QUID 2017, pp. 1457-1462, Special Issue N°1- ISSN: 1692-343X, Medellín-Colombia

SCENARIO FORECASTING OF TENDENCIES OF DEVELOPMENT OF MACROECONOMIC INDICATORS OF THE REGION ON THE BASIS OF MODELS OF THE MULTIPLE CHOICE (ON THE EXAMPLE OF THE REPUBLIC OF TATARSTAN)

(Recibido el 10-05-2017. Aprobado el 12-08-2017)

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Abstract. The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University (Number for publications: 26.8732.2017/8.9).
The purpose of the study is to develop an algorithm for scenario forecasting of macroeconomic indicators when deciding on the development strategy of the region using the economic and mathematical methods of multiple choice. Based on the macrostructural modeling method, we developed a model for forecasting the development of the main macroeconomic indicators. We implemented an approach to forecasting the development trends of macroeconomic indicators in the region based on the binary choice model. Using the binary choice model allowed developing the most probable directions of the economic situation development - optimistic and realistic forecast scenario.

Key words: regional economy, regional development strategy, forecasting, multiple choice models, macrostructural modeling.

Citar, estilo APA: Hayrutdinova, Y., Aksyanova, A., Safiullin. M. & Elshin, L. (2017). Scenario forecasting of tendencies of development of macroeconomic indicators of the region on the basis of models of the multiple choice (on the example of the republic of Tatarstan). *Revista QUID (Special Issue).* 1457-1462

1. INTRODUCTION

The modern mechanisms of regulation and development of the economy do not fit into the norms of automatic and renewable development processes and are characterized by the frequent violations of some patterns established in the past. The economic development of national and regional systems can manifest itself in a highly unpredictable manner (Safiullin, Elshin & Prygunova, 2016) (Friedmann, 1966). The dynamics of economic growth can be sharply replaced by negative values and vice versa, the economic decline can drastically shift into the phase of progressive growth bypassing the processes of a smooth (phase) transition from one state to another in accordance with the theory of cyclic development. The volatility of the observed development trajectories of socio-economic systems actualizes the need for multivariate calculations that determine the forecast trajectories of the socio-economic shifts (Izard, 1966) (Granberg, 2006). In other words, the most popular mechanisms for planning and state regulation of the economy are the methods of scenario modeling that allow assessing the effect of the change in the differentiation of values of various factors on the aggregate indicator under study. At the same time, it should be noted that this issue is given a lot of attention in the scientific and research and professional environmentat present, as well as it has been developed an extensive set of methods and approaches. In our opinion, the most promising, among the considered set of methods for scenario modeling of economic systems, are methods based on the use of binary choice models. They allow us developing the most probable directions for the development of economic situation, relying, among other things, on the probabilistic estimation methods (Nazarenko & Zvyagintseva, 2012) (Aksyanova & Khairutdinova, 2011). In this regard, we made the binary predictive estimates of the most probable scenarios of the development based on the adaptation of the V.V. Davnis algorithm (Davnis & Tinyakova, 2005) to the factors and analyzed phenomena inherent in a single region of the Russian Federation, - the Republic of Tatarstan - in this study.

2. MATERIALS AND METHODS

To construct a combined scenario forecasting model, we used a modified mechanism for combining stochastic forecasting methods with the expert estimation methods proposed by V.V. Davnis (2005), including application of the binary choice model.

At the initial stage, we implemented the developed mechanism for constructing a macrostructural model for forecasting the macroeconomic indicators in the region. The model is a system of econometric equations, consisting of six interrelated equations (Davnis & Tinyakova, 2005). At the same time, by projecting this model to the region under study (the Republic of Tatarstan), we took into account the specific parameters of its development for the purpose of the highly adapted V.V. Davnis model to the social and economic parameters and peculiarities of this region. This allowed obtaining a system of qualitative forecasts, which was confirmed by the data on the statistical significance of the equation ratios.

As a result of analyzing the main trends in the development of the economy of the Republic of Tatarstan, we identified the most significant factors of management and external environment that can influence the adjustment of economic development.

The volume of the gross regional product is taken as the main indicator of the development trajectory of the economic system.

Given that the quality and speed of the economic growth of the republic are largely determined by the traditionally high level of investment activity, characterized by the highest ratings in Russia as a whole, the volume of investment in the fixed assets is chosen as the endogenous variable of the second equation of the macrostructural forecasting model.

The next significant indicator of the development and well-being of the citizens of the region is the retail trade turnover, which indicates the level of effective demand of the population. In terms of retail trade turnover, the Republic ranks 9th among the subjects of the Russian Federation.

The Republic of Tatarstan is an active participant in the foreign economic activity of the Russian Federation, occupying the 1st place in the Volga Federal District in terms of foreign trade turnover. Therefore, the export volume indicator was also included in the model as an endogenous variable.

An important place in the regional economy is occupied by tax revenues (incomes), which are the basis for the formation of the budget revenue. The endogenous variable of the sixth equation is the volume of shipped goods of own production, works performed and services rendered by own strength in the industry.

The mathematical model contains eight exogenous variables. During the model construction, we examined the cause-effect relationships between the endogenous and exogenous variables on the qualitative level, taking into account the mutual influence of factors on each other. To evaluate the relationships, we used the methods of correlation and regression analysis, an unconventional methodology of the Durbin-Watson criterion, suggesting the implementation of a series of procedures aimed at determining the critical value of this criterion for its difference from zero. This allows rejecting or, conversely, accepting the most reliable hypotheses that form the basis for the evaluations and analysis implemented.

We also used the tests of the cause-effect relationships of Granger. We checked the quality of each equation of a system of interrelated econometric equations, which made it possible to conclude that the model corresponded to the described process. Thus, a macrostructural model was the basis for the methodology approbation

$$\begin{cases} Y_1 = a_1 + b_{11} * Y_2 + a_{12} * X_8 + a_{13} * X_9 \\ Y_2 = a_2 + b_{21} * Y_{2\_1} + a_{22} * X_2 \\ Y_3 = a_3 + a_{31} * X_3 + b_{32} * Y_6 \\ Y_4 = a_4 + b_{41} * Y_2 + a_{42} * X_4 \\ Y_5 = a_5 + b_{51} * Y_1 + a_{52} * X_8 \\ Y_6 = a_6 + a_{61} * X_{6\_1} \end{cases} \quad (1)$$

, where

Y_1–GRP, mln.roubles (in comparable prices);

X_1– volume of oil production, ths. tons;

Y_2– investments in fixed assets;

Y_3– turnover of retail trade, mln.roubles;

X_2– growth rate of investments in fixed assets in the Russian Federation, in %;

X_3– money supply (unit M2);

Y_4– export volume, mln. US dollars;

Y_5– tax revenues, mln.roubles;

X_4– rates of increase in oil prices, USD/barrel;

Y_6– volume of shipped goods of own production, works performed and services rendered by own strength in the industry, mln. roubles;

X_8– average annual number of persons employed in the economy, ths.people;

X_9– agricultural products of all categories, mln.roubles) (Davnis & Tinyakova, 2005).

When developing the regional forecasts, the main idea was to use a multi-trend model that provided an adequate description of the processes with several ways of development.

The essence of the proposed method is as follows. Initially, we created an autoregressive model for each exogenous variable of the macrostructural model. As is known, the traditional autoregressive model is a time series model in which the values of time series are linearly dependent on the previous values of the same series at a given moment:

$$\tilde{x}_t = a_0 + a_1 x_{t-1} + a_2 x_{t-2} + \cdots + a_m x_{t-m} + \varepsilon_t \quad (2)$$

As a rule, it is not always possible to obtain a successful model identification that meets all the quality criteria. Therefore, almost always there is a need to use dummy variables, which are introduced by calculating the deviation of calculated values from actual ones

$$x_t - \tilde{\hat{x}}_t,\ t = \overline{m+1, T} \quad (3)$$

The dummy variables allow us breaking the investigated set of observations into two components, in accordance with the following rule:

$$\begin{cases} x_t - \tilde{\hat{x}}_t \le 0, & t \in I_0, \\ x_t - \tilde{\hat{x}}_t > 0, & t \in I_1. \end{cases} \quad (4)$$

The result of this division is a vector f_1 (called a dummy variable) consisting of 0 and 1. Adding an additional (new) variable to the equation leads to the appearance of the following equation:

$$\tilde{x}_t = a_0 + a_1 x_{t-1} + a_2 x_{t-2} + \cdots + a_m x_{t-m} + d_1 f_{1t} + \varepsilon_t \quad (5)$$

$$t = \overline{m+1, T},$$

in which d_1 - ratio value at a dummy variable; f_{1t} - ratio value at a dummy variable at the moment t (Aksyanova & Khairutdinova, 2011).

In this study, the goal was neither to achieve a high quality of the constraint equation, but to obtain a "splitting" tool, i.e. identification of the dummy variable state with different trajectories of development (optimistic and pessimistic trajectories). A model with one dummy variable provides two forecast trajectories, the differentiation of which is determined by the considered effects.

The resulting model is called multi-trend. There is a need to obtain probabilistic estimates of the plausibility of predictive trajectories, based on the approaches defined by the multinomial logit model:

$$\mathrm{P}(x_i = j) = \frac{e^{x^* i b_j}}{1 + \sum_{j=0}^{J-1} e^{x^* i b_j}}, \quad j = \overline{1, J-1},$$

$$\mathrm{P}(x_i = J) = \frac{1}{1 + \sum_{j=0}^{J-1} e^{x^* j b_j}} \quad (6)$$

According to the method of V.V. Davnis (Nazarenko & Zvyagintseva, 2012), the expert estimates are used as a vector of independent variables $x_i{}^*$, according to which the alternative options are distinguished.In the study, the independent variable $x_i{}^*$ was represented a variable having direct impact on the endogenous variable x_i.

As a result, it is possible to build a combined model for forecasting the endogenous indicators y_i along two development trajectories at $f_1 = 1$ and at $f_1 = 0$

$$\mathrm{P}\left(\tilde{\hat{x}}_{t+1}^k\right) = \mathrm{P}_{t+1}^k,$$

$$\tilde{\hat{x}}_{t+1}^k = \hat{a}_0 + \hat{a}_1 x_t + \hat{a}_2 x_{t-1} + \cdots + \hat{a}_m x_{t-m+1} + \vec{f}^{\,k} \vec{d} \quad (7)$$

$$\mathrm{P}_{t+1}^k = \frac{\exp\left(x^*{}_{t+1} \vec{\hat{b}}^{\,k}\right)}{1 + \sum_{k=0}^{K} \exp\left(x^*{}_{t+1} \vec{\hat{b}}^{\,k}\right)},$$

where $\hat{x}_{t+1}^k$ - k-th forecast calculation option; x_t - delayed values of the dependent variable; a_j - evaluation of the j-th regression ratio; P^k - reality probability of the k-th forecast estimate option; $\vec{f}^{\,k}$ - vector of values that took the dummy variables in the k-th option; $\vec{d}$ - ratio vector for dummy variables; $\vec{b}^{\,k}$ - evaluation of the parameter vector of logit model of multiple choice of the *k*-th option; $x^*{}_{t+1}$ - vector of values describing the conditions expected in the anticipatory period (Aksyanova & Khairutdinova, 2011).

3. RESULTS AND DISCUSSION

In this study, the combined model is used to forecast the macroeconomic indicators of the socio-economic development of the region (Republic of Tatarstan).

According to the above algorithm, the first-order autoregressive models were created for each exogenous change in the macrostructural model (1) (Table 1):

Table 1. Results of creating the autoregressive models for exogenous variables of macrostructural model of socio-economic forecasting.

Variable	X_1	X_2	X_3	X_4	X_5	X_6
Autoregression equation	$x_1 = 1154.26 + 0.97x_{1-1}$	$x_2 = 50.07 + 0.51x_{2-1}$	$x_3 = 625.79 + 1.1x_{3-1}$	$x_4 = 8.47 + 0.87x_{4-1}$	$x_5 = 102.16 + 0.95x_{5-1}$	$x_6 = 36.36 + 0.65x_{6-1}$
R^2 - determination ratio	0.97	0.38	0.98	0.8	0.97	0.76
F- Fisher criterion	555.4	12.96	1245.2	81.6	709.4	29.8

An analysis of the presented statistical characteristics of the quality of autoregressive models (Table 1) made it possible to reveal that all the equations obtained for exogenous variables were statistically significant, except for the autoregressive equation for the variable x_2 -the growth rates of investment in fixed assets in the Russian Federation.

The quality of the autoregression equation for the factor x_2 should to be increased by introducing a dummy variable that identifies the random effect. To obtain the values f_1, we calculated deviations of the calculated values of dependence equation from the actual values according to rule (4). If the deviation value was positive, then the dummy variable f_1 took the value of 1, otherwise - the value of 0.

Using a dummy variable allowed obtaining the following regression equation with a dummy and a lag variable:

$$x_2 = a_0 + df_1 + a_1 x_{2-1}, \quad \text{where}$$

$$f_1 = \begin{cases} 0, if & x_t - \tilde{\tilde{x}}_t \le 0, \\ 1, if & x_t - \tilde{\tilde{x}}_t > 0 \end{cases} \qquad (8)$$

After identification, the following model was obtained:

$$x_2 = 30.63 + 0.61 f_1 + 16{,}47 x_{2-1} \qquad (9)$$

(7.6) (6.9)

All the ratios of the resulting equation are significant.

When obtaining the forecast values for 2016, the trajectory split into 2 possible options: for $f_1 = 0$ and $f_1 = 1$. The direction of the situation development $f_1 = 1$ is taken as an optimistic scenario, and at $f_1 = 0$ – a pessimistic scenario.

The corresponding forecast values of the growth rates of investments in the fixed capital of the Russian Federation were 102.34% and 85.87% (Figure 1):

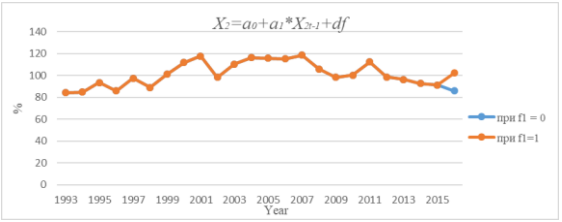

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Figure 1. Dynamics of investment in fixed capital of the Russian Federation on optimistic and pessimistic development trajectories.

Taking into account the splitting of the exogenous factor x_2 into two development trajectories, we obtained the following predictive dynamics for the endogenous variable Y_2 (investment in the fixed capital of the RT) (Figure 2):

оптимистичный прогноз	optimistic forecast
пессимистичный прогноз	pessimistic forecast

Figure 2. Dynamics of investment in fixed capital of the RT on optimistic and pessimistic development trajectories.

4.CONCLUSIONS

The results of the implemented estimates and calculations demonstrate a significant level of influence of investment activity on the parameters of the social and economic development of the

Republic of Tatarstan. This impact is due, first of all, to the level of the effective infrastructure security of economic processes, the degree of depreciation of fixed assets, etc. in the sectoral context existing in the region. This, in turn, predetermines a high level of investment attractiveness and, as a result, the significant growth rates of investments in fixed assets and the economy growth as a whole.

In this regard, the degree of depreciation of fixed assets was taken as an indicator.

By using the "STATISTICA" package, we obtained the distribution of probabilities of the onset of a forecast optimistic or realistic directions and a model of the form: $\mathrm{P}(f_1 = 0) = \frac{1}{1 + \exp(-7.33 + 0.16 \cdot x^*)}$ where x^* – degree of depreciation of fixed assets, %. The Wald statistics show the ratio significance.

Based on the results of the multiple choice model, the most probable is the predicted value of the indicator under study, calculated on the basis of an optimistic development trajectory. Thus, this model gives the forecasted value of investments in fixed assets of the Republic of Tatarstan - 667,351.6 bln. roubles. with a probability of 66%.

4. SUMMARY

In the conducted research, we applied the technique to find the forecast values of macroeconomic indicators of the region development in the form of alternative trajectories with probabilistic estimates of the degree of their reality. The forecasted values of investments in fixed assets of the Republic of Tatarstan are calculated according to the optimistic and pessimistic development trajectory, taking into account the influence of external factors.

The obtained model allows finding the forecast values for one time period in advance. If it is necessary to forecast for a more distant future, this procedure is repeated, while the forecast estimate obtained at the first step is used as the actual initial information (Logunov, 2016).

The application of the developed methods and models is possible for making predictive calculations in the process of justifying management decisions, taking into account the worst-case scenario in the future.

ACKNOWLEDGEMENTS

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University (Number for publications: 26.9776.2017/8.9).

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