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Innovative Approaches for Modeling the Impact of Monetary Policy on Economic Development

Yakubova Shamshinur Shukhratovna 1

Abstract:
The scientific article presents an analysis of innovative approaches to macroeconomic modeling of the impact of monetary policy on the country's economic growth, highlights the essence of macroeconometric modeling, provides suggestions and recommendations on the application of macroeconomic modeling approaches to monetary policy.

Keywords: macro econometric modeling, economic growth, monetary policy, vector autoregressive models, error correction model, panel microdata analysis.

1 Candidate of Economic Sciences, Associate Professor
Head of the Department of "Accounting and Audit" Karshi Engineering and Economic Institute

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Introduction. Modeling the impact of monetary policy on the macroeconomic parameters of output and aggregate demand, and ultimately on sustainable economic growth, starting with the works of J. Keynes, I. Fisher, and M. Friedman, has been and remains a subject of constant scientific interest and serves as a basis for making managerial decisions in the central banks of almost all countries. However, in many foreign works, the reactions of the economy to the use of instruments for regulating money supply and interest rates were studied for countries with developed financial markets, and therefore the results obtained cannot be directly adapted for our country, where full-fledged market mechanisms of the functioning of the stock market and the banking sector are still being formed.

Unlike developed economies, a transitional economy is characterized by the fact that it does not fully operate the basic theoretical concepts and approaches on which any macroeconomic model should be based. For this reason, it is difficult to build complex macroeconomic models that describe the real economy and include all aspects of the impact of macroeconomic regulation on the dynamics of GDP, employment, investment and savings, and foreign trade indicators.

Analysis of thematic literature. An important role in the theoretical understanding of the essence of this urgent problem for the republic was played by the works of domestic scientists S.V. Chepel, Sh.Z. Abdullaeva, S.S. Gulyamov, E.F. Trushin, O.K. Iminov, O. Olimdzhanov, T. Malikov, O.Sh. Namozov, B.M. Dushaev, T.I. Bobokulov and others, in which an empirical analysis of the interaction of monetary policy with the most important economic processes, such as inflation, economic growth in sectors of the economy, finances of the state, enterprises and the population in an economy in transition, is carried out. Also in the works carried out, monetary and non-monetary factors are considered that determine the saturation of the economy with money supply.

At the same time, in the studies of Russian scientists S.R. Moiseev, S.M. Drobyshevsky, Kozlovskaya, V.P. Trunin, F.S. Kartaev, K.V. Yudaeva, as well as foreign researchers J.M. Keynes, M. Friedman, Huert de Soto, D. Hammond, F. Mishkin, B. Bernanke, J. Taylor, R. Mandell, G. Gertler and many others, the internal aspects of modeling monetary policy, the rules of monetary policies for the Central Bank, various targeting regimes and their features, issues of modeling optimal monetary policy, etc.

Despite the fact that a lot of research has been carried out and is being carried out to study and model the impact of monetary policy on macroeconomic parameters in foreign economies, certain issues of scientific substantiation and modeling of the effective impact of indirect instruments on economic growth and other macroeconomic parameters in relation to our republic remain unresolved. the end studied and require further elaboration.

Methods. The methodology for studying the influence of monetary policy on economic growth is based on a theoretical and methodological analysis of modern approaches and models used in the process of econometric modeling, the study of special literary sources, methods and methods for constructing models of the influence of monetary policy mechanisms on economic growth indicators.

Results. Consideration of the problems of constructing models of the influence of monetary policy on economic growth should begin with the concept of macroeconometric modeling. As world practice shows, macroeconometric modeling is accepted as an effective tool for building aggregated macroeconomic models, on the basis of which decisions are made to implement the appropriate economic policy. So, Fedorova G.V. his research gives the following definition: "By

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macroeconomic modeling we mean research in the aggregated form of retrospective and prospective processes taking place in the country's economy, using economic and mathematical modeling" [1]. At the same time, as an object of macroeconomic research, the author of the article cites the country's economy as a whole, taking into account all the main aspects of economic life. Depending on the goals of research, these aspects can be considered in a more or less aggregated form, varied, or taken into account in some fixed state. The tool of macroeconomic research is an economic and mathematical model, within the framework of which a simplified description of the economy is produced, subordinate to the objectives of the research. The model description of the economy contains a task in one form or another of the structure and nature of the interactions of economic agents. The description of the structure determines, firstly, the composition of the subjects, and, secondly, the relationships between the subjects considered in the model [1].

Analysis. A review of works devoted to macroeconomic modeling of monetary policy in developed and developing countries leads to the conclusion that at present, the economic literature most often analyzes the impact of monetary policy shocks on the real sector of the economy and, accordingly, money transmission channels in the short term on the basis of the so-called "vector autoregressive approach" (VAR approach), in the development of which were greatly contributed by R. Lucas, T. Sargent, K. Sims and a number of other macroeconomists in the 1970s. [3-5]. In addition, in recent decades, special attention has begun to be paid to other, new approaches, such as modeling based on panel analysis of microeconomic data, modeling monetary policy rules, developing stochastic dynamic general equilibrium models (DSGE - Dynamic Stochastic General Equilibrium Model), and also an attempt to integrate VAR models with other approaches (SVAR (structural vector-autoregressive) - structural vector autoregressive models, FAVAR (factor-augmented structural vector-autoregressive) - vector autoregressive models supplemented by factors). One way or another, all approaches, regardless of their form and structure, are intended mainly for one purpose - building an accurate model that reflects the impact of monetary policy measures on macroeconomic indicators, and identifying the existing channels of the transmission mechanism and their features.

A different grouping of methodological approaches to assessing the channels of influence of monetary policy on the real sector of the economy is proposed by researchers at the E.T. Gaydar [6]:

- vector autoregressive method;
- descriptive approach;
- panel analysis on microdata.

Discussion. The foundations for using vector autoregression (VAR) models to study the macroeconomic consequences of unforeseen policy changes were laid by C. Sims [4]. Further studies by B. Bernanke and A.Blinder [7] and C. Sims [8], as well as a number of other studies by L. Christiano, M. Eichenbaum and C. Evans [9] revealed how the vector autoregression (VAR) method works for identifying and measuring the impact of monetary policy innovation on macroeconomic variables. Vector autoregression (VAR) models can use a reduced number of theoretical constraints, making them easy to use and identify structural shocks. The VAR (vector autoregressive) method is widely used by proponents of the atheoretical approach and is a system of equations in which each variable is used to determine every other variable in the model. Each variable depends on its own past values and the past values of all other variables in

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the system.

The VAR methodology is based on an equation of the form:

$$Ay_t = C(L)y_{t-1} + \xi_t = C_1 y_{t-1} + \ldots + C_p y_{t-p} + \xi_t, y_t = (y_1, \ldots, y_k)^T, \quad (1.1)$$

where ξ_t - is an innovative sequence of independent identically distributed random (k × 1) - vectors with zero mathematical expectation [7, 13]. In reduced form:

$$y_t = \prod 1 y_{t-1} + \ldots + \prod p y_{t-p} + u_t, \quad (1.2)$$

where $\prod j = A^{-1}C_j$, $u_t = A^{-1}\xi_t$. Moreover, u_t is also an innovative sequence of independent identically distributed random vectors with zero mathematical expectation and covariance matrix $\sum$.

Unlike structural models, VAR models do not attempt to impose constraints, say in economic theory, on which variables affect others. These models can be useful in showing which variables are statistically reliable as the main indicators of inflation. However, unlike structural models, VAR models do not attempt to explain through a causal transmission mechanism how changes in monetary policy affect price inflation.

Thus, when applying the vector autoregressive method to assess the channels of money transmission, it is necessary to remember about the possible instability of the estimates obtained with its help. At the same time, it should be noted that the VAR methodology is dominant in the empirical monetary economy, since it not only makes it possible to describe a wide range of real data, but also provides an opportunity to analyze alternative theories and hypotheses [6, 15].

In a **descriptive approach**, monetary shocks are determined not by formal statistical procedures, but by descriptive analysis of time series of economic variables. In addition, the descriptive approach allows for qualitative judgment in the application of quantitative assessments. For example, the analysis may take into account various regulations that describe monetary policy and explain the reasons that led to certain policy changes. When using a descriptive approach, researchers often go beyond graphical analysis. To increase the objectivity of the estimates obtained, an equation is often estimated that describes the behavior of the variable of interest to the researcher under normal conditions over the entire observation period. To do this, a regression of this variable (X_t) is built on its lagged values (X_{t-i}, $i \in N$), as well as current (Y_t) and lagged (Y_{t-i} , $i \in N$) volumes of output, the use of which as a regressor allows us to take into account cyclical changes in the economy.

Let the variable X be used to identify a specific transmission channel. Then, in the general case, the equation for it looks like

$$\Delta \ln X_t = a + bt \sum_{i=1}^{18} c_i \Delta \ln X_{t-i} + \sum_{i=-6}^{6} d_i \Delta \ln Y_{t-i} \quad (1.3)$$

After that, the predicted value of the variable is constructed, starting from the moment of the shock, and the accumulated forecast error is calculated:

$$CFE_T^X = \sum_{t=1}^{T} \left(\Delta \ln X_t - \Delta \widetilde{\ln X_t} \right), \quad (1.4)$$

where $\tilde{X}_t$ is the predicted value of the variable X.

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In general, the descriptive method for identifying the transmission mechanisms of monetary policy can be characterized as a method of preliminary analysis of the data used in the construction of econometric models. However, according to the authors [6, 16], this method is much less rigorous and objective than the vector autoregressive method and panel data analysis, and can only be illustrative.

When applying the third approach, based on a **panel analysis of microeconomic data**, the effectiveness of individual channels of monetary policy is assessed. According to foreign researchers [10], certain conditions must be met when checking whether a country has an efficient bank lending channel: firstly, the functioning of firms and households must depend on the availability of bank loans, and, secondly, monetary authorities should be able to change the volume of banks' supply of credit resources.

Consider the specification of a model that is often used in microeconomic analysis of money transmission channels. Let L_{it} characterize the bank's lending activity (these can be all bank loans or loans issued to only one type of economic agent, for example, legal entities), B_{it} describes individual banking characteristics (for example, the size of the bank), M_t characterizes the monetary policy, and more the value of M_t corresponds to the extended expansionary policy. Then we can say that the value $\partial L_{it}/\partial B_{it}$ shows how much individual characteristics affect the issuance of loans by banks, and the value of the derivative $\partial L_{it}/\partial M_t$ characterizes the sensitivity of the volumes of issued loans and loans to the actions of monetary authorities.

The hypothesis being tested is that the sensitivity of the volume of loans to monetary policy is higher for banks with poorer individual characteristics (small size, smaller volume of issued loans, lower ratio of equity to assets), i.e. that $\partial^2 L_{it}/\partial B_{it}\partial M_t < 0$.

For example, to measure the value $\partial^2 L_{it}/\partial B_{it}\partial M_t$ banks of various sizes in the work of Kashyap and Stein [11], the following equation is estimated at different time intervals:

$$\Delta \ln(L_{it}) = \sum_{j=1}^{4} \alpha_{tj} \Delta \ln(L_{it-j}) + \beta_t B_{it-1} + \sum_{k=1}^{12} \Psi_{kt} FBR_{ik} + \varepsilon_{it} \quad (1.5)$$

In equation (1.5), the dummy variable FBR_{ik} is responsible for the various federal reserve districts and allows to take into account the differences in the economic characteristics of different districts, and ε_{it} is the random independent errors.

The β_t coefficient shows the significance of liquidity constraints for banks of this class in period *t*. At the second stage of the analysis, the authors estimate the β_t coefficient for two different specifications.

The first specification takes into account only the change in monetary policy:

$$\beta_t = \eta + \sum_{j=0}^{4} \varphi_j \Delta M_{t-j} + \delta TIME_t + u_t \quad (1.6)$$

where $TIME_t$ is responsible for the time trend.

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The second specification takes into account the GDP growth rate:

$$\beta_t = \eta + \sum_{j=0}^{4} \varphi_j \Delta M_{t-j} + \sum_{j=0}^{4} \gamma_j \Delta GDP_{t-j} + \delta TIME_t + u_t \quad (1.7)$$

In both cases, the hypothesis is that for small banks, expansionary monetary policy should lead to a decrease in β_t, i.e. the sum of the coefficients before M_t ($\sum_{j=0}^{4} \varphi_j$) must be statistically significant and negative. The authors showed that the behavior of banks varies greatly depending on their size: while for large banks the sum of the coefficients before M_t is often positive, for small banks it is most often negative.

The main disadvantage of the microeconomic approach in the analysis of panel data is the assessment of the effectiveness of one of the stages of the monetary policy channel, and not the entire channel. This aspect leads to the conclusion that for this approach to be applied in the economy there must be an effective banking system that immediately responds to changes in monetary policy.

In addition to the models considered, in recent years in econometric studies, the **error correction model (ECM)** is most often used, to the development of which scientists R. Engle and K. Granger made a huge contribution, investigating the nonstationarity and cointegration of time series [12]. Scientists have shown that if the variables are cointegrated, then an error correction model is included in them. This model describes the process during which the variables I (1) in case of deviation return to equilibrium.

Engle and Granger developed a two-step process for evaluating an error correction model. At the first stage, the regression of time series cointegration is estimated. The second stage consists of building an error correction model.

In algebraic form, the error correction model can be expressed as follows:

$$\Delta Y_t = \beta_0 \Delta X_t + \sum_{i=1}^{p-1} \delta_i \Delta Y_{t-i} + \sum_{i=1}^{q-1} \gamma_i \Delta X_{t-i} - \alpha_p(1)\left[Y_{t-1} - \frac{\theta}{\alpha_p(1)} - \frac{\beta_q(1)}{\alpha_p(1)} X_{t-1}\right] + \varepsilon_t$$

The expression in square brackets represents a corrective term that "corrects" the lag structure by deviations from the long-term equilibrium in the previous step. This is clearly seen after replacing all deviations with zeros, which corresponds to the equilibrium state[1].

The meaning of the model and the name becomes clear if we note that the expression in square brackets can be interpreted as a deviation from long-term equilibrium at time *t-1*. Indeed, long-term equilibrium is determined by the ratio:

$$\left[\overline{Y} - \frac{\theta}{1-\alpha_1} - \frac{\beta_0+\beta_1}{1-\alpha_1}\overline{X}\right] = 0,$$

[1] It should be noted that there are different interpretations of the term “error correction model” in Russian. Thus, G. Kantorovich and other employees of the Laboratory of Macrostructural Modeling of the Russian Economy at the Center for Fundamental Research at the Higher School of Economics believe that a more successful translation of this term, reflecting its meaning, is the “error correction model”.

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therefore, the expression in square brackets is positive if the value of Y_{t-1} exceeds the equilibrium value corresponding to X_{t-1}. Thus, the current (short-term) change in *Y* is presented as the sum of two terms. The first of them is an instant response to the current short-term change in *X,* the second is an adjustment for the previous deviation from the long-term equilibrium. In this case, since the condition $|\alpha_1| < 1$, must be satisfied for the stationarity of the Y_t process, the coefficient at the residual is negative This means that the second term "pulls" the Y_t process to a long-term relationship with the $X_t$process. Thus, this approach, also referred to in the econometric literature as the "error correction model" [12], allows you to conveniently combine short-term and long-term dynamics within one model, and its coefficients have a meaningful economic interpretation.

Conclusion. Thus, in this article we have tried to conduct a brief analysis of the existing approaches used in the macroeconometric study of monetary policy and its impact on the economy. The limited size of the work does not allow us to dwell on each approach in detail and consider different types of their modification. Nevertheless, some conclusions can be drawn from the analysis performed.

The descriptive approach is a simple and statistically less intensive way of initially examining the impact of changes in monetary policy on real output and inflation. However, the absence of any standard rule that unambiguously determines this effect, as well as the absence of clear statistical procedures, can lead to biased conclusions. Therefore, this approach is advisable to carry out as an initial analysis and in combination with other, more in-depth, from an econometric point of view, approaches.

Unlike traditional models, the vector autoregression approach allows for cross-sectional causal relationships inherent in economic processes. However, a specific feature of the transition economy, the possible heterogeneity of the data, can be the reason for the instability of the results obtained using VAR-modeling. In addition, a necessary condition for the application of this approach is the presence of long time series, since an increase in the number of included variables negatively affects the number of degrees of freedom of the model. Nevertheless, this approach is, if not final, then a very useful tool for clarifying the interactions between various variables.

The use of the DSGE approach requires large samples, a complex mathematical apparatus and qualified specialists, which so far makes it impractical to use it in our case.

The error correction model is of no small importance due to its specificity and ability to reflect both short-term and long-term relationships between variables. In addition, it allows us to identify the existing relationships between non-stationary time series in the case of their cointegration. At the same time, as in vector autoregressive models, a necessary condition is the presence of long time series of variables. Despite this, the application of this model is considered appropriate when studying the macroeconomic relationships between the real and monetary sectors of the economy.

Based on this, we can conclude that for the specific features of our economy, it would be advisable to develop a macroeconomic model based on the Keynesian and monetary theory of money, with its subsequent complication by applying the approach of constructing an error correction model.

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Thus, models can play a useful role, but they should always be viewed with a fair amount of skepticism. To be successful, the economist must strive to combine modeling with sound judgment.

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