Development of multifactor forecasting model based on fuzzy time series

Liliya Anatolievna Demidova[1] and Maksim Anatolievich Stepanov[2]

[1]Department of Corporate Information Systems , Institute of Information Technologies

Russian Technological University – MIREA

Vernadsky Avenue,78, Moscow, 119454, Russia

liliya.demidova@rambler.ru

[2]Department of computers, Faculty of Computing Engineering

Ryazan State Radio Engineering University named after V.F. Utkin

Gagarin Str., 59/1, Ryazan, 390005, Russia

smastefan@gmail.com

THEORETICAL PART

The tools of the fuzzy set theory is actively used in solving various applied problems characterized by one or another level of information uncertainty at the disposal of analysts. These can be problems of forecasting TSs, risk assessment, development of fuzzy inference systems, etc. A herewith, in recent years, both typical fuzzy sets, also called type-1 fuzzy sets (T1FSs), and their extension, type-2 fuzzy sets (T2FSs), have been actively used.

T2FSs allow to take into account more information, but at the same time they require more calculations. Obviously, in this case, it is necessary to use simple computational operations to reduce the computational complexity.

Let there be T1FS “approximately equal to 5” (Figure 1). To this T1FS we can be determine the crisp degree of membership, equal to 1, for the number 5; and the crisp membership degree of 0.5 for the number 3.

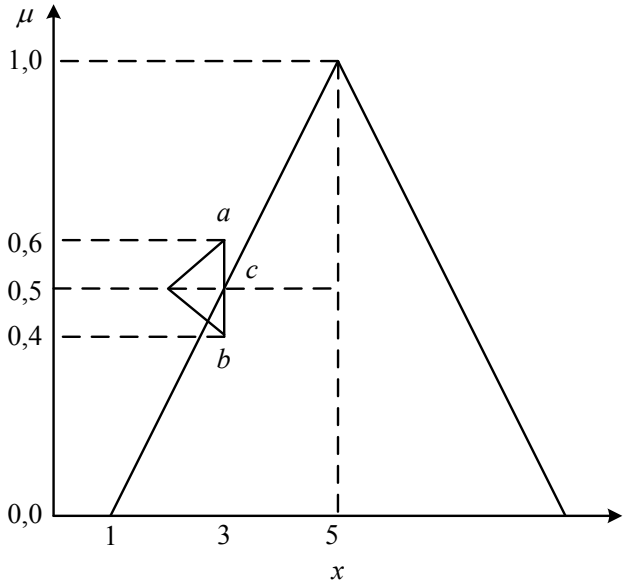

Figure 1. Membership functions for T1FS and T2FS

THE FOLLOWING STEPS OF THE IMPLEMENTATION OF A FUZZY FORECASTING MODEL

1. Determination of the change interval of factor increments values based on known element values of TS: $[D_{min}, D_{max}]$, where $D_{min} = min(d_k(t) - d_k(t\text{-}1))$,
$D_{max} = max(d_k(t) - d_k(t\text{-}1))$.
As we use three TSs characterizing the same economic indicator, then D_{min} and D_{max} are defined as the minimum and maximum values of the factor for all increments of three TSs.

2. Definition of two real numbers D_1 and D_2 whose use allows to divide the universe $U = [D_{min} - D_1 , D_{max} + D_2]$ at n intervals of equal length: $u_1, u_2,..., u_n$.

3. Definition of linguistic terms A_r $(r = 1, n)$, represented by fuzzy sets of the factor.

4. Fuzzification of the known values of the three TSs.

5. Formation of fuzzy logic dependencies for three TSs.

6. Forming groups of fuzzy logical dependencies for three TSs by combining fuzzy logical dependencies with the same left side in the same group.

THE FOLLOWING STEPS OF THE IMPLEMENTATION OF A FUZZY FORECASTING MODEL

7. Determination of the union and intersection of groups of fuzzy logical dependencies for three TSs.

8. Defuzzification TSs values based union and intersection groups of fuzzy logical dependencies for calculating crisp factor increment values for each (t+1)-th time point $t = \overline{0, m-1}$ excluding or considering repeats the fuzzy sets in the right part of the group of fuzzy logical dependencies.

9. Calculation of the factor increment value $y(t+1)$ for t-th time point $t = \overline{0, m-1}$, which is the average value of the sum of values for (t+1)-th time point determined for union and intersection of groups of fuzzy logic dependencies which are the consequence of the t-th time point.

10. Calculation of the forecasted value $f(t+1)$ as the sum of the real element value $d(t)$ of TS factor for t-th time point $t = \overline{1, m}$ and the factor increment value $y(t+1)$.

THE FOLLOWING STEPS OF THE IMPLEMENTATION OF A FUZZY FORECASTING MODEL

11. Calculation of average forecasting error rate:

$$AFER = \frac{\sum_{t=1}^{m} \left| \left(f(t) - d(t) \right) / d(t) \right|}{m} \cdot 100\%$$

where $f(t)$ and $d(t)$ are the forecasted and actual values for t-th time point;
m is the number of elements of TS.

12. The analysis of results and the construction of graphics and dependences for the actual and forecasted values of TS elements.

EXPERIMENTAL PART

The approbation of the proposed approach to the development of forecasting models was carried out on the examples of a number of economic indicators described by the TS groups, which have the same source of occurrence, but different trajectories of evolution. In particular, 3 TSs, characterizing the economic indicator "Lukoil share price" from 2008-01-09 to 2008-02-07, were considered. A herewith, data from 2008-01-09 to 2008-02-06 were used to build the model, and forecasting was performed for 2008-02-07.
In the course of the research, several experiments, involving the development of various forecasting models, were carried out. The choice of the best model was carried out using GA.

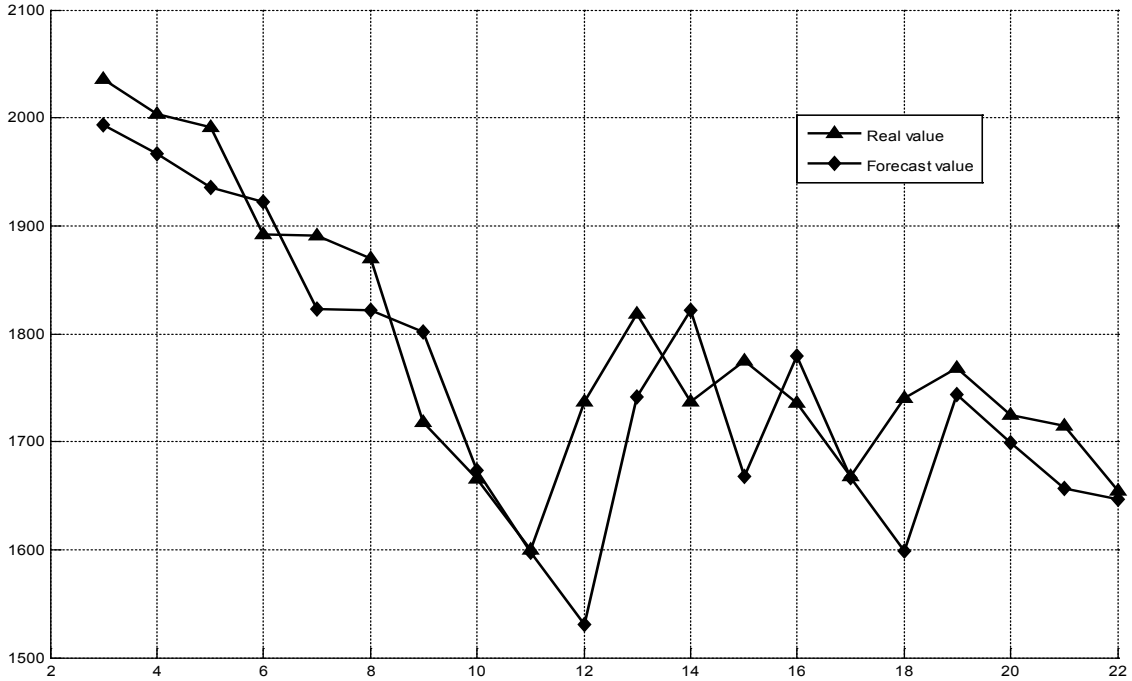

Fig. 2. The results of forecasting the economic indicator using T1FSs ("closing" TS)

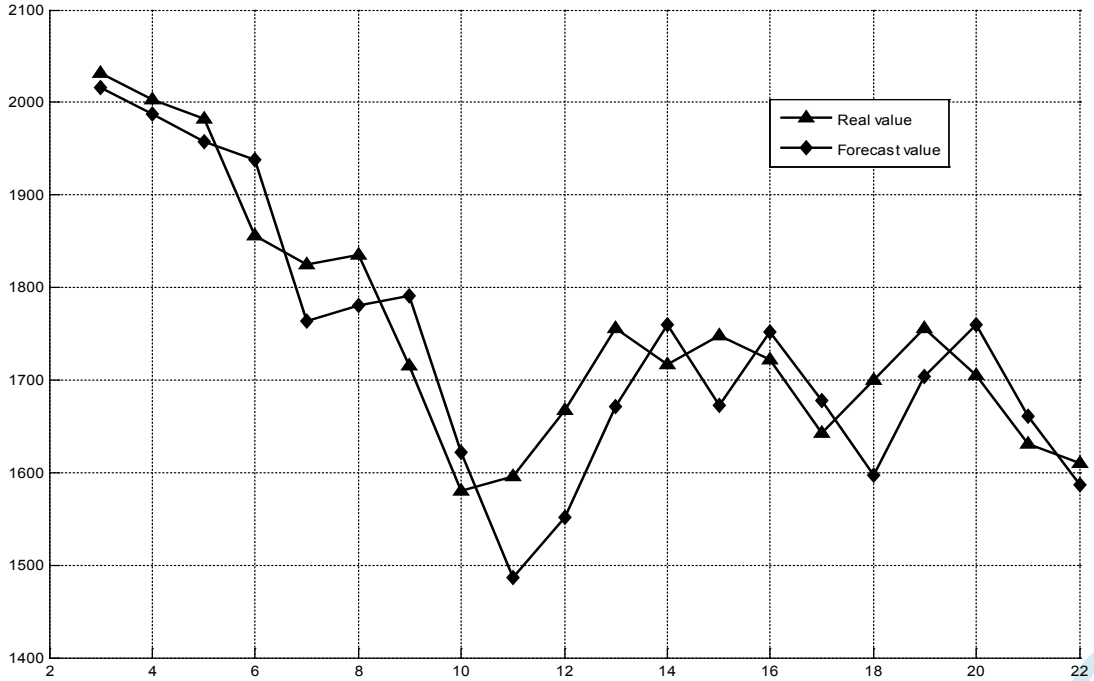

Fig. 3. The results of forecasting the economic indicator using T1FSs ("low" TS)

EXPERIMENTAL PART

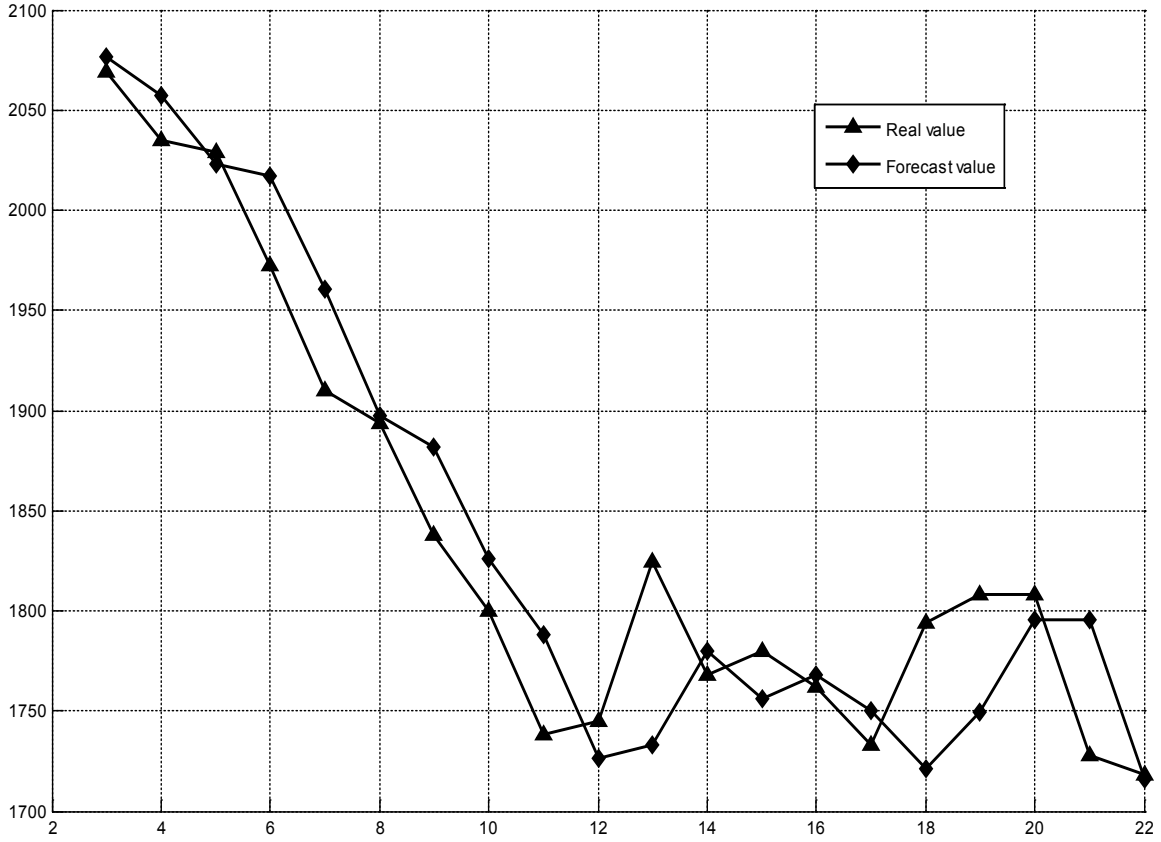

Fig. 4. The results of forecasting the economic indicator using T1FSs (“high” TS)

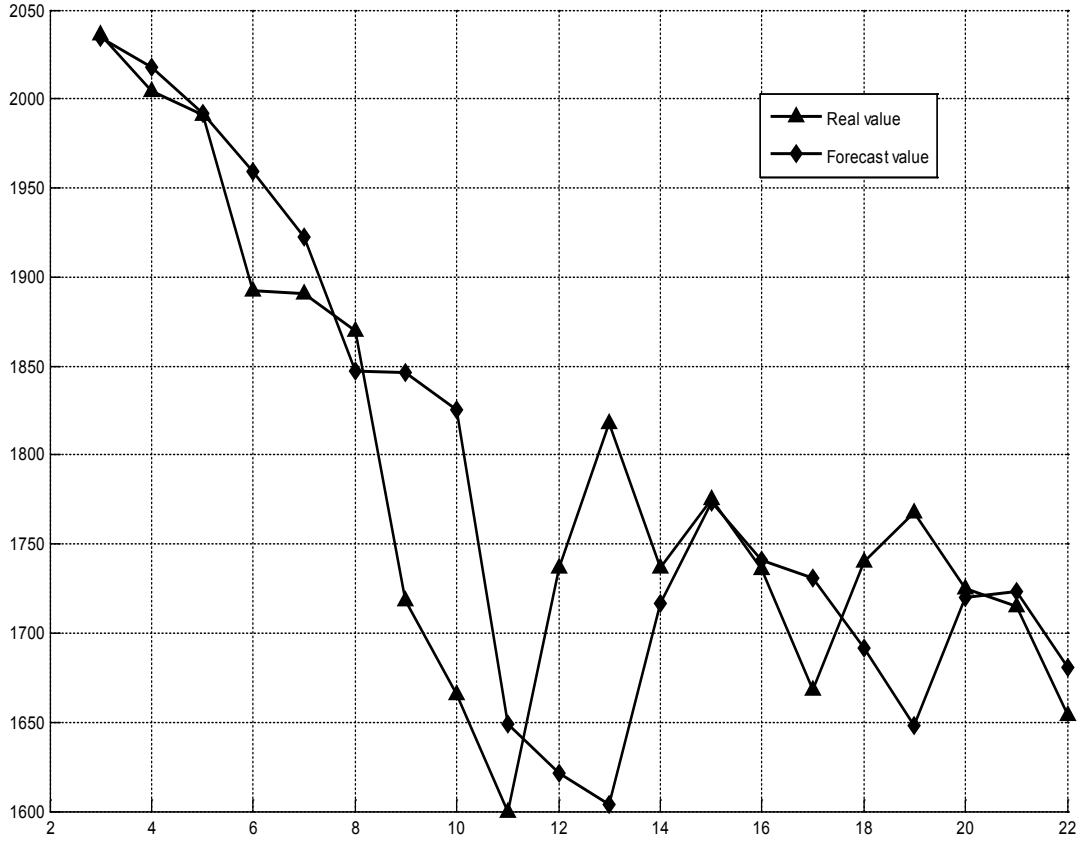

Fig. 5. The results of forecasting the economic indicator using T2FSs (“closing”)

APPROBATION OF THE FOU-MODEL

The values for forecasting models based on T1FSs and T2FSs for the "closing" TS were 3.215% and 3.151%, respectively. These results indicate the effectiveness of the use of T2FSs with aim to increase the accuracy of training of the forecasting model.

A herewith, for forecasting models based on T1FSs and T2FSs, forecasting errors for the time point of 2008-02-07 amounted to 0.470% and 1.603%, respectively.

Note that the values for forecasting models based on T1FSs and T2FSs for "low" and "high" TSs were 3.258% and 1.747%.

CONCLUSION

The results of the experiments confirm the effectiveness of the proposed approach to the development of multifactor forecasting models, which assumes the presentation of the TSs available to the analyst using the tools of fuzzy sets theory in order to form groups of fuzzy logical dependencies and obtain on their basis the averaged forecast values. The choice of the optimal parameter values of the forecasting models using GA made it possible to minimize the value.

The purpose of further research may be to assess the level of uncertainty in the behavior of TS, described by the proposed forecasting models.