Fuzzy Logic and Financial Time Series

There are manifold methods used for the predictions of time series. In addition to the classical method such as Box-Jenkins methodology, Kalman filter, etc., we can use artificial neural networks, genetic algorithms or fuzzy logic. See articles 1,2,3,4,5,6,7. This article describes the search for the use of fuzzy logic for the purposes of prediction of financial time series.

We used the Fuzzy Inference System (FIS) of Sugeno type for the prediction of time series. The FIS Sugeno is designed in such a way to give one output with n inputs. The inputs of FIS are represented by the values of time series preceding the value that we want to predict. The output value is prediction value. The long-term testing shows that the quality of prediction is given by the set up of the number of members of time series which creates the input of FIS. The FIS does not describe the course of time series when the number of members is either low or high (the low or high sensitivity of regulator).

The FIS has been tuned to the initial part of time series to set up the number of input values of time series. The cluster method has been used for the purposes of assigning members of time series to clusters. The number of clusters define the number of input linguistics value of input linguistics variable. We choose the output of FIS Sugemo in the form of linear dependence. We found the constants for set up of the FIS suitable for the searched time series by the optimization of Sugeno methods above preceding members of time series. The design and tuning of FIS Sugeno has been made in the program Matlab – FuzzyTolbox.

The quality of prediction of heat consumption has been calculated according to match of prediction of tendency of prediction of development of time series with reality and according to average error MAPE defined

$$\mathrm{MAPE} = \frac{1}{L}\left(\sum_{i=1}^{L}(\mathrm{abs}(P_i - R_i)/R_i)\right),$$

where $R_1, R_2, \ldots, R_L$ are real values of time series and $P_1, P_2, \ldots, P_L$ are the predicted members of time series where L is the number of predicted values.

Example I. Time series of Nasdaq index

The first case which has been tested was the time series of development of Nasdaq index negotiable on the New York stock exchange. The values were used in the interval from 09:30 13.06.2003 to 16:00 01.07.2003 within the following two days (10 minutes sampling, 520+40 values). The graph of time series is on the Fig.1.

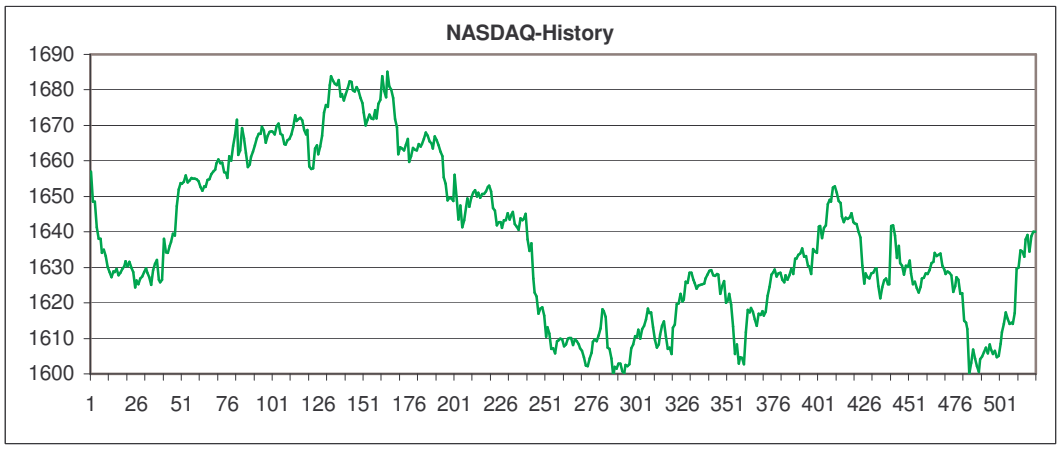


Fig.1. Nasdaq index – history

The suitable FIS Sugeno is represented by 3 input variables and 9 input values for the purposes of prediction of Nasdaq index time series. See fig. 2, 3.

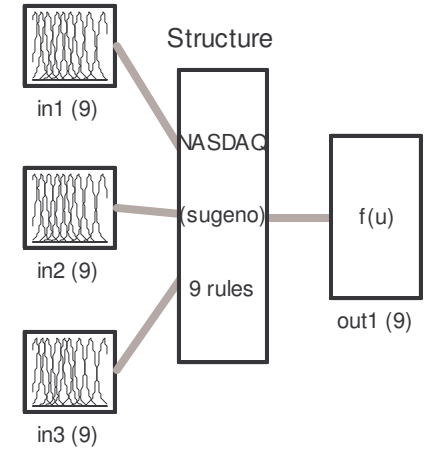


Fig. 2. FIS Sugeno of Nasdaq index

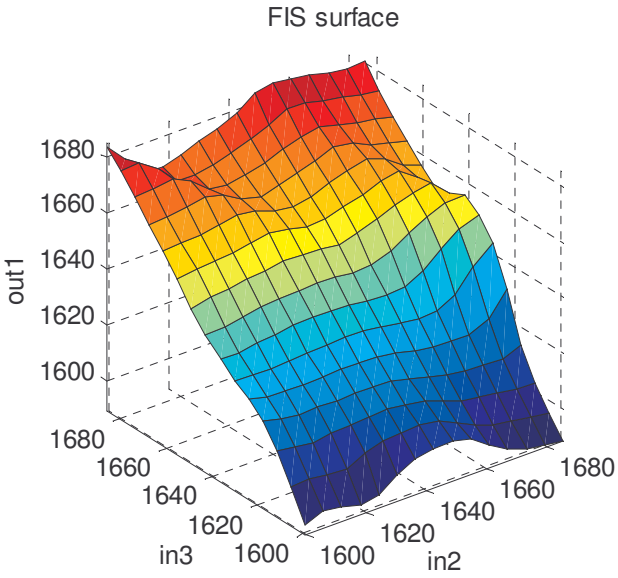


Fig. 3. The part of FIS surface

The evaluation of match of tendency of prediction with reality gives the correct prediction in 62.5 %. The fig.4. shows the values +1 (-1), which present increasing (decreasing) real tendency and predicted tendency.

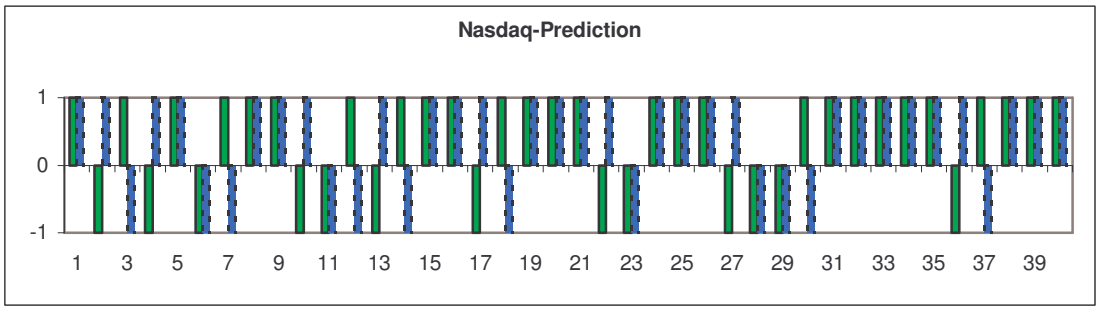


Fig. 4. Nasdaq index - prediction

The prediction by means of fuzzy logic made the value of MAPE = 0.0013. The Fig.5. shows the real values (solid line) and values of prediction (dashed line) of time series.

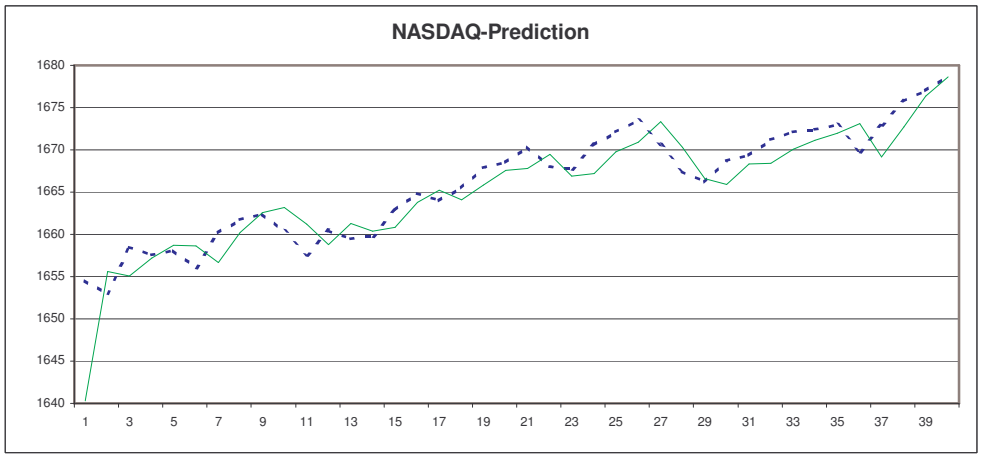
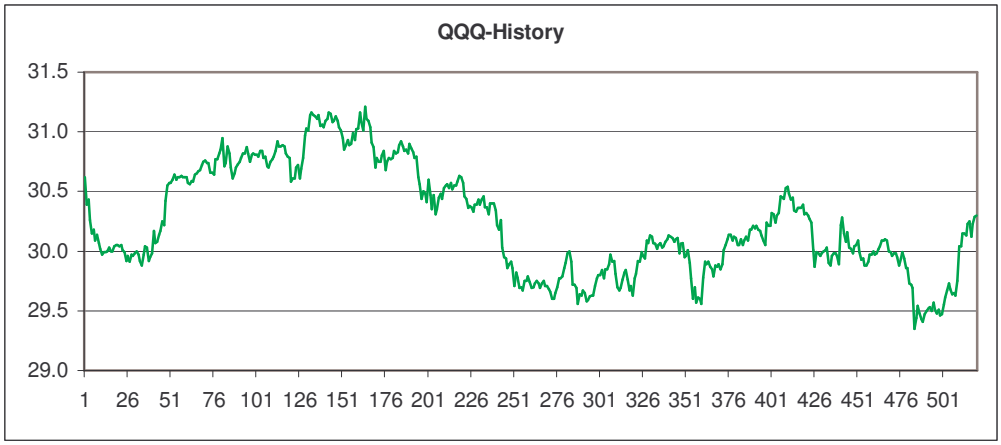


Fig.5. Nasdaq index – prediction

Example II. - Time series of QQQ index

The second case which has been tested was the time series of development of QQQ index negotiable on the New York stock exchange. The values were used in the interval from 09:30 13.06.2003 to 16:00 01.07.2003 within the following two days (10 minutes sampling, 520+40 values). The graph of time series is on the Fig.6.



Obr.6. QQQ index - history

The suitable FIS Sugeno is represented by 2 input variables and 8 input values for the purposes of prediction of QQQ index time series. See fig. 7, 8.

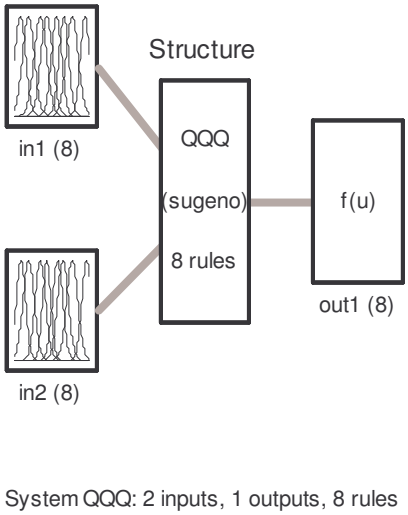


Fig. 7. FIS Sugeno of QQQ index

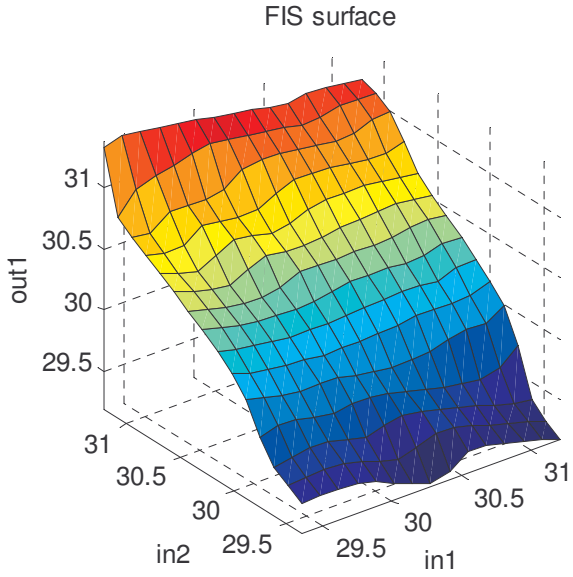


Fig. 8. The part of FIS surface

The evaluation of match of tendency of prediction with reality gives the correct prediction in 65.0 %. The fig.9. shows the values +1 (-1), which present increasing (decreasing) real tendency and predicted tendency.

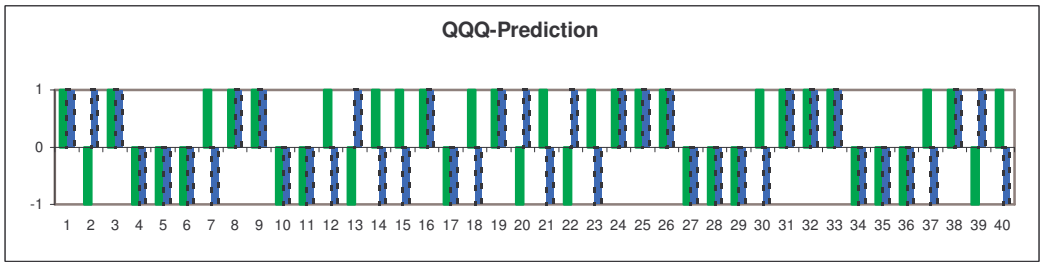


Fig. 9. QQQ index - prediction

The prediction by means of fuzzy logic made the value of MAPE = 0.0016. The Fig.10. shows the real values (solid line) and values of prediction (dashed line) of time series.

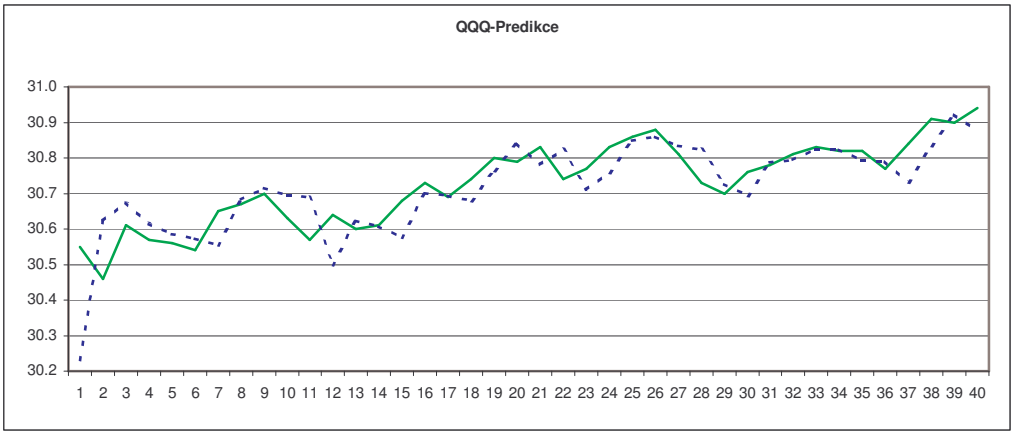


Fig. 10. Index QQQ – prediction

Conclusion

The paper describes the design of the calculation method of prediction of financial time series by means of fuzzy logic. Other methods such as Box-Jenkins methodology, Kalman filter, Elliot's waves, artificial neural networks, genetics algorithms, etc., (see 1,2,3,4,5,6,7) rank the use of fuzzy logic for prediction of financial time series to the most successful ones. The prediction error MAPE and the prediction of tendency of development of time series give evidence of usable prediction method for the process of decision making on the capital markets.