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2. ECONOMICS AND ADMINISTRATION

MODELS OF ANALYSIS AND FORECASTING OF MONETARY POLICY PARAMETERS

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Abstract. *An important prerequisite for the implementation of effective monetary policy under the regime of inflation targeting is the ability of the central bank to predict the basic parameters and to simulate different scenarios of monetary policy development adequately. The study shows the results of the analysis conducted of the advantages and disadvantages of existing approaches that solve the task of modeling and forecasting monetary policy parameters. The results of this analysis testify to the inability of the dominant approach to modeling and forecasting monetary policy settings effectively to solve the set tasks. On the basis of quarterly information for 24 reporting periods (since 2014), a methodology for modeling the dynamics of the main parameters of the NBU's monetary policy, which allows to identify the direction and lag of cause and effect relationships between them were proposed. The developed model includes 10 equations and 2 identities, which has 24 variables, including 12 endogenous, 8 exogenous and 4 auxiliary variables: trend and seasonal dummy variables. Based on the model developed, calculated indicators of the tightness connection factor of the variable with the result in each equation, namely the coefficients of elasticity, the beta-coefficients and indirect beta-coefficients. Forecast for the next six periods of such endogenous variables of the model developed as: NBU discount rate, absolute increase of the consumer price index, real GDP per thousand people, real exchange rate was calculated. The proposed methodology can form the basis for supplementing the existing system of analysis, stress testing and forecasting of the state regulatory center as well as interested organizations.*

Keywords*: analysis, monetary policy, the discount rate, simultaneous model, macroeconomic model.*

INTRODUCTION

Crisis events of 2008 demonstrated the inability to solve effectively the problem of predicting the onset of the crisis, but also reflect the destructive effects of the crisis with the basic tools of macroeconomic modeling in the central banks of many countries, such as class of DSGE-models (dynamic stochastic general equilibrium). This forces the scientific community to revise the feasibility of further application of these models. For the most part, scientists agree that, along with research on improving DSGE models, one should also pay attention to the use of other classes of models, in particular structural econometric models. So, now it's necessary to conduct a study of the use of SEM (structural econometric model) in the realities of the domestic economy regarding the available statistical framework and formation of scientific and methodological recommendations regarding the implementation of such models.

An important contribution to research tends on the development of approaches to macroeconomic modeling of various levels of complexity, including and modeling of monetary policy parameters are devoted in research works of such domestic and foreign scientists: V. Vitlinsky, I. Lukyanenko, O. Ulanovsky, S. Kozlovsky, V. Kozlovsky, O. Sharapov, V. Derbentsev, S. Mishchenko, S. Naumenkova , V. Mishchenko, V. Ivanov, R. Lysenko, J. Taylor, J. Wayne, R. Clarida, D. Brasch, L. Bol, B. Krushkovich, A. Neukovich and others.

The purpose of the study is to improve existing and develop new theoretical foundations and scientific and methodological approaches to solving the problem of forecasting monetary policy parameters.

According to the goal, the following *tasks* were formulated and solved:

– characterized the role and place of monetary policy and the central bank in achieving macroeconomic stabilization;

– analysis of existing classes of macroeconomic models aimed at analysis and forecasting of monetary policy parameters;

– the methodology of modeling and forecasting of macroeconomic indicators, the dynamics of which determines the main parameters of monetary policy;

– the results of the structural model analysis and forecasting, and results of the neural network prediction were compared.

The scientific novelty of the obtained results lies in the development of the existing scientific methodological tools of macroeconometric modeling and approaches to forecasting the parameters of monetary policy. In particular, according to the results of the Granger test for identifying the direction of causality between the studied indicators, the use of the corrected Akaike criterion to determine the lag values of factor endogenous and exogenous variables, the use of auxiliary trend variables and dummy seasonal variables on which to evaluate the effectiveness of monetary policy.

Further research in this area will allow to expand the set of endogenous and managed exogenous indicators included in the model and to use a wider range of applied econometric tools for their analysis.

ANALYTICAL REVIEW OF LITERATURE

The results of the analysis presented in scientific papers [1; 2] considerations of both domestic and foreign scientists make it possible to summarize the definitions of the essence of monetary policy as a set of regulatory measures by the central bank or with its participation with the aim of macroeconomic stabilization and the formation of confidence in the national currency.

In our study, we share the views presented in [3, p. 29], according to which macroeconomic stability is a complex concept defined as the internal non-susceptibility of the economic system to the action of destabilizing factors in time and its ability to overcome imbalances that arise.

In recent years, in Ukraine a significant relationship between the parameters of monetary policy and the state of the economy [4] could be observed. Therefore, in the context of macroeconomic stabilization and in the context of the inflation targeting regime, under the effectiveness of monetary policy, we will consider the approximation of the inflation rate to the target value determined by the central bank [5].

After taking into account that at beginning of 2014, the NBU made the transition to a floating exchange rate regime of the national currency due to a current account deficit on the balance of payments ($ 16.5 billion), with a decrease in foreign exchange reserves and the requirements of IMF cooperation on reform [6, p. 12], it should be noted that the difference between effective monetary policy during the floating exchange rate and effective monetary policy during the fixed exchange rate. Therefore, in the current conditions of the floating exchange rate, it is more advisable to consider NBU monetary policy precisely from the moment of transition to this regime.

Resolution of the NBU Board of Ministers from August 18, 2015 No. 541 "On the Fundamental Principles of Monetary Policy for 2016-2020" defines the main directions of monetary policy of Ukraine for the specified period. This resolution [5] provides for the transition to the inflation targeting regime, according to which it is determined that low and stable inflation is one of the main contributions to sustainable economic growth that can be provided by the central bank.

The benchmark for the annual change in the price index is currently set to 5 % +/- 1 pp. The main tool for achieving this goal is to change the key interest rate of the monetary policy, especially the discount rate. According to the Law of Ukraine "About the National Bank" [12], the NBU discount rate is one of the monetary instruments by which the National Bank of Ukraine sets a benchmark for banks and other entities of the monetary market of the value of attracted and placed funds.

The decision-making process on monetary policy in central banks with inflation-targeting is based on FPAS monetary policy (Forecasting and Policy Analysis System) [7, p. 59]. FPAS provides the use of a set of models of various classes and complexity, each of which is used to study a particular problem. In general, a theoretically substantiated basic model is distinguished, which is used as the main tool for forecasting and simulation experiments, and the auxiliary models that are necessary to supplement the base model by solving the problems of current state estimation, short-term forecasting, analysis of specific issues.

Various models may be used as the basic model, however, models with several equations or a system of simultaneous equations are better than models with one regression equation, since the first one allow us to provide a broader analysis of the dynamic relationships that exist between macroeconomic variables. Having analyzed the literature [7; 8; 9; 10], in general, the following classes of macroeconomic models can be distinguished and used as basic ones:

– structural econometric model;
– vector autoregression;
– dynamic stochastic general equilibrium.

Structural econometric models are associated with simultaneous equations models, as well as large-scale macroeconometric models. The basis of such models is a system of regression equations between time series that reflects empirical relationships based on econometric estimates, that is, they use large samples to calculate forecasts based largely on historical correlations rather than theoretical relationships. Examples of such models are the US macroeconometric models: Klein, Klein-Goldberger, Wharton, MPS, Brooking model, DRI, FRB/US [8, p. 117].

Vector autoregressive models are dynamic models of several time series, which are a generalization of the one-dimensional autoregression model (AR model). This allows more than one variable to be used in such a way that in the model each variable is defined by its own lag values, lag values of other variables and residuals. Unlike

SEM, VAR models are devoid of structural constraints, but as the number of VAR time series and lags increases, the number of model parameters increases sharp.

VAR models, like SEM, have two major drawbacks: lack of microeconomic justification and Lucas's criticism. Attempts to overcome these shortcomings have led to the formation of DSGE models as the core model of central banks of many developed countries, in particular, NAWM of the European Central Bank, TOTEM II - Bank of Canada, BEQM and COMPASS - Bank of England, NEMO - Bank of Norway, RAMSES II - Bank of Sweden, Aino - Bank of Finland, G3 of the Czech National Bank.

Dynamic stochastic general equilibrium models can be viewed as a macroeconomic modeling method that attempts to analyze and justify economic phenomena such as economic growth and business cycles, as well as the impact of economic policy, including monetary policy, using econometric models based on using the theory of general equilibrium and the principles of microeconomics.

As noted [11, p. 50], DSGE models are based on microeconomic foundations, which are then aggregated to a macro level, which allows to provide modeling of expectations the best way. DSGE models are also able to model various policy regimes by including various monetary policy rules in the models, for example, the Taylor discount rate rule.

The limitations imposed by the theory and complexity of DSGE models cause central banks to use simplified or incomplete dynamic stochastic models as the base models of their FPAS. The specificity of such simplification leads to some difficulties, in particular when determining the impact of the financial sector on the real economy [7, p. 63]. An example of this model are the Quarterly Forecast Model of the Czech National Bank, which was used as the basis for its own similar models by the central banks of many countries, including Ukraine, Russia, Turkey, Serbia, Armenia, Georgia, Romania, Chile and others.

As mentioned in the NBU Board Decision of January 1, 2019 No. 1-rd “On Methods and Forms of Forecasting Macroeconomic Indicators of Economic and Social Development of Ukraine, as well as Monetary Policy ” [13], the quarterly forecast model of the NBU (QPM) is the basic semi-structural New Keynesian model for long- and medium-term forecasts and complemented variables that allow you to analyze a small open economy, "dollarized" economy and so on.

The global financial crisis contributed to the formation of active criticism of the use of DSGE - models [8; 14]. A number of scientists, in particular Simon Wren-Lewis in the article "Ending the microfoundations hegemony" [14], proposed to use structural econometric models (SEM). According to the author, SEM are intermediate between DSGE and VAR-models in their ability to reproduce the dynamics of macroeconomic indicators [10, p. 29]. Also, David Hendry and John Mulbauer in the article “The future of macroeconomics: macro theory and models at the Bank of England” analyze Lucas’s criticism that the interest of the scientific community has moved away from SEM, and which contributed to the creation of DSGE models [15]. One of the conclusions made by the authors is that the crisis events demonstrated the need for the existence of models that are assembled on empirical modeling, and not on a simplified and unrealistic theory [10, p. 30].

In addition, there are studies that demonstrate the limitations of the effective use of such classic monetary policy rules, typically J. Taylor's and its modifications for the NBU monetary policy [8]. Given this, it is appropriate to investigate the use of the SEM tools as addition to the existing basic NBU model.

In accordance with this, one can propose the following version of the problem statement: to propose such an approach to macroeconomic modeling, in which it is possible to identify the direction and nature of causal relationships between the macroeconomic indicators available in the statistical databases of the State Statistics Service and the NBU, determine the lag value of the influence between the available indicators in the resulting structure. And than develop a model based on the result with the goal of both assessing and analyzing the effectiveness of the current monetary policy, and designing scenarios of macroeconomic development in the short and medium term, which will expand the existing tools for macroeconomic modeling and forecasting. Moreover, this approach should open prospects for the inclusion in the final model of new blocks that can characterize critical sectors of the economy, in particular banking and financial, and serve as the foundation for their further research in this area.

OBJECT, SUBJECT MATTER AND METHODS OF RESEARCH

The object of the research is the processes of formation of monetary policy parameters.

The subject of the research is theoretical and methodological provisions, economic and mathematical methods and models of analysis and forecasting of monetary policy parameters.

The achievement of this goal in the conducted research, as well as the maintenance of scientifically sound results and the formation of the proposed methodology became possible through the use of the following *research methods*:

– collecting, normalizing, analyzing and comparing information;

– analysis of existing statistical framework;

– use of the Granger test to identify the direction of causality between the studied indicators;

– use of the corrected Akaike criterion to determine the magnitude of the lag of factor endogenous and exogenous changes in them;

– analysis of distributions of values of variables and values of Pearson correlation coefficients between variables;

– use of auxiliary trend variables and dummy seasonal variables to account for the relevant effects in the model;

– construction of structural econometric model and its estimation by means of 2SLS with fulfillment of its preconditions;

– analysis of coefficients of determination, F-test, dynamics, autocorrelograms and residual distribution in order to determine the adequacy of the estimated equations of the developed model;

– calculation of indicators of the close relationship of the factor variable with the resultant in each equation, namely elasticity coefficients, beta-coefficients and indirect beta-coefficients and analysis of the obtained results.

WORK RESULTS

According to earlier statement of the problem and taking into account of criticism, the advantages and disadvantages of each class of models, we decided to chose instruments of structural econometric models for solving the problem of forecasting the key macroeconomic indicators that characterize monetary policy. The practical implementation of the calculations presented in this paper involves the use of the statistical computing environment R (RStudio) [16; 17], in particular packages «systemfit», «forecast», «lmtest», «mctest», «GGally».

For the development of the model of analysis and forecasting, a set of indicators, which have been presented by the State Statistics Service [18] and the NBU [19], was selected from the existing static base, reflecting the macroeconomic situation in the country and available since 2014. As a result, the following endogenous, exogenous as well as ancillary variables are identified:

Endogenous variables:

RTE – NBU discount rate,%;

INF – absolute increase in consumer price index up to December of previous year, base - 1 sq. M. 2014,%;

GDP – real GDP per thousands of persons, million UAH;

ER – real official hryvnia exchange rate against the dollar average for the quarter, UAH;

BAL – consolidated balance sheet, USD million;

UNP – unemployment rate in Ukraine, thousand;

ARR – real wage arrears at the end of the quarter, UAH million;

WGE – real average quarterly wage, UAH;

INV^d – direct investment, millions of dollars;

INV^p – portfolio investments, millions of dollars;

ΔB – difference between consolidated revenues and consolidated expenses, million UAH;

ΔE – net exports, USD million;

Exogenous variables:

INF^{exp} – inflationary expectations of banks and enterprises for the next 12 months,%;

TRN – money transfers to Ukraine from abroad, millions of dollars;

NDS – volume of sales of industrial products, real, million UAH;

RTL – volume of retail trade turnover, real, million UAH;

XPN – actual consolidated budget expenditures, UAH million;

INC – real consolidated budget revenues, UAH million;

IMP – import of goods and services, millions of dollars;

EXP – export of goods and services, millions of dollars;

Auxiliary variables:

T – trend;

S – seasonal dummy variables that reflect the difference between the first quarter and the following.

On the basis of the Granger test, the direction of causality between the selected indicators was identified. The lag duration was determined by the method of all possible regressions by corrected Akaike information criterion (AICc), which is adapted for small samples [20, p. 164]. The result is the following system of simultaneous structural equations:

$RTE_t = a_{12} * INF_t + a_{13} * GDP_t + b_{10} + b_{11} * INF_t^{exp} + d_{11} * T_{(1,t)} + \sum_{i=2}^{4} d_{1i} * S_{(1i,t)} + u_1;$
$INF_t = a_{21} * RTE_{t-4} + a_{26} * UNP_{t-3} + b_{20} + b_{21} * INF_{t-4}^{exp} + d_{21} * T_{(2,t)} + \sum_{i=2}^{4} d_{2i} * S_{(2i,t)} + u_2;$
$GDP_t = a_{34} * ER_{t-2} + a_{35} * BAL_{t-2} + a_{311} * \Delta B_{t-2} + b_{30} + b_{33} * NDS_t + b_{34} * RTL_t + d_{31} * T_{(3,t)} + \sum_{i=2}^{4} d_{3i} * S_{(3i,t)} + u_3;$
$ER_t = a_{42} * INF_{t-4} + a_{45} * BAL_{t-3} + b_{40} + d_{41} * T_{(4,t)} + \sum_{i=2}^{4} d_{4i} * S_{(4i,t)} + u_4;$
$BAL_t = a_{54} * ER_t + a_{59} * INV_t^d + a_{510} * INV_t^p + a_{512} * \Delta E_t + b_{50} + d_{51} * T_{(5,t)} + \sum_{i=2}^{4} d_{5i} * S_{(5i,t)} + u_5;$
$UNP_t = a_{67} * ARR_t + b_{60} + b_{61} * TRN_t + b_{65} * XPN_{t-2} + d_{61} * T_{(6,t)} + \sum_{i=2}^{4} d_{6i} * S_{(6i,t)} + u_6;$
$ARR_t = a_{78} * WGE_{t-2} + b_{70} + b_{75} * XPN_{t-1} + d_{71} * T_{(7,t)} + \sum_{i=2}^{4} d_{7i} * S_{(7i,t)} + u_7;$
$WGE_t = a_{83} * GDP_t + b_{80} + b_{85} * XPN_{t-1} + d_{81} * T_{(8,t)} + \sum_{i=2}^{4} d_{8i} * S_{(8i,t)} + u_8;$
$INV_t^d = a_{92} * INF_{t-3} + b_{90} + b_{91} * INF_{t-3}^{exp} + d_{91} * T_{(9,t)} + \sum_{i=2}^{4} d_{9i} * S_{(9i,t)} + u_9;$
$INV_t^p = a_{103} * GDP_t + a_{104} * ER_t + a_{106} * UNP_t + b_{100} + d_{101} * T_{(10,t)} + \sum_{i=2}^{4} d_{10i} * S_{(10i,t)} + u_{10}$; $\Delta B_t = INC_t - XNP_t$; $\Delta E_t = EXP_t - IMP_t$.

The presented system was evaluated by 2SLS after preliminary analysis of the fulfillment of its preconditions and has the following form:

$RTE_t = 0.116 * INF_t - 1.537 * GDP_t - 0.118 + 1.442 * INF_t^{exp} + 1.362 * T_{(1,t)} - 5.720 * S_{(12,t)} - 6.035 * S_{(13,t)} - 9.207 * S_{(14,t)}, R^2 = 0.97, F = 39.86;$
$INF_t = -0.76 * RTE_{t-4} + 0.02 * UNP_{t-3} - 18.795 - 0.08 * INF_{t-4}^{exp} - 0.19 * T_{(2,t)} + 23.25 * S_{(22,t)} + 16.366 * S_{(23,t)} + 18.957 * S_{(24,t)}, R^2 = 0.86, F = 3.17;$
$GDP_t = -0.087 * ER_{t-2} - 5.4\text{E}-06 * BAL_{t-2} - 4{,}8\text{E}-05 * \Delta B_{t-2} + 1.889 + 6\text{E}-05 * NDS_t + 3.8\text{E}-06 * RTL_t + 0.152 * T_{(3,t)} + 0.335 * S_{(32,t)} + 2.506 * S_{(33,t)} - 0.965 * S_{(34,t)}, R^2 = 0.99, F = 62.562;$
$ER_t = 0.031 * INF_{t-4} + 0.003 * BAL_{t-3} + 20.104 - 0.079 * T_{(4,t)} - 5.735 * S_{(42,t)} - 5.710 * S_{(43,t)} - 7.425 * S_{(44,t)}, R^2 = 0.97, F = 56.855;$
$BAL_t = -273.16 * ER_t + 1.13 * INV_t^d + 1.9 * INV_t^p + 1.56 * \Delta E_t + 2379.46 + 303.9 * T_{(5,t)} - 127.9 * S_{(52,t)} - 239.7 * S_{(53,t)} - 293.5 * S_{(54,t)}, R^2 = 0.85, F = 3.71;$
$UNP_t = 0.044 * ARR_t + 1813.79 - 0.084 * TRN_t + 0.001 * XPN_{t-2} - 4.286 * T_{(6,t)} - 60.028 * S_{(62,t)} - 68.425 * S_{(63,t)} - 14.376 * S_{(64,t)}, R^2 = 0.77, F = 2.048;$
$ARR_t = 0.1 * WGE_{t-2} + 863.29 + 0.005 * XPN_{t-1} - 14.409 * T_{(7,t)} - 264.07 * S_{(72,t)} - 155.15 * S_{(73,t)} - 397.82 * S_{(74,t)}, R^2 = 0.86, F = 5{,}424;$
$WGE_t = 531.82 * GDP_t - 1215.3 + 0.004 * XPN_{t-1} - 7.025 * T_{(8,t)} - 127.47 * S_{(82,t)} - 857.01 * S_{(83,t)} - 604.97 * S_{(84,t)}, R^2 = 0.99, F = 113.94;$
$INV_t^d = 10.625 * INF_{t-3} - 180.71 + 39.431 * INF_{t-3}^{exp} + 19.491 * T_{(9,t)} + 188.61 * S_{(92,t)} - 21.736 * S_{(93,t)} + 115.814 * S_{(94,t)}, R^2 = 0.67, F = 1.389;$
$INV_t^p = -141.73 * GDP_t - 53.19 * ER_t - 4.440 * UNP_t + 9321.58 + 74.182 * T_{(10,t)} - 615.14 * S_{(102,t)} - 173.91 * S_{(103,t)} - 1019.3 * S_{(104,t)}, R^2 = 0.76, F = 2.37.$

Fisher's F-criteria proved to be adequate except for the UNP (unemployment rate in Ukraine) and INV^d (direct investment) equations.

For the purpose of exploring the model's forecasting capabilities, it is first proposed to make a 2014-2018 study-based forecast on the 2019 test sample and compare it with the actual data. Limitations on the availability of statistical information determine the forecast framework for 2 quarters.

Analysis of values of prediction accuracy indicators [20, p. 79-81] in the training and test samples, namely root mean squared error (RMSE), mean absolute error (MAE), mean absolute percentage error (MARE), mean absolute scaled error (MASE) showed that not all models are the same well solve the forecasting problem. The equations of ARR (arrears of salary) was the worst in solving the problem of forecasting and best - RTE (discount rate of NBU).

The results of the test sample of the developed methodology provide the basis for calculating the predicted values of endogenous variables based on available data for 2014-2019. In order to compare the results obtained, it is proposed to use a neural network modeling tools. The structure of artificial neural networks allows to better reproduce the dynamics of socio-economic indicators, whose nature is characterized by uncertainty, unpredictability and the presence of nonlinear relationships [21; 22, p. 324]. That is why we proposed method NNAR (Neural network autoregression), which has enough good prognostic features [22, p. 325]. The disadvantage of using NNAR is the lack of structural links and exogenous variables, but the existence of differences between the predicted values obtained through neural networks and SEM may reflect the effect of the relationships between the variables included in the structural model. Model NNAR provided in the package «forecast» [23].

Predicted values of exogenous variables for the next 6 quarters, that is, up to 4 quarter of 2020, were obtained using trend models using seasonal dummy variables.

According to the table. 3.1 forecast quality indicators of the main macroeconomic indicators, we can conclude that the NNAR model mainly has the best predictive properties. Anyway, structural model is better coped with forecasting real GDP.

Table 3.1

The value of the forecast quality indicators

	RTE		INF		GDP		ER	
	SEM	NNAR	SEM	NNAR	SEM	NNAR	SEM	NNAR
RMSE	1,1562	0,6183	6,4081	1,9622	0,1813	0,425	0,5548	0,5532
MAE	0,7837	0,4776	4,8445	1,467	0,1598	0,3235	0,4498	0,4706
MAPE	5,0647	2,931	180,95	46,944	1,7425	3,6216	3,1207	3,3113
MASE	0,1077	0,0656	0,6398	0,1938	0,1374	0,2782	0,5118	0,5354

In the table. 3.2 highlights the importance projections of key macroeconomic indicators, such as the discount rate of the NBU, the increase in consumer prices, the real GDP for 1000 people and the real exchange rate, where the real figures are based on the price in December 2013.

Table 3.2

Forecasts of SEM and NNAR macroeconomic indicators

	RTE		INF		GDP		ER	
	SEM	NNAR	SEM	NNAR	SEM	NNAR	SEM	NNAR
2019 Q3	14,778	16,404	0,4765	2,7884	12,555	13,246	13,866	12,871
2019 Q4	12,462	15,273	1,3989	3,1824	11,918	10,756	11,501	8,9232
2020 Q1	11,389	14,15	-4,023	-14,2	13,415	14,312	18,198	16,384
2020 Q2	9,22	13,497	1,0773	1,763	12,346	13,173	13,719	14,335
2020 Q3	8,135	13,497	0,93	3,2192	13,647	13,741	13,296	13,304
2020 Q4	6,954	13,616	2,1189	3,2286	12,871	12,225	11,526	5,3667

The predicted value of the consumer price index indicator according to the obtained structural model for the last quarter of 2020 will be 5.5784 % (fig. 3.1), which corresponds to the NBU inflation target and is indicative of the effectiveness of monetary policy, while maintaining existing trends and the absence of shocks. However, the NBU's estimated quarterly interest rate for the 4th quarter of 2020 may be somewhat inaccurate, since the model does not account for the neutral rate and possible shocks.

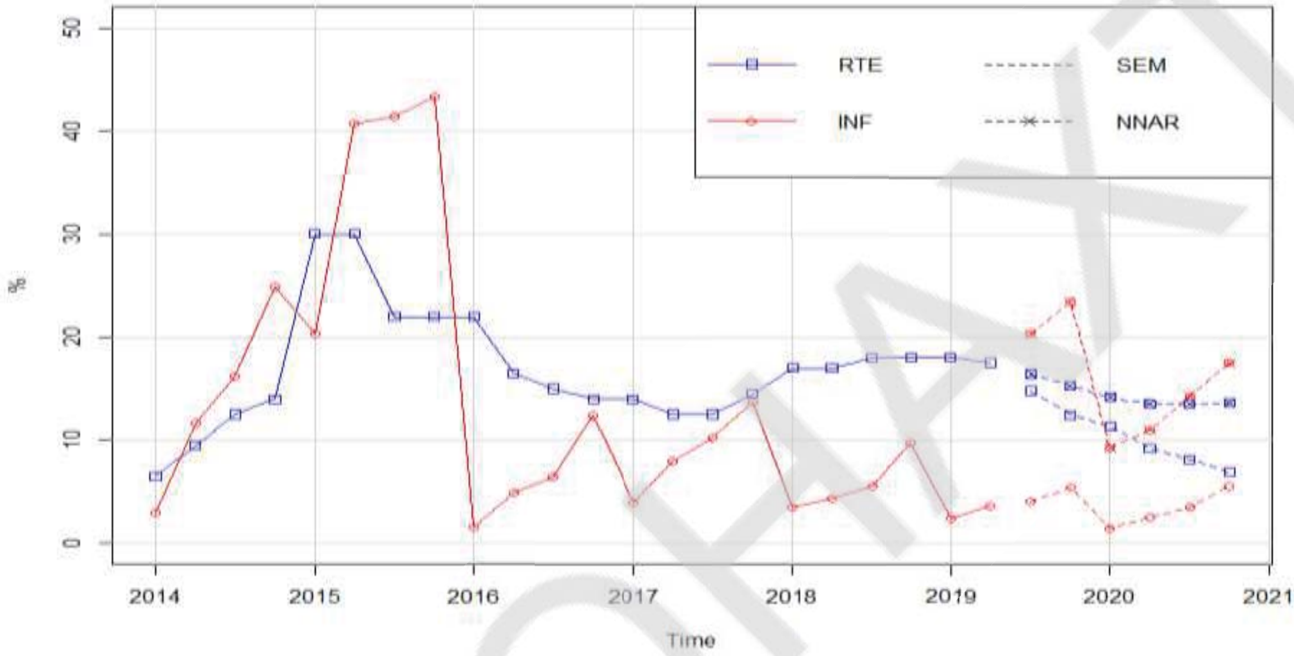

Figure 3.1. NBU interest rate and CPI dynamics and forecasts by SEM and NNAR

To study the influence between the variables in the structural equation system, the calculated values of the elasticity coefficients, beta-coefficients, and indirect beta-coefficients were analyzed.

The elasticity coefficients reflect how much of the average the resulting variable in a single equation will change as one factor variable grows by 1% of its average over the fixed values of the other exogenous variables [24, p. 89].

Beta-coefficients reflect the magnitude of the mean deviation of the resulting variable with increasing the corresponding value of the factor variable by the magnitude of its standard deviation with a fixed value of the remaining factor variables. Indirect beta-coefficients correspond to the magnitude of the indirect effect, that is, the influence through other factor variables of the equation [24, p. 90-91].

Before starting interpretation of the results obtained from the estimated parameters of the model, we should pay attention to their statistical significance, as the relevant conclusions can be made only on the basis of statistically significant estimates:

RTE – all estimates but the intersection is statistically significant;
INF – statistically significant estimate of S_2;
GDP – statistically significant estimates of ER, NDS, T, S_3, S_4;
ER – statistically significant all estimates except T;
BAL – all estimates are insignificant;
UNP – statistically significant intersection estimate;

ARR – statistically significant intersection estimates, S_2, S_4, and XPN;
WGE – statistically significant intersection estimates, S_3, S_4, and GDP;
INV^d – statistically significant estimate of INF^{exp};
INV^p – all estimates are insignificant.

The biggest impact on the NBU discount rate by the coefficients of elasticity and beta coefficients is the real GDP per 1000 people (-0.8 % and -0.493) and inflation expectations (1.2 % and 1.408). At the same time, the inflation indicator is the largest indirect influence due to the inflation expectations index (0.377) and real GDP per capita through the inflation expectations index (-1.011).

The approach proposed makes it possible to identify the direction of causality between macroeconomic indicators and to build and evaluate a system of simultaneous equations. Because the relationships based on empirical data are unstable, we recommend to follow all steps of the proposed methodology each time new data emerges.

CONCLUSIONS

In the framework of this work, an analysis of the existing approaches to macroeconomic modeling of the dynamics of monetary policy indicators is carried out, a methodology for constructing a macroeconometric model of the formation of the monetary policy parameters of the domestic economy is proposed taking into account the dynamics of the main available macroeconomic indicators. The calculated predicted values of the endogenous variables of the developed model are compared with the predicted values of the NNAR - model of the corresponding variables. Comparison of approaches makes it possible to identify possible effects of the existing relationships between indicators in the structural model. To interpret the results of the structural model, elasticity coefficients, beta coefficients, and indirect beta coefficients are calculated.

Thus, the use of the capabilities of applied econometric tools, in particular, systems of simultaneous structural equations to solve the problem of macroeconomic modeling, allowed to obtain competitive scientific results. Further development of this area of research towards inclusion in the model of a larger range of endogenous and managed exogenous indicators , use of autoregressive values of endogenous variables , use of dummy variables to describe such qualitative changes as change of political power, economic institutions and other qualitative changes, the block structure of critical sectors of the economy today, in particular the banking and financial sectors and the broader range of modern econometric applications This tool will be complemented by the NBU macroeconomic modeling toolkit. In addition, the emergence of new data will help to improve the methodology presented.

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