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TUNING OF THE AUTOMATED SYSTEM FOR MAKING EXPERT DECISIONS BASED ON GARCH-MODELS USAGE

The given paper considers the technique of tuning at different time intervals the automated system for taking expert decisions at financial markets based on results forecast applying nonlinear GARCH-methods.

Key words: *system, optimization, modeling, GARCH-methods, expert decision, financial market, profit, risk.*

Actuality

Main concepts of traditional models of capital management and classic analytical methods of financial markets analysis more and more frequently face problems, which do not have effective solutions within the frame of constant paradigms. These methods and approaches were not intended for description and modeling of rapid changes, unpredictable jumps and complicated interactions of separate components of modern market process.

Gradually it became obvious that changes in the financial world take place so intensively, and their qualitative indications are so unexpected, that for an analysis and prediction of financial markets the synthesis of new analytical and computational approaches which originate in different areas of human knowledge became main practical necessity [1].

In recent years interest to the search of nonlinear models which would adequately reproduce complex pictures of financial dynamic processes has grown since it has already become clear that for analysis of such markets linear approach does not allow to model irregular behavior, characteristic of most financial assets. It is explained by the fact , that nonlinear models can define and describe very complex processes occurring in financial data flows. At the same time linear approach does not allow to take into account and to analyze irregular behavior which is demonstrated by numerous financial assets.

Nowadays so-called nonlinear GARCH-methods become more and more popular and are used for solution of various optimization problems. Their application spheres comprise: risk-management, financial markets, technological objects and so on. It was revealed, that conventional models intended for analysis of high-frequency data constantly changing in time, can not exactly and efficiently describe their behavior. Unlike the above-mentioned models , GARCH-models enable correctly and with sufficient accuracy describe the behavior of time series and quickly react on any changes emerging in the process of observation (presence of jumps, vibrations in historical data row, etc.) [2, 3].

In the process of analysis and prediction of complex financial processes it is practically impossible to do without such universal instrument as nonlinear methods of complex systems optimization . The usage of GARCH-algorithms gradually becomes competitive approach to the solution of forecast problems, classification, financial time series rows modeling, and also to the solution of optimization problems in the spheres of financial analysis and risk-management . For this reason the application of such mathematical models for creation of automated expert system for information behavior forecast in considerable time intervals becomes very actual.

Goal of research

The goal of research is tuning of automated expert system for decision-making on the basis of prediction results by GARCH–methods and search of optimal time interval, when system demonstrates the most efficient operation.

Main part

To achieve defined goal it is necessary:

- develop the mathematical model of financial assets behavior prediction for decision-making (data pre-processing, choice of equation type, GARCH-coefficients calculation);
- develop the algorithm of expert model operation, technique of prediction and decision making by user;
- analyze the efficiency of financial assets behavior prediction and expert decision making by system on three different time intervals of 15 minutes, 30 minutes and 45 minutes. The index of system operation efficiency is selected income value, to be obtained which as a result of implementation of decisions, taken by the system.

On the basis of recent research and literary sources analysis we decided to choose GARCH-methods for the development of mathematical model of assets behavior prediction [1, 2].

In the previous works [4, 5]stages of development of mathematical model intended for financial assets behavior prediction were described in details . General view of mathematical model equation which will be further used by the system for prediction, is presented as [3]:

$$y_t = \alpha_1 X1_t + \alpha_2 X2_t + \gamma\varepsilon_{t-1} + \delta \cdot \sum_{i=1,p} \sigma_{t-i}{}^2 , \tag{1}$$

where y_t is dependent variable, $X1_t, X2_t$ are independent variables, ε_{t-1} is an error, α_1, α_2 are regression coefficients, γ is ARCH-process coefficient, v_t is a GARCH-process coefficient[4, 5].

In accordance with the task, set in the paper, regarding the development of expert decision-making system based on results predicted by a GARCH-model, it is expedient to elaborate algorithm intended for operation with the given system. It consists of the followings stages:

Prediction stage.

In order to carry out prediction of portfolio financial instruments (assets) behavior the system requires the followings information:

- array A of open price values the size of which is [M, N], where M is an amount of instruments ($i := 1..M$),
- N is an amount of time moments ($j := 1..N$).

It should be noted that the content of the array is dynamic and changes with at the next time moment. That is, the first array value is removed, and at the end of array line the new open price value is written down at time moment j. The prediction results are presented in the form of data array P of size [M, N].

At prediction stages the followings values which will be needed at the next stage of expert decision making are calculated:

1. Expectation of m_predict$_i$:

$$m\_predict_i = \sum_{j=1}^{N} \frac{P_{i,j}}{N} , \tag{2}$$

where $P_{i,j}$ is predicted open price value P at J time moment j ,j=1..N ;

N is number of open price values for instrument P_i.

2. Standard deviation for real and predicted value σ_i and σ_predict$_i$

$$\sigma_i = \sqrt{V_i} \text{ и } \sigma\_predict_i = \sqrt{V\_predict_i} , \tag{3}$$

where $V\_predict_i = \sum_{j=1}^{N} \frac{(m\_predict_i - P_{i,j})}{N}$ - variance of predicted price for instrument P_i;

$V_i = \sum_{j=1}^{N} \frac{(m_i - A_{i,j})}{N}$ - variance of real price for instrument A_i.

Obtaining of prediction data is carried out by the algorithm presented in [4,5].Besides, the research contains the technique of elaboration of results evaluation scale, according to which the system generates expert decision.

Decision-making stage.

After obtaining prediction results the system checks conditions and makes the proper expert decision. For this purpose every instrument is described as a vector-record of V_i (Symbol, Price, Type, Qty), which consists of the followings elements:

– Symbol is the instrument name t;
– Price is a current open price of instrument;
– Type is a type of position for an instrument which has two values: long is long position and short is short position;
– Qty is number of this instrument;
– OpenTime is opening position time;
– CloseTime is a closing-time position;

In addition, it is needed to define the Instrument_Righ_Limit variable, which will describe the level of asset share in a portfolio. Usually this value is equal to 5%. Variable Total_Porfolio_Value will present the total assets price in a portfolio.

Step1. Set the counter of assets quantity in portfolio $i := 1$, $i := 1..M$. Define the variables Instrument_Righ_Limit and Total_Porfolio_Value:

$$\text{Instrument\_Righ\_Limit} := 5\%$$

$$Total\_Portfolio\_Value := \sum_{i=1}^{M} V.Qty_i * V.\Pr ice_i \tag{4}$$

Step 2. Check the condition:

if $P.\Pr ice_{i,N} < V.\Pr ice_{i,N}$, then move to next step 3;

if $P.\Pr ice_{i,N} > V.\Pr ice_{i,N}$ then move to next step 4.

Step 3. Check the following conditions and make the proper expert decision:

- $If\ \sigma_i > (m\_predict_i - \sigma\_predict_i / 2)\ AND\ \sigma < (m\_predict_i + \sigma\_predict_i / 2)$, then

  $If\ \ V.Type_i = long$, then $V.Qty_i = V.Qty_i - \Delta Qty$ and

  $if\ \ V.Qty_i \le 0$, then $V.CloseTime_i = current\_time$;

- $If\ \ V.Type_i = short$ and $V.Qty_i + \Delta Qty < Instrument\_Righ\_Limit$ and $V.\Pr ice_i * V.Qty_i < Total\_Portfolio\_Value$, then

  $V.Qty_i = V.Qty_i + \Delta Qty$ and $V.OpenTime_i = current\_time$;

- $If \begin{array}{l} \sigma_i > (m\_predict_i + \sigma\_predict_i / 2) AND \sigma < (m\_predict_i + \sigma\_predict_i) \\ OR \sigma_i > (m\_predict_i - \sigma\_predict_i) AND \sigma_i < (m\_predict_i - \sigma\_predict_i / 2) \end{array}$, then

  $If\ \ V.Type_i = long$, then record V_i is not changed

  $If\ V.Type_i = short$, then record V_i is not changed;

- $If\ \sigma_i > (m\_predict_i + \sigma\_predict_i) OR \sigma_i < (m\_predict_i - \sigma\_predict_i)$, then

  $If\ \ V.Type_i = long$ and $V.Qty_i + \Delta Qty < Instrument\_Righ\_Limit$ and $V.\Pr ice_i * V.Qty_i < Total\_Portfolio\_Value$, then

$V.Qty_i = V.Qty_i + \Delta Qty$ and $V.OpenTime_i = current\_time$

If $V.Type_i = short$, then $V.Qty_i = V.Qty_i - \Delta Qty$ and

if $V.Qty_i \leq 0$, то $V.CloseTime_i = current\_time$;

Step 4. To check the following conditions and make the proper expert decision:

- *If* $\sigma_i > (m\_predict_i - \sigma\_predict_i / 2) AND \sigma < (m\_predict_i + \sigma\_predict_i / 2)$, then

  If $V.Type_i = long$ and $V.Qty_i + \Delta Qty < Instrument\_Righ\_Limit$ and $V.\Pr ice_i * V.Qty_i < Total\_Portfolio\_Value$, then

  $V.Qty_i = V.Qty_i + \Delta Qty$ and $V.OpenTime_i = current\_time$

  If $V.Type_i = short$, then $V.Qty_i = V.Qty_i - \Delta Qty$ and

  if $V.Qty_i \leq 0$, то $V.CloseTime_i = current\_time$;

- *If* $\begin{matrix} \sigma_i > (m\_predict_i + \sigma\_predict_i / 2) AND \sigma < (m\_predict_i + \sigma\_predict_i) \\ OR \sigma_i > (m\_predict_i - \sigma\_predict_i) AND \sigma_i < (m\_predict_i - \sigma\_predict_i / 2) \end{matrix}$, then

  If $V.Type_i = long$, then record V_i does not changed

  If $V.Type_i = short$, then record V_i does not changed;

- *If* $\sigma_i > (m\_predict_i + \sigma\_predict_i) OR \sigma_i < (m\_predict_i - \sigma\_predict_i)$, then

  If $V.Type_i = long$, то $V.Qty_i = V.Qty_i - \Delta Qty$ and

  if $V.Qty_i \leq 0$, то $V.CloseTime_i = current\_time$

  If $V.Type_i = short$, $V.Qty_i + \Delta Qty < Instrument\_Righ\_Limit$ and $V.\Pr ice_i * V.Qty_i < Total\_Portfolio\_Value$, then

  $V.Qty_i = V.Qty_i + \Delta Qty$ and $V.OpenTime_i = current\_time$;

Step 5. Set counter of assets quantity $i := i + 1$, $i := 1..M$

Step 6. Repeat steps 2-5 till $i > M$.

For analysis and verification of prediction efficiency and expert decision making by system on the different time intervals time series of date 02/01/2003 were used. The given information was taken from Free Historical Futures Data, supplied by Turtle Trader Company. The system operation was checked at 15-minute, 30-minute and 45-minute intervals. The criterion of prediction efficiency was the number of successfully predicted cases which by estimation scale in accordance with the value of standard deviation received signal «Strong» (for cases «Buy» and «Sell») and signal «Not Strong» and «Weak» (for case «Wait»).

Data obtained as a result of system operation on three selected time intervals, are presented in Table 1.

Table1

Prediction results of different time intervals

Time interval, min	Number of successfully predicted cases	Number of decisions "Buy"	Number of decisions "Sell	Number of decisions "Wait"
15 minutes	67	20	5	42
30 minutes	63	12	4	47
45 minutes	60	11	4	46

Having analyzed the prediction results in different time intervals and taking into account the quantity of successfully predicted cases, we can make a conclusion , that given expert model showed the best prediction results in the interval of 15 minutes.

Conclusions

In the given research decision making algorithm is developed for expert system on the basis of prediction results using nonlinear GARCH-methods. Mathematical model was suggested, incremental descriptive algorithm is proposed using which the system makes a decision and performs financial operations. Authors adjust the system at different time intervals, analyze the income values. Results obtained show, that most operation efficiency the system demonstrates in short time intervals.

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