showed that the models and forecasting techniques used in policy analysis process, depends on the considered time horizon. For mid-term forecast are used the sophisticated models, based on the structure of the transmission mechanism of the monetary policy impulses. For short-term forecast, are used mainly simple approaches, with high flexibility. The common features of the forecasting systems in all central banks is that their theoretical framework is based on the DSGE models, which focus on the investigation of the macroeconomic dynamics of the national economy during the business cycle. Besides is important to mention that all forecasting systems are integrated approaches, where all fundamental factors are interlinked and are investigated as a part of some economic processes.

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