A Fuzzy Approach to Stock Market Timing

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***Abstract*—To determine the buy and sell time is one of the most important issues for investors in stock market. In this paper, a fuzzy approach to stock market timing is investigated. A fuzzy decision system is constructed based on experiences and techniques of stock and future opportunist. The fuzzy rules are optimized by taking exchange volume into account for better fitting the stock market of mainland China. Simulations are conducted to some well-known stocks in China's A-share market, and the simulation result reveals that the proposed method has desirable performance in a rapid change market.**

Keywords- fuzzy logic, timing, A-share stock market

I. INTRODUCTION

One of the most important problems that stock market practitioners have to face is to determine when to buy and sell stocks. To solve this problem, people need to follow a simple rule "Buy low and then sell high". Unfortunately, it is difficult to predict the price movement of the stock well, because the stock prices are affected by a number of known as well as unknown economic factors and emotions of human investors. As a result, it's hard to determine when the price is high and when the price is low.

On the other hand, stock chart patterns tend to repeat themselves [1]. The players in stock market are always human. Though they change generation by generation, the basic thinking and behavior mode of human being still keeps similar. This means that knowledge from historical figures can be applied to nowadays market [2]. Recent research suggested that it is possible to construct trading system by fuzzy logic and technical analysis indicators [3, 4, 5].

In this paper, an efficient approach to building a stock timing system with fuzzy logic is proposed. The rule base of the fuzzy engine is constructed from the experiences and techniques of trading in the stock and commodity markets by Jesse Livermore, a great stock trader in the early 20th century. These experiences and techniques are fuzzy in nature, since they are linguistic description of stock and futures markets without too precise numbers.

Owing to the advantages of fuzzy logic, these experiences and techniques can be translated into the IF-THEN form, and thus can be applied to the fuzzy expert system that provides precise timing decisions. Simulation is conducted to evaluate the earning capacity of the fuzzy expert system in China's A-share market.

The rest of this paper is organized as follows. Section II introduces the aforementioned experiences and techniques of stock market and how to represent them using fuzzy logic. Section III gives the simulation result when applying this fuzzy expert system to mainland china A-share stock market and conclusions are drawn in Section IV.

II. FUZZY APPROACH TO STOCK MARKET TIMING

A. Experiences and Techniques

Since human investors react in a more or less rational manner to similar situations, similar characteristics and trends can be found in market price. Although this is not sufficient to predict the price precisely, the trend has more probability to be distinguished [6].

The price of a stock oscillates within an interval before it determines its own direction [7]. An upward breakout means the price of this stock begins to rise while a downward breakout means the price begins to fall. Furthermore, research on the volume-volatility relationship exposes that there is a positive correlation between these two variables [8]. Empirical knowledge reveals that a real upward breakout normally occurs with large exchange volume. IF-THEN rules can be constructed based on the above knowledge: IF an upward breakout happens with large exchange volume, THEN a buy signal appears; IF a downward breakout happens, THEN a sell signal appears.

In a bullish market, your game is to keep buying stocks until the trend tends to over [7]. Because when investors sell the stock, it's hard to determine when to buy it again. This is also true in a bearish market that the best strategy is to sell the entire stock then wait until some evidence implies that the bearish period is over. Similarly, another set of IF-THEN rules can also be constructed from such knowledge: IF it's a bullish (bearish) market, THEN buy (sell).

B. Representing Experiences and Techniques with Fuzzy Logic

Fuzzy expert system is a general system for performing approximate reasoning. It can be formally defined as a mapping from an input space to an output space by making use of a set of IF-THEN conditional statements or rules [9]. In what follows, the procedure of constructing the fuzzy expert system is discussed, which includes mainly the fuzzification of input variables, the construction of numerical rule base and the generation of timing decision.

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1) Fuzzification

The fuzzification subsystem consists of three parts: short term price breakout, short term exchange volume charge and long term price trend.

The percentage of the short term price upward or downward penetrating the oscillation interval is calculated. The oscillation interval for the i^{th} day is defined between the minimum price and maximum price in $(i\text{-}18)^{th}$ to $(i\text{-}3)^{th}$ day. The fuzzification method of short term price is demonstrated in Fig.1. The stock price at the i^{th} day, if it is 10% (5%) higher than the highest point of the interval, means a strong (weak) upward breakout occurs; while the price at the i^{th} day if it is 10% (5%) lower than the lowest point of the interval means a strong (weak) downward breakout occurs. The price at the i^{th} day in the interval means the price still oscillates.

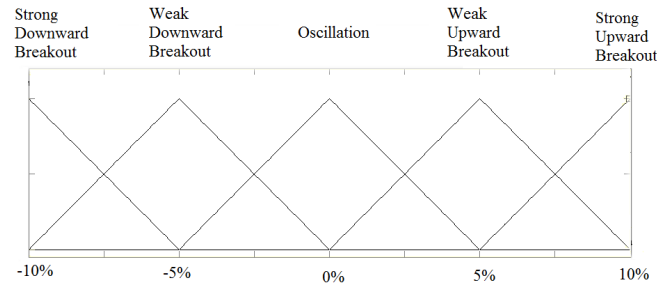


Figure 1. Membership functions of short term price change

The difference between the exchange volume at the i^{th} day and the 15 days moving average of exchange volume is calculated. Fig. 2 illustrates the membership functions for fuzzification.

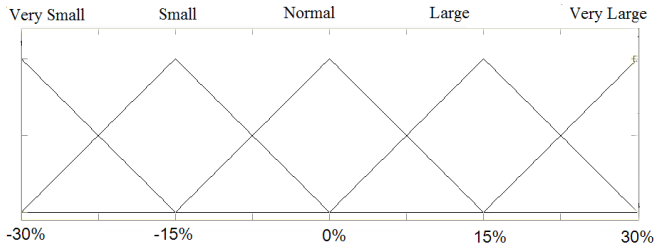


Figure 2. Membership functions of exchange volume change

Long term history price data is used to determine whether the market is bullish, bearish or in common state. To prevent the system from making wrong decision, 10 days moving average (*MA10*) of stock price is used here. Forgetting factor (0.98) and the days from a local (200 days moving window) maximum (*D_Max*) or minimum (*D_Min*) to nowadays can be applied to represent the fact that the bullish or bearish market will disappear as time goes on. The proposed method computes the oscillator *bob(i)* for the i^{th} day as

$$bob(i) = 0.98^{D\_Max(i)} \times \frac{MA10(i) - global\_Max}{global\_Max} + 0.98^{D\_Min(i)} \times \frac{MA10(i) - global\_Min}{global\_Min} \quad (1)$$

In a bullish market *bob(i)* should be larger than 0.05 while in a bearish market it should be smaller than -0.05. These two values are determined empirically. Standard triangle membership function is applied for the fuzzification of *bob(i)*.

2) Rule base

Corresponding to 3 kinds of market trend, i.e. bullish, bearish and common, which classified by *bob(i)*, three sub-rule bases are developed to construct the whole rule base for the proposed fuzzy system. They are generated mainly based on the aforementioned IF-THEN rules which abstracted from the experiences and techniques.

These sub-rule bases are under numerical form in which positive or negative sign means that the rule suggests buying or selling stock respectively and the absolute value represents the strength of the suggestion.

- For the bullish market, the strategy is to buy and keep. Therefore, all numerical values in this sub-rule base are 2.
- For the bearish market, the strategy is to sell and wait. As a result, all numerical values in this sub-rule base are -2.
- For the market which does not have significant characteristic of bullish or bearish, the sub-rule base is as the rule table demonstrated in Table I.

TABLE I. RULE TABLE FOR COMMON MARKET

Suggestion		Short Term Price Change				
		-10%	***-5%***	***0%***	***5%***	***10%***
Short Term Exchange Volume Change	***-30%***	-2	-1	0	0	0
	-15%	-2	-1	0	0	0
	0%	-2	-1	0	1	1
	15%	-2	-1	0	1	2
	30%	-3	-2	0	2	2

3) Defuzzification

Minimum operation and COG (Center of Gravity) algorithm are applied to the defuzzification part of the proposed fuzzy expert system. After defuzzification, suggestions to buy, sell or keep are generated. The system makes decision based on its position of the stock and the suggestions generated by the fuzzy engine.

III. SIMULATION RESULT

The performance of the fuzzy expert system is evaluated by conducting simulation on five stocks in china's A-share market. The performances of the proposed system are compared with technical analysis oscillators and buy and hold strategy. In addition, the proposed system with different rules and membership functions is also investigated.

A. *Data Description*

The data used in simulation is daily closing prices and daily exchange volumes of five stocks. The basic information of these stocks, including stock code, name, number of samples (one day for one sample) and the first day, are listed in Table II. The last day of the simulation period, 2009-May-18, is the same for all the five stocks.

TABLE II. BASIC INFORMATION OF STOCK DATA

Code	Stock Name	Samples	Beginning
000002	VANKE-A	1224	2004-03-02
000651	GREE	1232	2004-03-02
002202	GOLDWIND	331	2007-12-26
600000	S/PUDONG DEV BANK	1212	2004-03-02
601918	SDIC XINJI	290	2007-12-19

B. *Transaction Cost*

To simulate a real business environment, exchange fee is deducted in each buy or sell action during the simulation. The transaction cost rate is set as 0.0025, which is consisted of tax 0.001 and commission fee 0.0015.

C. *Performance*

Table III shows the simulation results of the proposed system, buy and hold strategy and oscillator trade systems. The percentages in Table III are the total profit obtained by the corresponding trade system during the simulation period on the specified stock. Under the buy and hold strategy, the stocks are bought in the first day and are sold in the last day.

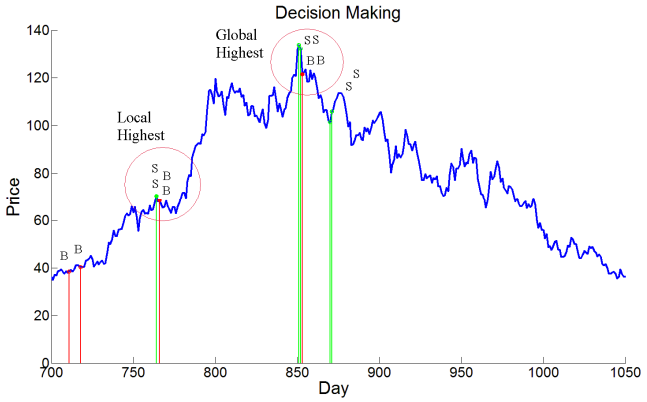
In the ROC (Rate of Change) trading system, six days moving average is used and the observation period is 12. Buy (sell) signal appears when ROC is larger (smaller) than 0. In the MACD (Moving Average Convergence Divergence) trading system, period parameters are set to be default values 12, 26 and 9. Buy (sell) signal is generated when MACD line is larger (smaller) than zero. In the RSI (Relative Strength Index) trading system, observation period is 12 days. When RSI becomes larger (smaller) than 20 (80), buy (sell) signal appears. For more details of these oscillators, see [12].

TABLE III. PERFORMANCE OF THE FUZZY SYSTEM

Stock Code	Proposed System	Buy and Hold	ROC	MACD	RSI
000002	1650.46%	714.52%	148.0%	139.6%	1.1%
000651	523.78%	1016.40%	200.3%	112.3%	28.6%
002202	62.12%	-28.64%	3.5%	-20%	-25.4%
600000	740.40%	333.58%	76.2%	-24%	57.8%
601918	132.29%	11.32%	121.5%	80.6%	-9.2%
Average	621.81%	409.44%	109.89%	77.13%	10.56%

From Table III, the average profit obtained by the proposed system is about 50% higher than the buy and hold strategy. Only for one stock, code 000651, the profit obtained by the system is lower than the buy and hold strategy. The reason may come from the large variance of the stock price, which makes the *bob*(*i*) value not able to represent the real situation of this stock.

(a) Part of decisions made by the system using the original rules



(b) Part of decisions made by the system using the changed rules

Figure 3. Decision making on 000002

A possible solution of this problem is to decrease the sensitivity of the membership functions of *bob(i)*. That is *bob(i)* should be larger than 0.15 instead of 0.05 to represent that the market is bullish while it should be smaller than -0.15 instead of -0.05, to represent that the market is bearish. With such an adjustment, the profit obtained by the system on this stock (000651) increases to 1121.59%.

Furthermore, after checking the timing decisions of the proposed system, we find that the system cannot locate the best trade price for sell. Fig. 3 (a) illustrates part of decisions made by the proposed system with original rules on 000002. In this figure, symbol "B" stands for "buy" and "S" for "sell". It is easy to notice that the selling action does not operate at the highest point.

To solve this problem, the rule base needs to be adjusted. Some experimental knowledge provides a possible solution to this problem. The rule base is changed according to such an observation: in a bull market the highest price is normally achieved when the exchange volume is small while the price is still rising.

Fig.3 (b) illustrates that after the rule base is changed, the system can find higher points to sell. But the total profit still declines a little, about 10%. Similar results are obtained in the simulation of other four stocks. This phenomenon implies that even though the system can find a higher price, it still cannot determine whether it is a local highest price or a global highest price. The system will buy the stock back soon after selling it, which leads to more frequent trade actions and thus the total profit cannot be increased.

IV. CONCLUSION

A fuzzy approach for stock market timing is proposed in this paper. The experiences and techniques of Livermore are formulated as a set of fuzzy IF-THEN rules. These rules are optimized for better fit for the mainland china market. Simulation result shows that acceptable performance is obtained in a rapid change market. The performance of the proposed method would be affected by the rules and membership functions, which is related to exchange strategy in the market. Future research may include rule base optimization, auto adaptation of membership function and stock price prediction.

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