As the neural network in this study is used as a non-linear supplement of linear ARIMA (1,1,1) + GARCH(1,1) approach, the network architecture allows linear input/output-links to be included.

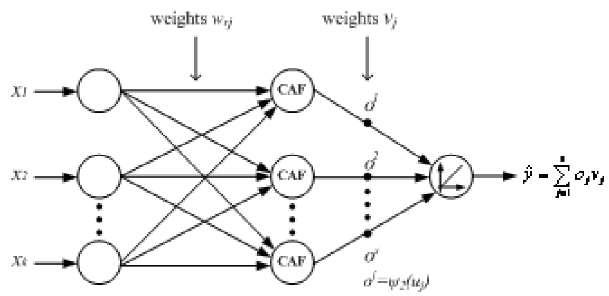

Fig. 3 Granular RBF neural network architecture with cloud activation function (CAF).

In order to avoid over-fitting, the network was kept simple (the number of hidden units were 10 the learning rate was set to 0.05. The ex post forecasts evaluation by statistical summary measures of model ́s forecast accuracy are given in Table I.

TABLE I Comparison of forecast summary statistics for EUR/USD exchange rate time series - statistical and neural approach: ex post period

Model	Forecast accuracy		
	RMSE	MAE	MAPE
ARIMA(1,1,1) + GARCH(1,1)	0.00793	0.00646	0.00495
Neural Approach Inputs: Δy_{t-1}, ε_{t-1}	0.00185	0.00145	0.00107

The fitted vs. actual EUR/USD exchange rates for the validation data set are graphically displayed in Fig. 4.

V. Empirical Comparison and Discussion

From Table I it is shown that both forecasting models used are very accurate. The development of the error rates on the validation data set showed a high inherent deterministic relationship of the underlying variables. Though promising results have been achieved with both approaches, for the chaotic financial markets a purely linear (statistical) approach for modeling relationships does not reflect the reality. For example if investors do not react to a small change in exchange rate at the first instance, but after crossing a certain interval or threshold react all the more, then a non-linear relationship between Δy_t and Δy_{t-3}, ε_{t-1} exist in model (6).

The training process and development of neural approach based on G RBF NN not only detected the functionality between the underlying variables as well as the short-run dynamics. Moreover, as we could see, the RBF NNs have such attributes as computational efficiency, simplicity, and ease adjusting to changes in the process being forecast. Thus, neural networks are usually used in the complicated problems of prediction because they minimize the analysis and modeling stages and the resolution time. Thus, we can expect more interests of the people who will make and at the some time use the forecast. If the managers are convinced that the forecasting system is sound and , they may make little use of the information given to them.

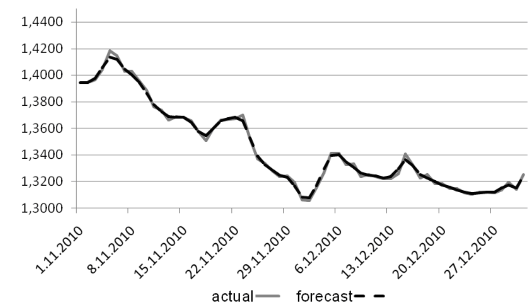

Fig. 4 Actual (solid) and forecast (dotted) values of the EUR/USD exchange rate forecast (neural approach).

VI . Conclusion

The results of the study showed that there are more ways of approaching the issue of risk reducing in managerial decision-making in companies, financial institutions and small enterprises. It was also proved that it is possible to achieve significant risk reduction in managerial decision-making by applying modern forecasting models based on information technology such as neural networks developed within artificial intelligence. In future research we plan to extend presented methodologies by applying fuzzy logic systems to incorporate structured human knowledge into workable learning algorithms.

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