THE IMPLEMENTATION OF NEURAL NETWORKS IN THE MANAGEMENT OF INVESTMENTS ON THE WARSZAWSKA GIEŁDA TOWAROWA (WGT)

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Summary

The paper focuses on the subject matter concerning derivatives such as future contracts, listed on the WGT. By means of numerical examples, problems concerning forecasting by neural networks and by the analysis of futures markets (creation of transactional systems) were illustrated.

Keywords: neural network, future contracts, commodity market

1. Introduction

The development of informatics and telecommunication technologies contributed to the development of market economy and its globalization. It enabled research studies on the models already known earlier, but not common due to limited calculative power such as, for example, methods of artificial intelligence - artificial neural networks, genetic algorithms [3].

The aim of the study was to work out a model of the implementation of artificial neural networks to the management of investments on Polish commodity markets and particularly on futures markets. In this study possibilities of creating a new real transactional system based on signals obtained by means of the examined neural networks models were analysed and discussed. Two groups of systems were tested: the systems based on signals generated by the neural networks models and the modified systems containing "stop-loss" levels.

2. Method, range and research material

The research method involved economic and informatics methods. From the group of economic methods , the technical analysis and the computer analysis of investments systems were used, whereas from the informatics group, the artificial neural networks.

The scope of the study involved the analysis and evaluation of the possibilities of obtaining a useful instrument assisting in making decisions in regard to the investments in commodity markets, particularly in the case of investing in future contracts using artificial neuron networks.

The empirical material was based on the data covering the period from January 1999 to December 2000 and divided into four categories:

1. The data concerning future contracts for USD listed on the WGT - including daily prices: opening price, lowest, highest and closing prices
2. The data connected with the listed contracts - an average USD exchange rate determined by NBP (National Bank of Poland) (exchange rate of contracts settlement).
3. The data affecting the exchange rate of USD in relation to PLN - interest rates on the interbank market WIBOR 1M and LIBOR 1M.
4. Selected stock indices – WIG, S&P500, DJIA.

The data from 1999 were divided into a learning set and testing set. The learning set was used for the optimization of interneuron weights connections. On the basis of a testing set, verification and selection of structures of the best prognostic values were carried out. The values of this period were used to select the best generalizing architectures. Further research work was carried out on the basis of the data from 2000 which were divided into five parts. Each of these parts was divided again into the learning and testing sets. Basing on the 2000 data an attempt to work out a transactional system was made. The essential data were scaled into the values within the range from 0.1 to 0.9 [1, 2].

3. The analysis of the results

At the first stage of the studies on the network a classical algorithm of reverse propagation was used. The networks selected for the analysis were examined using four methods of learning: basic algorithm of reverse propagation, two algorithms using heuristic knowledge – Quickprop and RPROP, and also a method of gradients coupled with regularization (SCG – scaled conjugate gradient).

The evaluation of the quality of the networks and the quality of the forecasts obtained by means of these networks was done using two measures of errors – SSE (Sum Squares Error – sum of deviations squares) and RSQ (Pearson square correlation indexes).

3.1. Optimization of the selected architectures of the networks

The data from 2000 were divided into five sets, each of which in turn was divided into a training set and a test set. The testing sets, which will serve as the basis for the forecasts and for the construction of transactional systems, encompassed the following periods and series of contracts:

- Set I: 16.02-19.04.2000, series USJ0,
- Set II: 5.04-20.06.2000, series USM0,
- Set III: 24.07-20.09.2000, series USQ0,
- Set IV: 22.09-14.11.2000, series USX0,
- Set V: 19.10-20.12.2000, series USZ0.

The smallest error SSE, in the training phase, was obtained for Set I (Fig. 1a) of architecture 12-10-1 in which weights were optimized by algorithm SCG (0.0034). The smallest error SSE, in the testing phase, was obtained for Set III (Fig. 1b) of architecture 12-12-9-1 in which weights were optimized by algorithm Rprop (0.0104). The average error SSE for all the sets (I-V) was: for training – 0.0201; for testing – 0.2317.

3.2. The profitability analysis of transactional systems

While creating transactional systems it was assumed that the closing price is forecast (Fig. 1c, d), whereas the opening price is known at the beginning of the session. It was assumed that there was always a possibility to make a contract at the opening or closing price. The presented systems make it possible to sign a contract at the beginning of the session and to close the position at the end of the session and in this way to avoid the risk of maintaining the position over the night [4].

The above assumptions made the analysis of the system possible, whereas the price consisted in the comparison of the following values: a profit or a loss in the examined period, the number of transactions bringing a profit/loss, an average profit/loss per transaction The signal of getting a long position was generated when the difference between the forecast closing price and the opening price was larger than a certain threshold value β. The signal of getting a short position was generated when the difference between the closing price and the opening price was smaller than -β. If the difference between the closing and opening price is within the range from -β to β a neutral signal is generated [5].

The following three systems were analysed:

- System I – β=30 PLN;
- System II – β=40 PLN;
- System III – β=50 PLN;

As regards System I the largest profit was obtained for Set III and series 12-12-11-1 Rprop (5960,00 PLN), the largest loss appeared during the period with which Set II (-1430,00 PLN), network 12-10-1 Rprop corresponded. From the investor's point of view it is also important to compare an average profit and loss per transaction and the ratio of the number of transactions with profits to those with losses. For System I and all the examined periods the largest average profit per transaction was achieved for network 12-12-11-1 Rprop – 143.90 PLN. For this structure the smallest average loss per transaction i.e. -61.17 PLN was obtained. The comparison of the number of profitable transactions (123) to those with losses (98) is also advantageous

A 10 PLN increase in the difference necessary for signing a contract resulted in a decrease in profitability. In System II (β=40 PLN) the best profit, like in the previous case, was achieved for set III and for the signals obtained on the basis of networks forecasts 12-12-11-1 Rprop (5890.00 PLN). The largest profit per transaction for the above mentioned structure amounted to 142.15 PLN, whereas the loss was -62.84 PLN. The relation between the number of profitable transactions (111) and those with a loss (106) worsened.

In System III, in which entry threshold increased to 50PLN, the profitability for the best period decreased (set III - 5200.00 PLN). Although the average profitability per transaction (139.91 PLN) did not drop significantly, nor did the average loss per transaction (-65.91 PLN), the ratio of profitable transactions (96) to the transactions with a loss (117) would be unacceptable for many investors. A potential investor would have to take account of the fact that on average per 8 profitable transactions there would be 10 transactions with a loss. Still worse is this relation in regard to set I of the same structure (12-12-11-1 Rprop), where per 10 transactions with a loss, 3 would be with a profit.

The largest total profits, independently of the studied structure, were obtained for System I (Fig. 1e). Comparing the architecture and the way of learning, the largest total gains were achieved for the signals generated by network 12-12-11-1 Rprop, where in relation to the used system the profit over the whole period amounted to the values from 12 792.00 PLN (System III) to 15 612.00 PLN (System I).

In real transactional systems investors use orders which make it possible to limit losses or a drawdown of the capital („stop-loss", „stop-limit"). In the further analysis orders of the "stop-loss" type were used. The essential problem of the situation in which we want to control the amount of possible losses is to determine the level of the loss an investor is able to accept. In the illustrated analysis

System I was modified by determining 3 levels of "stop" at which the position with a loss is closed.

- System IA – level "stop" - 70 PLN;

- System IB – level "stop" - 100 PLN;
- System IC – level "stop" - 150 PLN.

The introduction of level "stop" allows for the reduction of losses in case a transaction has been made on a wrong side of the market; profitable transactions are closed at the closing price.

For the system in which level "stop" was determined at 100 PLN (IB), a maximum total gain for the best structure (12-12-11-1 Rprop) decreased in comparison with System IA, by about 5% (23 474.00 PLN). The best results were obtained for set V and for the structure 12-10-1 Rprop (6331.00 PLN). The average loss per the most profitable structure increased to -27.44 PLN.

The observations of the previous systems (I A-B) are confirmed in respect of the system of the largest assumed level "stop" 150 PLN. The largest profit in an individual period was obtained for network 12-10-1 Rprop – set V (6111.00 PLN). The best network for the whole period was network 12-12-11-1 Rprop with a profit of 21734.00 PLN. The average loss per transaction grew in this case to -34.96 PLN. The introduction of the price level at which the transaction with a loss is closed considerably increased the profit of the whole examined range (Fig. 1f).

Independently of the studied system the largest gains were achieved, like in the previous phase (Systems I-III), for the strategy in which the signals were generated by structure 12-12-11-1 Rprop. During the whole investigated period the profits obtained for this network varied from 21734.00 PLN (IC) to 24854.00 PLN (IA). The total profit for the best system hedged by the determination of level "stop" increased in comparison to the previous systems (I-III) by 60-70%.

4. Conclusions

Models of neural networks were created and they enabled forecasting future contracts prices and this in turn was the basis for the construction of transactional system. The obtained results suggest that the use of artificial neural networks for the investments on stock markets is justified and will end in a financial success

The best results were achieved for the network of architecture 12-12-11-1; the learning algorithm was also significant, it was Rprop algorithm. Less threshold β enables to identify beginning of trends, the amount of threshold (β=30) did not result as taken random position (noise). A very important factor was the determination of an appropriate level of a drop in the value ("stop-loss") below which the position on the futures contract was closed. Thus the losses could be limited when the system generated inappropriate signal.

The results confirm the thesis that the implementation of artificial neural networks enables achieving measurable investments results and also makes mechanisms affecting the formation of the levels of future contracts prices on Polish commodity markets easier

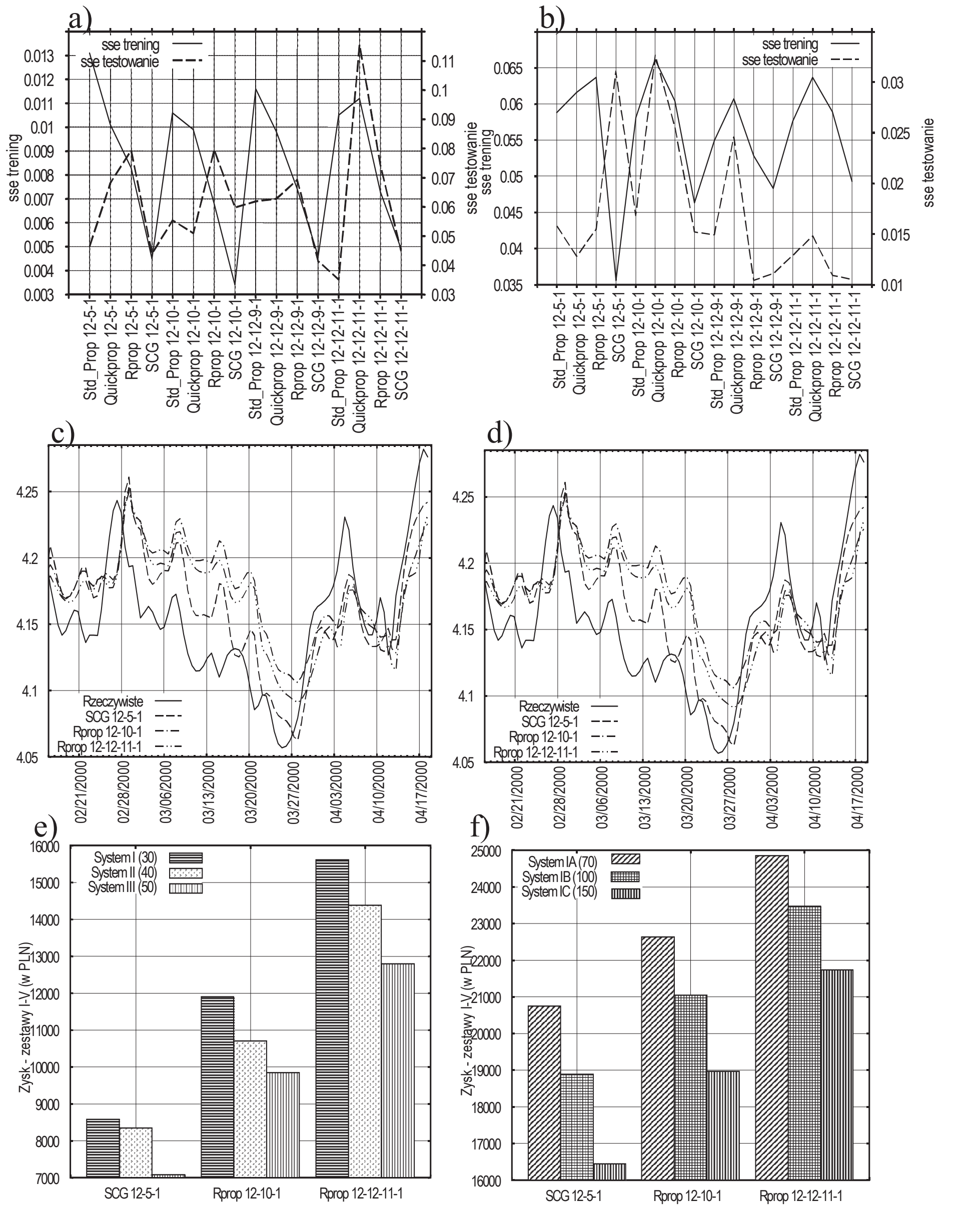

Fig. 1 Errors, forecasts and efficiency of chosen neural nets.

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