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ASSESSING THE CURRENT STATE OF THE STOCK MARKET UNDER UNCERTAINTY

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ABSTRACT

The article is devoted to development methods and models for the study and evaluation the current state of the stock market. For example, the stock market in the Russian Federation. In the stock market, it is very difficult to find the models to measure the securities prices changes, therefore the assessment problem the state of the stock market and forecast of its development are usually solved under conditions of incomplete information. This article presents the basic assessments such as indexes, the current volume of transactions, the volatility, capitalization of the stock market and oil prices. We explained the purpose of them and suggested states for the stock market: stable, transition, growth, unstable and stagnation. These proposed states of the stock market as the most corresponding to the real state of market. In this article we used model to assess the state of the stock market. This model allows us to classify the possible states of the stock market on the basis of measuring the assessment as mentioned above. Depending on the basic sets of the values of assessment the expert gives the linguistic variables, their term-sets and membership functions of fuzzy sets. The experts give set of the standard situations of the stock market. The model contains in its structure rules for assessing the current state of the stock market. The situations assessment model compares between the actual situations with the standard situations and gives inference about the state of the stock market at current time. To perform the research we designed program in an environment Matlab and gave an example of assessing the current state of the stock market.

Keywords: *The Stock Market, Assessing, Incomplete Information, Fuzzy Logic, Decision-Making*.

1. INTRODUCTION

The Securities Market or the stock market takes a special place in the country's economy. The stock market "lives by its own laws" and his state is determined by not only the economic state of particular country (for example Russian), but also the state of global economy. For distinguish the market by the manifestation of stationary / no stationary, Availability / absence of aftereffects, as well as a manifestation of changes of the linearity / nonlinearity for the parameter at different time intervals.

The peculiarity of the stock market is also associated with the appearance of unstable situations. These situations are characterized by the fact that prices of the shares packages change dramatically. As a result, participants in the stock market may be getting a lot of money and also may be lose them in a very short time.

The assessment problem the state of the stock market and forecast of its development is an actual problem. Solution the assessment problem the current state of the stock market will provide the successful solution for many other problems. The most important among these problems is the problem of investment the money [1 - 3]. The solution of the assessment problem of the state of the stock market is based on use the models. There are famous methods and models for predicting the state of the stock market, for example, convergence / divergence of moving averages, the forecast based on neural network ,autoregressive integrated moving average and others [4 - 7]. Shown [4, 8] there are many of mathematical models used to perform the forecast of the stock market. These models give good and reliable results, but only in

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the case of stability the state of the market. These models do not reflect the behavior of prices if the stock markets are unstable and unforeseen significant changes occur.

In the stock markets works specialists with in-depth knowledge and ability to do the assessment of the current state of market and forecast of its development. Therefore, it is necessary to use the knowledge of these experts and formalize this knowledge. The application of decision-making models based on expert's knowledge gives good results [9]. It should be noted that the use of expert's knowledge does not mean rejection of Statistical data. When formalizing the parameters of the securities market and for the model of assessing the state of the market we use the concept of fuzzy sets and linguistic variables [10 - 12]. Assessment model the state of the market when give the variables of problem allow to use the model of situational analysis [9, 13, 14]. The model works with expert data and the results of measurements of assessment the current market.

Assessment the securities market as a group of characteristic factors for situational models take from available public data of exchange trading in stock markets, that enough to accurately describe the current state of the stock market in the Russian Federation, using the model of situational analysis and information support toolbox.

2. THE FORMALIZATION OF THE PROBLEM PARAMETERS OF ASSESSING STATE OF THE STOCK MARKET

To assess the state of the stock market in the Russian Federation we proposed the following states: stable; transition; the state of the market growth (growth); unstable; an extremely unstable state (stagnation). Each of these states can be associated with a set of characteristic factors, each of which is based on publicly available data of exchange trading in stock markets [15, 16]:

- Indices (the average change in prices of a particular set of securities, for example, SP500, NASDAQ, RTS, MICEX, and others.);

- The volume of current transactions - allow understanding the market from the perspective of a quantitative number of transactions;

- Market volatility (shows the level of panic or relaxation for bidders at a time - for example, the VIX, or RTSVX for RTS) - is the amplitude of the fluctuations in price over a certain period of time and so on. It is not the horizontal direction of the trend, but the scope of the vertical jump and the swing highs and lows within a day;

- Stock market capitalization (the value can be defined as the product of the number of issued securities at their market price) this amount of capital represents in the form of income securities;

- The price of oil.

Let us explain a feature of the selected characteristic factors.

Indices - this instrument gives general idea about the state of pricing in the stock market. In other words, it shows where is moving the whole market.

The indicator "volume of current transactions" represents a change in rubles (in the value of securities), which reflects the value of transactions for the selected time interval. The indicator of trading volume allows assessing the strength or weakness of a market movement and works as confirmatory factor in the rise or fall.

Let us consider the example of manifestation of market volatility If the trading session and the price of the exchange tool vary in small range (1% of 1.5%), then in this situation considered a low-volatile. If the price rises in the morning up to + 15%, in the evening falls to 10% and the market closed at a value of 5%, then such exchange asset called volatile. Therefore, market volatility indicator shows how strong is jumping price and how effective is the trading of these securities.

Cost volume of capitalization is defined as the product of the number of issued securities at their market price. In the situation of certain amount of outstanding shares and bonds the absolute market capitalization is determined by the level of the corresponding prices and the relative change in its general form (increase or decrease) is shown in the dynamics of stock indices.

Practice in recent year's shows that the Russian stock market is highly dependent on European and the European market dependent on American. Status of US stock market shows a relationship (correlation fuzzy) on oil prices.

Experts consider each of the characteristic factors as a linguistic variable (LV), define a set $<\alpha i, T(\alpha i,), Xi, Gi, Mi>$, $i = \overline{1,n}$, where αi – name of LV; $T(\alpha i)$ - term-set LV αi; Xi – domain LV αi; Gi - syntactic rule; Mi - semantic rule [11, 13]. For each LV αi experts give the term-set

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T(αi) as sets of fuzzy variables $\alpha_i^j, i = \overline{1,n}, j = \overline{1, m_i}$, where mi – domain of term-set T(αi).

Fuzzy variables α_i^j are defined by the sets $< \alpha_i^j, \tilde{C}(\alpha_i^j), Xi >$, where $\tilde{C}(\alpha_i^j) = \{ < \mu_{C(\alpha_i^j)}(x_i) / x_i > \}$, xi∈Xi – fuzzy subset of sets Xi, $\mu_{C(\alpha_i^j)}(x_i)$ - membership function elements of xi∈Xi in fuzzy set $\tilde{C}(\alpha_i^j)$.

3. SITUATIONAL MODEL FOR ASSESSMENT THE STATE OF THE STOCK MARKET

For assessment the state of the stock market we use situational model. The use of this model gives good results in solving different problems and it is shown in many studies, for example, [9, 17 - 19]. Also there are famous methods for constructing models of assessing the current state of the stock market [4 - 7].

In this article, we show a model for selection (identification) the current state of the stock market, in this model the experts give standard fuzzy situations. Parameters of characteristic factors are measured and the results of the measured values are in form of the basic sets Xi $i = \overline{1,n}$. The measured values of characteristic factors have the membership degrees of fuzzy variables α_i^j. In the result determine the real fuzzy situation on the stock market.

Set of standard fuzzy situations $S^* = \{\tilde{S}_1^*, \tilde{S}_2^*, \ldots, \tilde{S}_R^*\}$ divide into subsets $S_j^* \in S^*, S_i^* \times S_j^* = \varnothing, i, j = \overline{1,n}, i \neq j$, with each subset corresponds to a unique solution about the status of the stock market: h1 - stable; h2 - transition; h3 - growth; h4 – unstable and h5 - stagnation. Each standard fuzzy situation the experts mapped him to this or that of the states of the stock market. The use of situational model allows comparing the real fuzzy situations with standard fuzzy situations of the stock market. The essence of the model is displayed in Figure. 1.

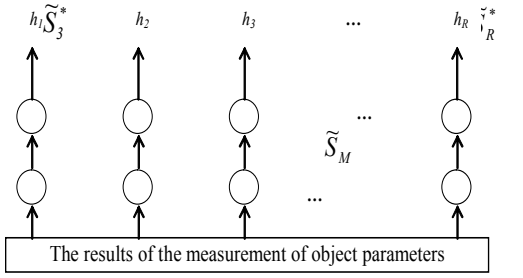

Figure. 1. Situational model for assessment the state

Now we will explain the formalizing situational model. Standard fuzzy situations defined as fuzzy sets of the second level [20, 21]:

$$\tilde{S}_i = \{ < (\mu_{\alpha_1}(x_1)/x_1)/\alpha_1 >, \ldots, < (\mu_{\alpha_5}(x_5)/x_5)/\alpha_5 > \}, (1)$$

Where α_i, $(i=\overline{1,n})$, where i is the number of linguistic variables and characterizing the components the standard fuzzy situations.

The state of object is characterized by some of real fuzzy situations and to identify its grade of membership required measuring the values of the factors for state of stock market. To determine the degree of proximity the real and standard fuzzy situations initially we use fuzzy operation of the fuzzy sets theory to determine the degree of fuzzy equality. If the real fuzzy situation is not equal (fuzzy equality) to any of the standard fuzzy situations (degree of fuzzy equality less than 0.5), then in this situation it is necessary to use the definition operation the fuzzy inclusion.

The degree of fuzzy equality of the two fuzzy sets $\tilde{S}_i$ and $\tilde{S}_j^*$ determined by the formula [13, 22]:

$$\mu(\tilde{S}_i, \tilde{S}_j^*) = \underset{y_l \in Y}{\&} \mu(\mu_{S_i}(y_l), \mu_{S_j^*}(y_l)),$$
$$\mu(\tilde{S}_i, \tilde{S}_j^*) = v(\tilde{S}_i, \tilde{S}_j^*) \,\&\, v(\tilde{S}_i, \tilde{S}_j^*).$$

The degree of fuzzy equality $\mu(\tilde{S}_i, \tilde{S}_j^*)$ is determined by formulas:

$$\mu(\tilde{S}_i, \tilde{S}_j^*) = \underset{y_l \in Y}{\&} \mu(\mu_{S_i}(y_l), \mu_{S_j^*}(y_l)),$$

$$\mu(\mu_{S_i}(y_l), \mu_{S_j^*}(y_l)) = \underset{T_k^l \in T_l}{\&} C(\mu_{\mu_{S_i}(y_l)}(T_k^l), \mu_{\mu_{S_j^*}(y_l)}(T_k^l)),$$

$$C(\mu_{\mu_{S_i}(y_l)}(T_k^l), \mu_{\mu_{S_j^*}(y_l)}(T_k^l)) = \mu_{\mu_{S_i}(y_l)}(T_k^l) \leftrightarrow \mu_{\mu_{S_j^*}(y_l)}(T_k^l),$$

$$C(\mu_{\mu_{S_i}(y_l)}(T_k^l), \mu_{\mu_{S_j^*}(y_l)}(T_k^l)) = \mu_{\mu_{S_i}(y_l)}(T_k^l) \leftrightarrow \mu_{\mu_{S_j^*}(y_l)}(T_k^l),$$

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when $\mu_{\mu_{S_i}(y_l)}(T_k^l) \notin (1 - t, t)$ and $\mu_{\mu_{S_j^*}(y_l)}(T_k^l) \notin (1 - t, t);$

$$C(\mu_{\mu_{S_i}(y_l)}(T_k^l), \mu_{\mu_{S_j^*}(y_l)}(T_k^l)) = 1,$$ when

$$\mu_{\mu_{S_i}(y_l)}(T_k^l) \in (1 - t, t)$$

or $\mu_{\mu_{S_j^*}(y_l)}(T_k^l) \in (1 - t, t).$

The degree of membership $\tilde{S}_i$ in $\tilde{S}_j^*$, $\tilde{S}_i \subseteq \tilde{S}_j^*$ is determined by formulas [13]:

$$v(\tilde{S}_i, \tilde{S}_j^*) = \&_{y \in Y} v(\mu_{S_i}(y), \mu_{S_j^*}(y)),$$

$$v(\tilde{A},\tilde{B}) = \&_{x \in X}(\mu_A(x) \to \mu_B(x)), \tilde{A} \to \tilde{B} = max(1 - \tilde{A}, \tilde{B}).$$

In the formulas of determining the degree of fuzzy equality and fuzzy inclusion used the fuzzy equivalence operation [13]:

$$\tilde{A} \leftrightarrow \tilde{B} = min\{[max(1 - \tilde{A}, \tilde{B})], [max(1 - \tilde{B}, \tilde{A})]\}.$$

4. INFORMATION SUPPORT TOOLBOX

To assessment the state of the stock market we have designed program in Matlab environment [23]. The algorithm of this program is shown in Figure. 2. The algorithm shows the steps of identifying the state of the stock market: measuring characteristic factors, fuzzification, inference, defuzzification and the state of stock market at any given time.

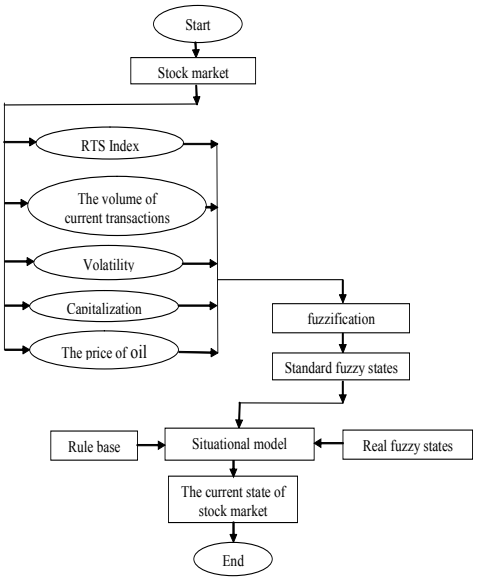

Figure. 2. The Algorithm Of The Information Support Toolbox

The advantage of the using Matlab: Allow you without expensive to implement numerous of effective mathematical algorithms for almost all activity areas. For example, do not need to write program to build membership function of fuzzy sets independently and solving of equations systems or optimization and so on.

5. THE RESULTS OF THE STUDY

Start the program to perform the research. Interface the program shown in Figure. 3.The program contains two interfaces: one is for the expert and other one is for a user. Initially, the expert gives the number of linguistic variables, their term-sets and membership functions of fuzzy variables.

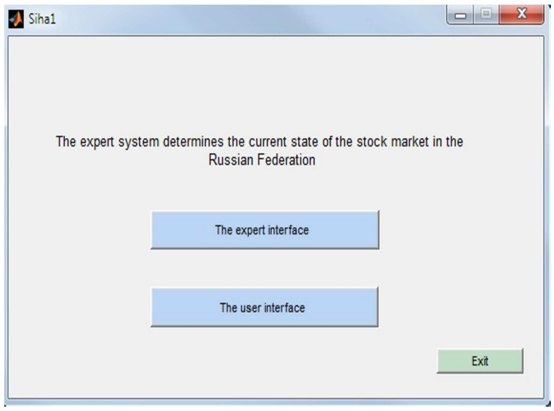

Figure. 3. The Main Interface Of Information Support

In the following we identified five linguistic variables with their term-sets to assess the current state of the stock market in the Russian Federation:

- α1 – RTS index, which has a term-set T(α1)={α_1^1 - Very Small; α_1^2 - Small; α_1^3 - Medium; α_1^4 - Big; α_1^5 - Very Big};

- α2 – The volume of current transactions, which has a term-set T(α2)={α_2^1 - Very Small; α_2^2 - Small; α_2^3 - Medium; α_2^4 - Big; α_2^5 - Very Big};

- α3 – Volatility in term-set of T(α3)={α_3^1 - Very Low; α_3^2 - Low; α_3^3 - Medium; α_3^4 - High; α_3^5 - Very High};

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- α4 – Capitalization, which has a term-set T(α4)={ α_4^1 - Very Low; α_4^2 - Low; α_4^3 - Medium; α_4^4 - High; α_4^5 - Very High};

- α5 – The price of oil, which has a term-set T(α5)={ α_5^1 - Very Low; α_5^2 - Low; α_5^3 - Medium; α_5^4 - High; α_5^5 - Very High};

Figure. 4-8 shows the results of determination by experts and the results of entering the LVs, FVs and their membership functions:

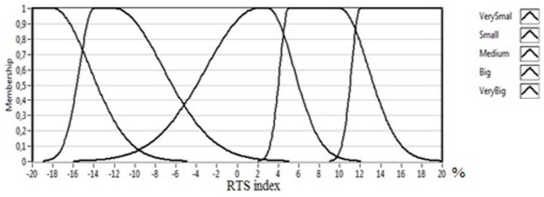

Figure. 4. The Membership Functions Of The Linguistic Variable α_1 – RTS Index

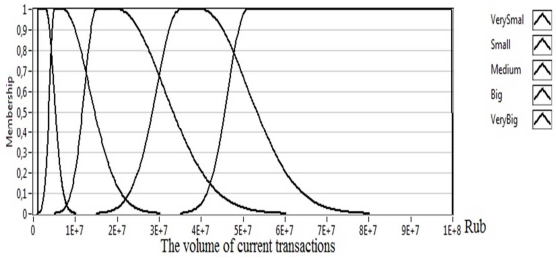

Figure. 5. The Membership Functions Of The Linguistic Variable α_1 – The Volume Of Current Transactions

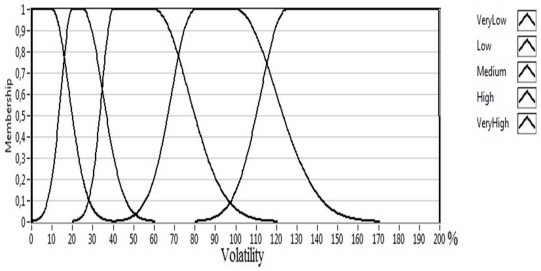

Figure. 6. The Membership Functions Of The Linguistic Variable α_1 – Volatility

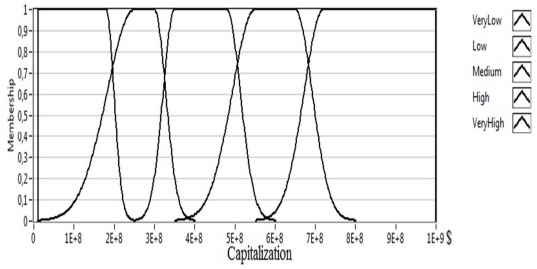

Figure. 7. The Membership Functions Of The Linguistic Variable α_1 – Capitalization

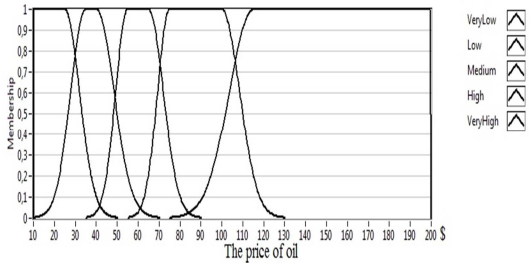

Figure. 8. The Membership Functions Of The Linguistic Variable α_1 – The Price Of Oil

In the proposed example we give parameters for the five of the standard fuzzy situation of the stock market:

- $\tilde{S}_1^*$ ={<<0/VerySmall>, <0,3/Small>, <0,6/Medium>, <0,8/Big>, <1/VeryBig>/ *RTS index* >, <<0/VerySmall>, <0,2/Small>, <0,7/Medium>, <0,8/Big>, <1/VeryBig>/ *The volume of current transactions*>, <<1/VeryLow>, <0,5/Low>, <0,2/Medium>, <0/High>, <0/VeryHigh>/ *Volatility* >, <<0/VeryLow>, <0,1/Low>, <0,3/Medium>, <0,7/High>, <1/VeryHigh>/ *Capitalization* >, <<0/VeryLow>, <0,2/Low>, <0,6/Medium>, <0,8/High>, <1/VeryHigh>/ *The price of oil* >}.

- $\tilde{S}_2^*$ ={<<0,1/ VerySmall >, <0,4/Small>, <0,8/Medium>, <1/Big>, <0,6/VeryBig>/ *RTS index* >, <<0,7/ VerySmall >, <1/Small>, <0,7/Medium>, <0,2/Bigh>, <0/VeryBig>/ *The volume of current transactions*>, <<0,1/VeryLow>, <0,6/Low>, <1/Medium>, <0,6/High>, <0,1/VeryHigh>/ *Volatility* >, <<0/VeryLow>, <0,1/Low>, <0,6/Medium>, <1/High>, <0,7/VeryHigh>/ *Capitalization* >, <<0,1/ VeryLow >, <0,6/Low>, <1/Medium>, <0,6/High>, <0,1/VerHigh>/ *The price of oil*>};

- $\tilde{S}_3^*$ ={<<0/ VerySmall >, <0/Small>, <0,2/Medium>, <0,8/Big>, <1/VeryBig>/ *RTS index* >, <<0/ VerySmall >, <0,2/Small>, <0,5/Medium>, <0,8/Big>, <1/VeryBig>/ *The volume of current transactions*>, <<0,8/ VeryLow >, <1/Low>, <0,5/Medium>, <0/High>, <0/VeryHigh>/ *Volatility* >, <<0,2/VeryLow>, <0,6/Low>, <1/Medium>, <0,7/High>, <0,3/VeryHigh>/ *Capitalization* >, <<0/ VeryLow >, <0,1/Low>, <0,5/cMedium>, <1/High>, <0,8/VeryHigh>/ *The price of oil*>};

- $\tilde{S}_4^*$ ={<<0,9/ VerySmall>, <0,7/Small>, <0,3/Medium>, <0/Big>, <0/VeryBig>/ *RTS*

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index >, <<0,8/VerySmall>, <1/Small>, <0,5/Meduim>, <0,1/Big>, <0/VeryBig>/ *The volume of current transactions*>, <<0/ VeryLow >, <0/Low>, <0,2/Medium>, <0,7/High>, <1/VeryHigh>/ *Volatility* >, <<0,3/ VeryLow >, <0,7/Low>, <1/Medium>, <0,5/High>, <0,1/VeryHigh>/ *Capitalization* >, <<0,3/ VeryLow >, <1/Low>, <0,5/Medium>, <0,1/High>, <0/VeryHigh>/ *The price of oil*>};

- $\tilde{S}_5^*$={<<1/VerySmall>, <0,9/Small>, <0,1/Medium>, <0/Big>, <0/VeryBig>/ *RTS index* >, <<0,5/VerySmall>, <0,8/Small>, <1/Medium>, <0,5/Big>, <0,1/VeryBig>/ *The volume of current transactions*>, <<0/ VeryLow >, <0,2/Small>, <1/Medium>, <0,7/High>, <0,5/VeryHigh>/ *Volatility* >, <<1/ VeryLow >, <0,7/Low>, <0,3/Medium>, <0/High>, <0/VeryHigh>/ *Capitalization* >, <<1/ VeryLow >, <0,7/Low>, <0,2/Medium>, <0/High>, <0/VeryHigh>/ *The price of oil*>}.

The number of these standard fuzzy situations of the stock market can be more.

The decision-making for the state of the stock market going by the rules:

- h1 - if the real fuzzy situation is close to the first standard fuzzy situation $\tilde{S}_1^*$, then the current state of the stock market - stable;

- h2 - if the real fuzzy situation is close to the second standard fuzzy situation $\tilde{S}_2^*$, then the current state of the stock market - transitional;

- h3 - if the real fuzzy situation is close to the third standard fuzzy situation $\tilde{S}_3^*$, then the current state of the stock market - growth;

- h4 - if the real fuzzy situation is close to the fourth standard fuzzy situation $\tilde{S}_4^*$, then the current state of the stock market - unstable;

- h5 - if the real fuzzy situation is close to the fifth standard fuzzy situation $\tilde{S}_5^*$, then the current state of the stock market - stagnation.

Figure. 9 shows the result of input the standard fuzzy situations.

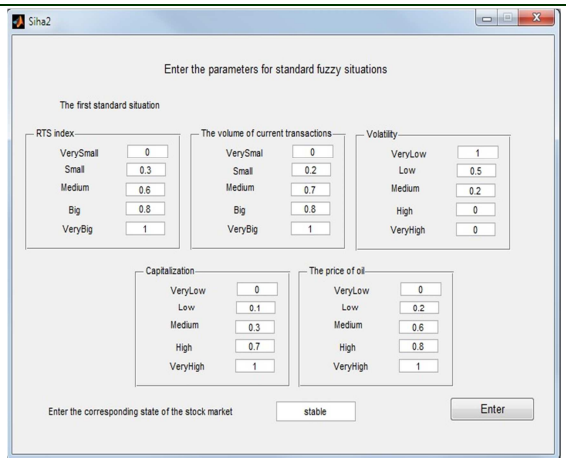

Figure. 9. Detail Of The Result Of Input Of Standard Fuzzy Situation

The next step is work with the interface of user; the user must enter the measured values for parameters of the characteristic factors for the RTS index, volume of transactions, the volatility, capitalization, oil prices. The measured values are in form of the basic set and have membership degrees of fuzzy variables. Figure. 10 shows the result of entering values of the characteristic factors.

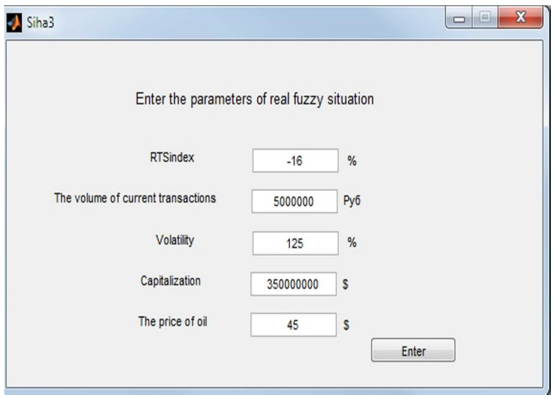

Figure. 10. The Specific Values For Parameters Of The Real Situation

The membership function of fuzzy sets $\tilde{C}(\alpha_i^j)$ for parameters is carried out according to the formula:

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$$f(x;a,b,c,d)=\begin{cases}0, & x\le a\\ 2\left(\frac{x-a}{b-a}\right)^2, & a\le x\le\frac{a+b}{2}\\ 1-2\left(\frac{x-b}{b-a}\right)^2, & \frac{a+b}{2}\le x\le b\\ 1, & b\le x\le c\\ 1-2\left(\frac{x-c}{d-c}\right)^2, & c\le x\le\frac{c+d}{2}\\ 2\left(\frac{x-d}{d-c}\right)^2, & \frac{c+d}{2}\le x\le d\\ 0, & x\ge d\end{cases} \quad (2)$$

Figure. 11 shows the results of the membership function values for the real fuzzy situation after the user enters the parameters of the characteristic factors (see. Figure. 10).

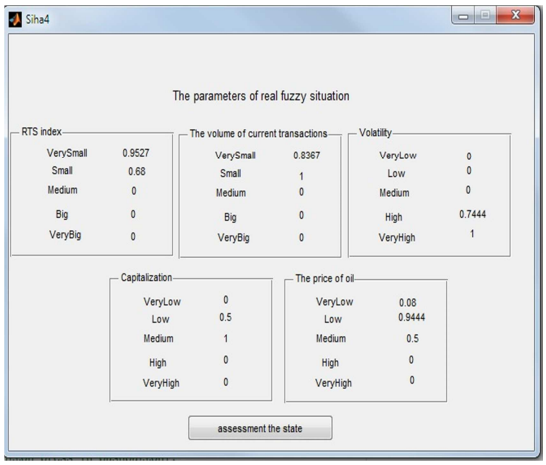

Figure. 11. The Values Of Membership Function For The Real Fuzzy Situation

The real fuzzy situation is determined by the set:

$\tilde{S}$ ={<<0,9527/VerySmall>, <0,68/Small>, <0/Medium>, <0/Big>, <0/VeryBig>/*RTSindex*>, <<0,8367/VerySmall>, <1/Small>, <0/Medium>, <0/Big>, <0/VeryBig>/ *The volume of current transactions* >, <<0/VeryLow >, <0/Low>, <0/Medium>, <0,7444/High>, <1/VeryHigh>/ *Volatility* >, <<0/VeryLow>, <0,5/Low>, <1/Medium>, <0/High>, <0/VeryHigh>/ *Capitalization* >, <<0,08/VeryLow>, <0,9444/Low>, <0,5/Medium>, <0/High>, <0/VeryHigh>/ *The price of oil* >}.

The expert identifies and enters the fuzzy threshold equality of real and standard fuzzy situations, such as (0.6) and presses the button «assessment the state» to assess the state of the stock market.

The program defines the close degree $\mu(\tilde{S}_i,\tilde{S}_j^*)$ for real fuzzy situation and each of the standard fuzzy situations and forms the current state of the stock market, as shown in Figure. 12.

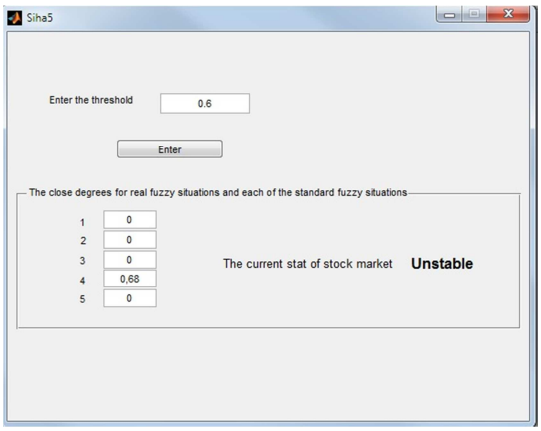

Figure. 12. The Output Of The Current State Of The Stock Market

6. CONCLUSIONS

In this article we proved the importance of assessing the current state of the stock market. This study has the following features: gave a set of characteristic factors and define their linguistic (verbal), gave the states of the stock market: stable; transition; growth; unstable and stagnation, experts define linguistic and fuzzy variables and also the membership functions of fuzzy variables to describe the state of the stock market, assessing the current state of the stock market is carried out using the model of situational analysis, experts determine the standard fuzzy situations, the real values of characteristic factors are measured and identified the real fuzzy situation of the stock market and the program gives the result of belonging the current state of the stock market to one of the states of the stock market: stable; transition; growth; unstable and stagnation. Thus, according to the results it is possible to conclude that the problem of determining the state of the stock market was solved in the condition of incomplete input data.

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