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Article · June 2010

DOI: 10.1109/ITSIM.2010.5561564

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Decision Making Using Fuzzy Logic for Stock Trading

Decision Support Sytem and Fuzzy Logic

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Abstract— **This paper presents the Fuzzy IF-THEN Rules for a decision support system in stock trading. The three following linguistic variables will be the input for the rule. There are; view from the expert, earning-per-share and price to earnings ratio. The purpose of this rule is to assist the investors during making a decision on their share. The investors need to make a right decision to gain a high profit in stock trading. Stock market is one of complex environment. Therefore by using this Artificial Intelligence (AI) application which is Fuzzy Logic (FL) can make it simpler as well as gives benefits to investors. Most of the earlier research works show that FL can work within stocks environment. All the fuzzy rules have been evaluated by using Fuzzy Inference System in MATLAB.**

Keywords- Fuzzy Logic, Fuzzy IF-THEN Rules, Decision Support System, Stock Trading

I. INTRODUCTION

The world of business is not only complex and competitive, but contains various multiple tasks. Most of the business organizations today have required using information technology (IT) application to improve their operational efficiency, product and service quality [1]. It shows IT becomes one of the important parts in business environment. Recently, there are many applications that have been applied to the business environment. One of the examples is the emergence of e-commerce. E-commerce becomes an acknowledged development in business as it is user friendly and provides many advantages to people. It makes the business process easier, faster, convenient and more effective. It is believed that by widening the application of information technology to another business area, such as stock market, it will provide an opportunity to investigate this field with an alternative perspective.

Stock market is the most popular investment places because of its expected high profit [2]. It can be categorized as one of the complex business environment. It is because the value of stock is constantly changing and the investors always need the update. The patterns of price are unpredictable so the investors need to be wise in their strategies of investment. They need to make a right decision before taking any action with their stock.

Based on the situation that mentioned above we can conclude it to a simple problem statement. In this problem those who are involved in stock trading always need to know the latest update of stock value. It is because the value is changes continuously. After get the update they have to make a decision about what they should do with the stocks. The decision must give a lot of advantages to them. In this case, investors with a lack of experience in stock trading always made a mistake while deciding to buy or sell the stocks. It is very important to all investors to make a good decision to gain a high profit or not to lose too much. Therefore the purpose of this study to provide a decision making rule for buying and selling share in stock market in order to help them make a right decision. Below are the objectives of this research.

- To develop an algorithm based on fuzzy rules for decision support system of stock trading.
- To form a set of fuzzy rules based on real stock data and expert knowledge.
- To provide a recommendation of decision-making for selling and buying stock.

Meanwhile, for this paper we only discus about the decision making process using fuzzy IF-THEN rules. Based on the general IF-THEN rule we come out with the decision rules with the expert opinions and the pattern of stock data as a knowledge base. This part will be explained further in section 4.

The remainder of this paper is organized as follows. Section 2 previews prior related works on decision support system for stock market based on fuzzy logic rules. After that, section 3 describes more detail about fuzzy logic and its theorems. Then, section 4 discusses the decision making in stock trading. Finally, conclusions are drawn in sections 5, which also mention future areas of investigation.

II. LITERATURE REVIEW

There is a great deal of literature to describe a decision support system that applied fuzzy logic as its knowledge based. There also shows that about stock market as a complex

environment that need an expert system to work within it. As a result it would appear that in recent years, decision making in stock market have become a popular issue among researchers and there are many related projects.

A. *Decision Support System*

Decision support system (DSS) is the computer technology solutions that can be used to support complex decision making and problem solving [3]. DSS has been made to assist decision-makers that always deal with many kinds of problem. J. P Shim in their paper proposed a Decision-making process model as shown in figure 1 below.

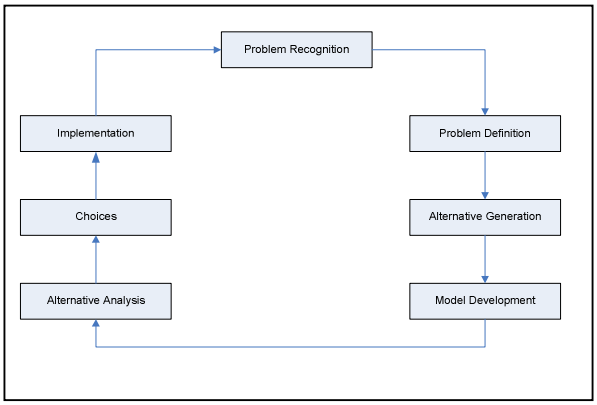

Figure 1. Decision making process model [3].

Chang-Shing Lee et al. in their paper proposed An Intelligent Fuzzy Meeting Agent for Decision Support System. This system contains three subagents to perform the intelligent meeting scheduling support task. There are 1) Meeting Negotiation Agent (MNA) 2) Fuzzy Inference Sample (FIA) and 3) Genetic Learning Agent. These three agents are work together to compute the result. The FIA and GLA assist the meeting host in holding the meeting while the MNA gathers the meeting member's names from meeting host and send them back to FIA [4]. Furthermore, the rapid development of the intelligent agent and multi-agent technology in the domain of distributed artificial intelligence has brought a new deep research of distributed decision support system [4].

B. *Fuzzy Logic in Stock Trading*

A research by [5] entitled Fuzzy Logic Based Stock Trading System study about the fuzzy expert system for decision making support in stock trading based on human skills. The objective of this study was to build and evaluate a human skill based decision support system for trading process using soft computing methods [5]. They used the fuzzy technique to form the decision -making algorithm. It is based on combination of stock trading data basis and expert's knowledge. Both expert knowledge and stock data were formulated in terms of fuzzy variables then converted into a set of fuzzy rules. Based on the experiments the result was achieved the objective of the study.

Another important issue in the stock trading is stock prediction. Stock prediction is very important to the investors as it actually determines timing of buying and selling the stock. The complexity of the stock market gives people difficulty to make a prediction. Therefore there was a research made by Y. F Wang entitled prediction stock price using fuzzy grey prediction system that studies about this issue. The purpose of this study is to predict the stock price instantly by using a combination of fuzzification techniques and grey theory [6]. Additionally, a study by Hiemstra, Y also concerning about stock prediction. Title of the research is stock market forecasting support system based on fuzzy logic. In this paper the author introduce architecture of fuzzy logic forecasting support system. They choose to use fuzzy logic because it the most appropriate methods for their research goals. The goals are 1) define and store knowledge to predict the stock market, 2) model vagueness and imperfection to the knowledge and 3) provide a declarative, interactive and explanatory prediction [7].

Besides that another previous work that related work the stock market and fuzzy logic is a study by Doura, H. et. al entitled investment using technical analysis and fuzzy logic. This work is applied fuzzy informational technologies to investment through technical analysis. It simulates human behaviour in stock trading such as the reaction about stock price movement and formation as well as buy/sell recommendation [8]. The result of this work is very impressive as it already tested in various companies. As a conclusion, based on the discussion above it shows that fuzzy logic is an appropriate method to deal with the complexity of stock market. It can be used in decision-making and forecasting stock price as well as strategies for a better investment.

III. FUZZY LOGIC

A. *Definition*

Fuzzy Logic is a superset of conventional logic that has been extended to he concept of partial truth which is the truth values between "completely true" and "completely false" [9]. It was introduced by Dr. L. A. Zadeh of UC/Berkely in the 1960's as means to model the uncertainty of natural language. Basically fuzzy logic has been applied in the fuzzy expert system. Fuzzy expert system can be defined as an expert system that uses a collection of fuzzy membership functions and rules instead of Boolean logic to reason about the data. The set of rules in a fuzzy expert system is commonly known as the rule base or knowledge base.

B. *Fuzzy Logic IF-THEN Rules*

According to Simutis, the relationship between input and output for stock trading can be written in IF-THEN fuzzy rules as follows [10]:

$$A^{(l)} : IF\, x_l\ is\, P_l^l\, AND...., AND\, x_n is Q_n^l\, THEN\, y\, is\, R^l$$

Where P_l^l is the fuzzy sets for input with elements $x = \{x_1, x_{2,} ....x_n\}$. A fuzzy set x is a membership function which maps each point in x onto the real interval [0.0, 1.0]. This is based from one of the definition of the fuzzy expert system which defined fuzzy expert system is a truth values for the membership values in the fuzzy sets. The value is indicated by a value on the range [0.0, 1.0] where 0.0 means absolute falseness and 1.0 representing absolute truth. Otherwise y is the output variables and its term is denoted by R^l .

IV. STOCK TRADING DECISION MAKING

The only thing that people want to achieve when involve in stock world. It is to obtain the high profit. Therefore they must have a good strategy in order to complete their aim. Most of the expertises suggest the perfect time to buy is during the stock price was low and otherwise [11]. This strategy was called as "buy low" and "sell high" [11]. However if the stock price is continuously low and finally drop, it will never give the investors achieve their plan. For that reason those who are interested occupy in stock market must have a basic knowledge about the history of the company or share they want to join into.

A. Buying and Selling Rule

There are 3 linguistic variables that will be used in the buying and selling rule; 1) expert opinion (E/O), 2) earnings per share and 3) price to earnings ratio.

- Views from the expert indicate that if the price is low then buy the stock otherwise sell the stock.
- Earning per share (EPS) shows that if the EPS is big then buy if not don't buy. It can be determined by using the formula net earnings divided by outstanding shares.
- Based on price per earnings ratio (P/E) buy the stock when it high and sell when it low. The calculation to get the value is P/E = Stock Price / EPS.

As a result the variables of all input are :

- E/O with terms LOW (L) and HIGH (H)
- EPS with terms BIG (BG) and SMALL (SM)
- P/E with term HIGH (HG) and LOW (LW)

These three inputs have been chosen because they play a major role as an indicator of company profitability. EPS refer to a profit on how much the net profit of the company is producing [12]. Experts said, it is better when the ratio is higher as the value of the share will increase [12]. In addition P/E is important to determine the amount that investors willing to pay for earnings as well as in general P/E may affect the growth of the company in future.

Since the main purpose is to determine whether the investors should buy or sell the stock, so the output must be the outcome after we conclude all the possibilities above. Then the variables for the output are:

Buying or selling recommendation (R) with terms STRONG BUY (STB), BUY (B), HOLD (HD), STRONG SELL (STS) and SELL (S). These recommendations based on the basic action that the investors will do in the stock trading activity. This recommendation has been denoted from a previous work [5] and they were a very suitable recommendation for stock trading.

B. Evaluation

Consider a very simple scenario. There are two company namely; company A and B. Both companies earn $1000. Company A has 110 shares outstanding otherwise company B has 150 shares outstanding. The share prices for the companies are $80 and $100 respectively. And the issue now here, which one of the company is most suggested to invest in.

The function of the rules above is to recommend user which one of the company they should own. Definitely investors want to invest to the company that will give them profits in return. So, here are the calculations:

x and y are member of set EPS and P/E respectively. Then let set EPS = X and set P/E = Y with

x is an object for set X, X (x); then X = {x}

y is an object for set Y, Y (y); then Y = {y}

While for company B, a and b are the member set of EPS and P/E. Let's assume that set EPS and P/E for company B are A and B. So we can say

a is an object for set A, A (a); then A = {a}

b is an object for set B, $B(b)$; then B = {b}

For company A, what should the investor do after know the info. Fuzzy set X and Y are characterized by a membership function $\mu_x(X)$ and $\mu_y(Y)$ that mapped each point to X onto the real interval [0.0, 1.0].

Now we use the Rule for the EPS. First we calculate the EPS, after that the P/E.

i. Company A

EPS = Net earnings / Outstanding shares

EPS = 1000 / 110

= 9.091

P/E = Stock Price / EPS

P/E = 80 / 9.091

= 8. 799

ii. Company B

EPS = Net earnings / Outstanding shares

EPS = 1000 / 150

= 6.667

P/E = Stock Price / EPS

P/E = 100 / 6.667

= 14.99

After we calculate all the related value, we can find the probabilistic result. However, before that we must know the probabilistic value for the output of the rules in term of real interval [0.0, 1.0]. Expert opinion stated when the price is low we buy and sell when it high. Figure 2 represent the parameter for EO membership function whether low or high. For the EPS rules, if the value approaches 0.0 it representing SMALL otherwise BIG when it approaching 1.0 as shown in figure 3. Figure 4 designate that the value is LOW when it approaching 0.0 and HIGH when the value near to 1.0.

The more the value approaching value 1.0 the strongest the membership function in the rules. In the output membership functions, the output is strong sell when the value approaching 0 and 1.0 when it near to 1. Figure 5 shows the parameter for all the possible output.

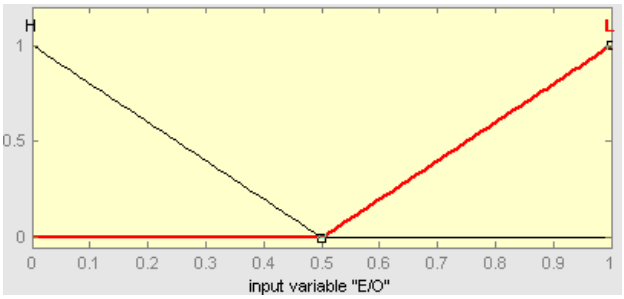

Figure 2. Parameter of the membership function for input variable E/O

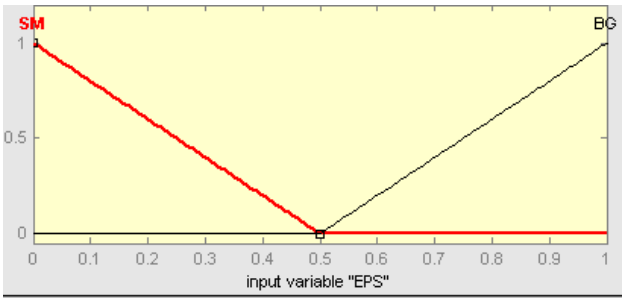

Figure 3. Parameter of the membership function for the input variable EPS

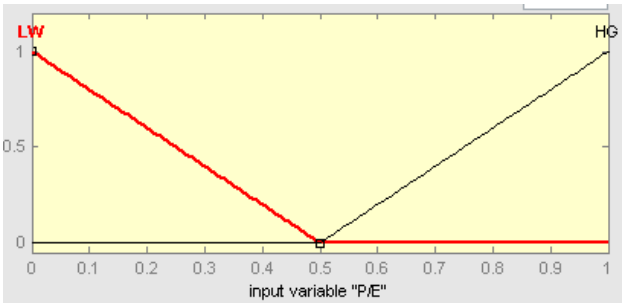

Figure 4. Parameter of the membership function for input variable P/E

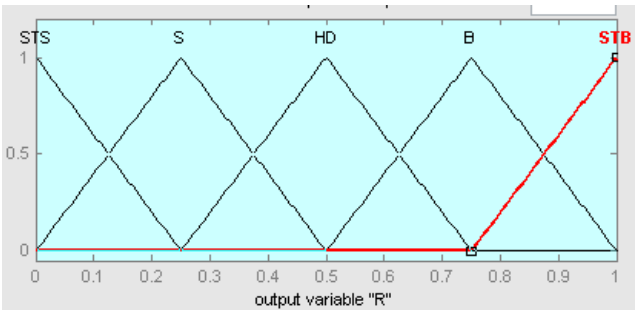

Figure 5. Parameter of the membership function for output variable

Back to the calculation above, since the value of the membership function in real interval, the result for the EPS and P/E must be convert to the real number in [0.0,1.0] interval. Therefore we get a company A with the characteristic (E/O, EPS, P/E) = (1.0, 0.9091, 0.8799) which E/O is L , EPS is BIG and P/E is LW. It can be write in IF-THEN rule as follow :

IF E/O is L AND EPS is BIG AND P/E is LW

The evaluation has been made by using Fuzzy Inference System (FIS) in MATLAB 7.1. Similar with the general fuzzy if-then evaluation formula, in FIS AND method is min, OR method is max and implication method is min. Figure 6 below show the result of the recommendation. Based on the output the value is R= 0.75 which mean buy. Now we can come out with a complete fuzzy rule for company A

IF E/O is L AND EPS is BG AND P/E is LW THEN R is B

Figure 6. Recommendation for company A.

The next example is what the investor should do with the company B. based on the previous calculation we get company B with characteristic (E/O, EPS, P/E) = (0.0, 0.667, 0.1499). Thus, the IF-THEN rule is

IF EO is H AND EPS is BG AND P/E is LW

Then the result in figure 7 indicate R=0.454. The value is approaching 0.5 which means Hold. For that reason the if-then rule for company B is

IF EO is H AND EPS is BG AND P/E is LW THEN R is HD.

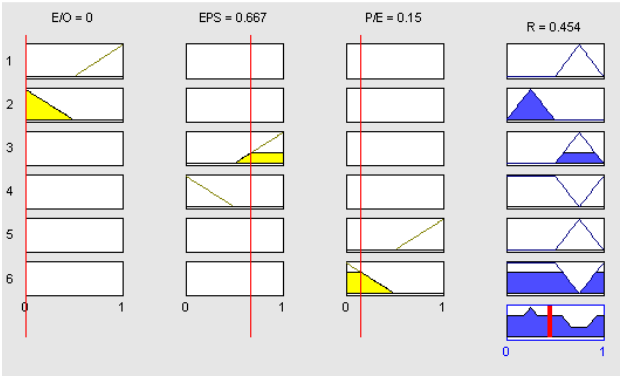

Figure 7. Recommendation for company B.

C. *Comparison*

Based on the evaluation that has been made in the previous section, there are a few criteria that the author can compare with others. Based on H. Dourra et. al they evaluate the stock performance based on investor risk, stock's price long term trend and volatility of the stock [13]. There are also another works that deal with decision making in stock but conceive another criteria in the stock trading. In Simutis [10] paper the author have five criteria to make a fuzzy rule for the decision making in stock trading. There are the price error factor, opinion from the expertise, general market direction and stock market moving direction. The author combines all these factors to come out with a set of fuzzy rule. As conclusion different systems uses different variables and give a good recommendation to the user.

D. *Discussion*

From the previous evaluation we can see that based on the rule people are suggested to invest in company A rather than company B. However the recommendation is actually useful to the investor who already owns the share of company B. Because it is a suitable time to sell share in company B and buy share in company A. Both actions are actually giving benefits to the investors.

According to the evaluation and the comparison that has been done we may conclude that, every recommendation give a lot of benefits to the investors. There are a lot of possible rules that will be form based on assorted input. Nevertheless it is just a recommendation and depends to the investors to follow or not.

It is because each investor has their strategy of investment. Besides that we also verify all the proposed rules using Fuzzy Inference System (FIS) in MATLAB 7.1. Figure 3 is the overview of the process to verify the rule using FIS.

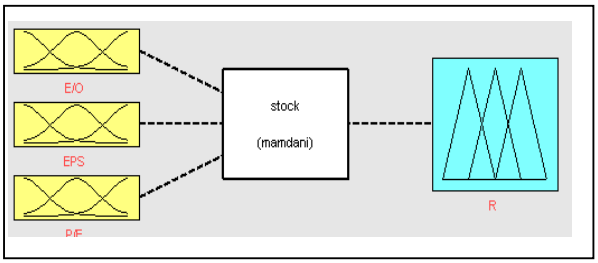

Figure 8. Input and Output in FIS MATLAB 7.1

V. CONCLUSION AND FUTURE WORK

This article is a part of the main project which studies a decision support system using fuzzy logic for stock trading in multi-agent system (MAS). In fact during this study we just build a framework not an entire system. The literature review presents numerous of previous work concerning fuzzy rule in decision making process. Therefore in future we hope can enhance the fuzzy if-then rule by using more input variable in order to make it more efficient and precise. Other than that it would be a good effort if we can develop a functional system by using this fuzzy rule.

ACKNOWLEDGMENT

The author(s) would like to thank everyone who involved in the making of this paper. All your cooperation is sincerely appreciated.

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