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Application of Fuzzy Logic in Financial Markets for Decision Making

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Abstract: Lately, administrative uses of artificial intelligence, particularly in the field of financial services, have received significant consideration. In this paper, a fuzzy logic expert system is developed to analyze financial Markets. Intricate models have for quite some time been utilized as a part of financial management to evaluate instability. With the developing accessibility of computing resources, advanced methods, for example, stress testing, stochastic modeling or even stochastic on stochastic modeling utilized for hedging programs are progressively pervasive. While money related experts take a stab at a superior comprehension of hazard and utilize complex models for hazard evaluation in business sectors, many dangers are still not surely knew. Some stay obscure, and new dangers have risen. Numerous Financial hazard sorts still can't be broke down adequately utilizing traditional likelihood models. The absence of experience information and entrapped circumstances and end results connections make it hard to survey the level of presentation to certain money related hazard sorts.

KEY WORDS: Forecasting, fuzzy-logic, NIFTY, stock market, linguistic values.

1. INTRODUCTION

It is exceptionally hard to anticipate the development of financial markets. Markets are dynamic and there are numerous intricate relationships and factors that influence currencies, indexes and commodities which make investing complicated and risky. The procedures in economy have nonlinear character. The system can generate randomly looking behavior but it can include the permanent cycles and trends if it is nonlinear and dynamic [1]. It is difficult to invest on the financial markets due to globalized economies, distinctive emergencies, bubbles, increasing debts, cost and diversities in commodities etc. These issues haphazardly escalate extreme imbalances on the market. For the investors, these imbalances are both threats and great opportunities. Psychology plays also a vital role on the financial markets -investors often and do not recognize these opportunities as they are afraid of the future improvement. This study attempts to confront extremely genuine but at the same time great issue of investment or when to purchase and sell the stocks at the same time minimizing the risk. Understanding the business sectors and having the capacity to foresee what would happen in the near future are the key aptitudes that each successful investor need to possess. This study utilizes a simple model with a couple of factors that simplify the intricate market environment to make good proposals for the investors, thus providing an important decision making support tool [2].

The one area where expert systems proved to be very useful is financial services sector. This is because of the multifaceted nature and repetitiveness of decisions in the finance area. Large numbers of financial institutions are putting resources into the innovation of expert system for every day operations. The field of finance is diverse and broad to a large extent. The system attributes and necessities are different for different application areas[3]. However, the need to create very large knowledge base, and the dynamic problem environments are some common attributes in these applications. Yiu and Kong (1992) compared semantic networks, rules, and frames as knowledge representation alternatives and suggested that the rule-based approach is the most accurate for expert systems in financial decision making. The authors inferred that the most important requirements and attributes of ES applications in finance area are development of a powerful graphical user interface and the need for constant updating and maintenance of the knowledge base. It is vital to resolve and streamline applications in the financial services sector; foreign exchange advice, capital investment decisions, guidance on purchasing shares and credit approval by the virtue of automation and innovative computing capabilities [4].

2. FUZZY LOGIC OVERVIEW

In 1965 L. A. Zadeh introduced Fuzzy Sets Theory. It is unique in relation to the customary Set Theory. The problem that cannot be unraveled by two-valued logic of the customary set theory can be raveled by utilizing the using membership function in fuzzy logic. After 1965, fuzzy sets have been applied to many fields such as Decision Analysis, Artificial Intelligence, System Theory, Economics and Control Theory and Medical Image processing. Fuzzy sets work as a way to capture vagueness and randomness in our everyday ventures and particularly technical systems like database systems. Inaccuracy is generally expressed by utilizing fuzzy etymological terms which are characterized as fuzzy sets represent them precisely. Membership function functions must be carefully defined as each fuzzy set is portrayed by its membership function [5].

This approach depicts a diagram of fuzzy set hypothesis and gives an audit of the writing.

Mostly decisions are made in an environment where facts and rules contain different facets of errors, imprecision, and vagueness. It is imperative that expert systems ought to be equipped with the uncertainty handling mechanism to enhance their performance as vulnerability is present in the majority of the application domain [6]. Linguistic variables are utilized instead of, or in addition to, numerical variables and simple relations between these variables and are defined by conditional statements with fuzzy logic operators, in a fuzzy expert system.

Fuzzy Set Theory is a mathematical tool for describing uncertainty, vagueness and impreciseness. The term "fuzzy" alludes to the circumstance in which there are no well defined boundaries for the set of activities or perceptions to which the depictions apply. Fuzzy Set Theory was proposed by Zadeh (1965). The group of objects with a continuum of membership grades is a fuzzy set. A membership functionthat assigns a grade of membership to each object, is associated with every fuzzy set. Generally, the membership grades assigned are between 0 and 1 [7]. At the point when the grade of membership for an object in a set is 1 then this object definitely belongs to that set; when the grade of membership for an object in a set is 0 then this object definitely does not belongs to that set. Marginal cases are set with numbers between 0 and 1. Fuzzylogic is a superset of customary (Boolean) logic that has been extended to handle the concept of truth values between completely true and completely false and partial truth fractional truth, truth values between totally genuine and totally false. The process in which any specific theory is generalized from a crisp (discrete) to a continuous (fuzzy) form is known as fuzzification [7][9].

A fuzzy subset F of a set S can be characterized as a set of pairs which are in order, each with the 1st component from S, second between the interval 0 to 1, with precisely one ordered pair present for every component of S. This characterizes a mapping between components of the set S and values between 0 to 1. Zero indicates complete non-membership, one indicates complete membership, and values in between 0 and 1 indicate intermediate degrees of membership [8] .

An expert system that uses a collection of fuzzy membership rules and functions rather than Boolean logic, to reason about data is a fuzzy expert system. The general inference process takes place in four steps:

1. Fuzzification - To determine the level of truth for each rule premise, the membership functions defined on the input variables are applied to their actual values.

2. Inference - The truth value for the premise of each rule is calculated, and is applied to the conclusion part of it. The result of this is that one fuzzy subset is assigned to each output variable for each rule.

3. Composition - All of the fuzzy subsets that are assigned to every output variables are combined together to form a single fuzzy subset for each output variable.

4. Defuzzification–It is the process of converting the fuzzy output set to a crisp number.

This section presented fuzzy logic and its significance. A survey of past studies was narrated demonstrating that fuzzy expert systems have viably been applied to numerous domains in financial decision making.

3. LITERATURE REVIEW

This research concentrates on the utilization of fuzzy logic and soft computing in finance domain which includes financial institutions and investment/equity markets. Decision makers and investors need to choose where, when and how to invest. This issue is extremely unpredictable and decision makers always try to utilize well trained algorithms, tools and methods that permit them to curb the risk. Fuzzy model that is designed in this approach is expected to be a decision making support tool for investors on the financial markets. This study aid to tackle extraordinary circumstances that happen on the financial markets and that are exceptionally hard to anticipate. Numerous researchers in the past has utilized soft computing as a part of business and finance . It recognizes the current imbalances on the market based on similarity to past known events. Many input variables are processed by the fuzzy model which then calculates recommendation for the investors. Rather than advancing transient hypothesis this study intends to give a decision making support model that helps the investor to find possibilities for making long-term profits with low risk and recognizes long-term critical imbalances[12][13].

The principal contrast between fuzzy set theory and traditional set theory is the nature of inclusion of the elements in the set. An element is either incorporated into the set or not, in traditional sets while in fuzzy sets an element is incorporated with a level of truth ordinarily extending from 0 to 1. Fuzzy logic models permit an object to be classified in more than one selective set with various levels of truth or confidence. Fuzzy rationale perceives the absence of precise data or the lack of knowledge and the cause-and-effect chain among variables is explicitly taken into consideration. Majority of the factors are depicted in etymological terms due to which fuzzy logic models are more intuitively similar to human reasoning. These fuzzy models are useful for demystifying, surveying and finding out about the risks that are not surely known [9].

3.1 Fuzzy Sets

In classical set theory, every object is either a member or a nonmember of a set. Even though, actually, because of imprecise data or insufficient knowledge, it is not generally clear whether an object is in a set or not. Conversely, fuzzy sets approximately interpret uncertainty. Conceptually, fuzzy set theory permits an object belonging to multiple exclusive sets in the reasoning framework. For every set, there is a level of truth that an object belongs to afuzzy set. Assuming that there are three levels of the score: low, average and high that can be considered as three sets. On the basis of classical set theory, the full set is comprised of these three exclusive sets. As soon as the credit scores I sknown,

the level of the score is resolved. Figure 1 demonstrates a case of classical sets for credit scores. When the credit score is 3.5 then it is 100 percent true that the credit score is high [12][16].

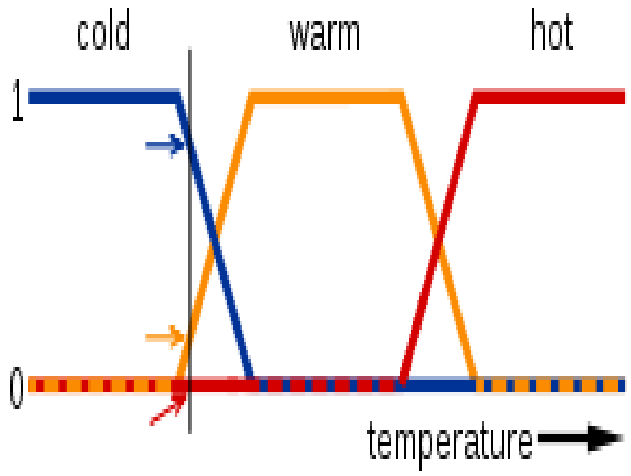

Figure 1. fuzzy set Example

In this example, the membership functions for the three sets are specified as follows (figure 2).

$$\mu^{High}(x) = \begin{cases} 0 & x \le 2.75 \\ (x-2.75)/1.25 & 2.75 < x \le 4 \\ 1 & x > 4 \end{cases}$$

$$\mu^{Average}(x) = \begin{cases} 0 & x \le 0.5 \\ (x-0.5)/1 & 0.5 < x \le 1.5 \\ 1 & 1.5 < x \le 1.75 \\ (4-x)/2.25 & 1.75 < x \le 4 \\ 0 & x > 4 \end{cases}$$

$$\mu^{Low}(x) = \begin{cases} 1 & x \le 0.5 \\ (1.5-x)/1 & 0.5 < x \le 1.5 \\ 0 & x > 1.5 \end{cases}$$

Figure 2. Sample Member Fucntions

An important attribute of fuzzy sets is that there are no hard standards about the definition of membership functioned. The mathematical form of the function as well as the parameters depends on the input from the experts. For whatever length of time that the membership functions are consistent, on a comparative basis, the conclusion based on fuzzy sets is still meaningful. For instance, the level of truth for a credit score of 4 having a place with fuzzy set "High" should not be less than 3. Also, just a single membership functions may be strictly increasing for a certain range of credit score. It might be conflicting if the level of truth for a credit score of 4 belonging to fuzzy set “High” is greater than that for a credit score of 3 while at the same time degree of truth for a credit score of 4 which belongs to fuzzy set “Average” is greater than that for a credit score of 3 [10][11].

3.2 Inference Rules and Fuzzy Hedges

It is possible because of logical operations on fuzzy sets is permissible to build inference rules to establish the relationship among various variables. One kind of fuzzy inference rule is known as the maximum minimum inference rule.
Following is the example showing the applicability of Inferences rules:

1. If A and B, then C.
The greatest level of truth for C is the lesser of the level of truth for A and that for B.

2. If A or B, then C.
The most extreme level of truth for C is the greater of the level of truth for A and that for B.

3. If not A, then C.
The greatest level of truth for C is one deducted by the level of truth for A.

3.3 Defuzzification

This is a process which estimates the value of dependent variable based on the resulting fuzzy set after applying the fuzzy inference rule. Three typical defuzzification methods are mentioned below.
1. Average method: In this the average numerical value of the dependent variable is in the output fuzzy set.
2. Average of maximum method: In this the average numerical value of the dependent variable with the maximum degree of truth is in the output fuzzy set.

3. Centroid method: In this the weighted average numerical value of the dependent variable is in the output fuzzy set. The weight is the degree of truth.
The weight is the level of truth.

4. FUZZY LOGIC SYSTEM

With all the components, a fuzzy logic system can be built in the steps mentioned below:

Step 1. Independent variables are selected as the indicators of the dependent variable or key determinants.

Step 2. Fuzzy sets are made for both dependent and independent factors. Rather than utilizing the numerical value, In terms of human language fuzzy setsutilized to portray a variable. The level of truth that every variable has a place with a certain fuzzy set is determined by the membership function.

Step 3. Inference guidelines are built in the system. A fuzzy hedge can be used to tweak the membership function as per the description of the inference rules.

Step 4. The output fuzzy set of the dependent variable is produced in view of the inference rules and independent

variables. A numerical value may be used to represent the output fuzzy set, after defuzzification.

Step 5. The outcome is then utilized for informed decision-making.

5. FINANCE STOCK MARKETS AND APPLICATION OF FUZZY APPROACH

Financial markets can be analyzed with the help of fuzzy logic system. Using the past market values in the fuzzy logic system we can analyze and predict future trends in a much accurate manner.

5.1 Stock Ranking

Corporate Evaluation which utilizes Fundamental Indicators]16] such as :

- Profitability – Returns on Assets and Equity.
- Management Performance – Assets and Inventories Turnover.
- Capital Structure – Assets to Liabilities and Liabilities to Equity.
- Marginal Account, Transaction Volume, Profit and Sales.
- Solicitors Regulation Authority [SRA]
- Popular Center of Area[COA]
- m**oving average convergence divergence[**MACD]
- **Relative Strength Index** [RSI]

5.2 Stock Selection

- Select 3 different stocks – one each showing steady state,uptrend and downtrend
- Attempt to show diverse profit making methodologies in stock trading
- All resulting procedures are connected on these 3 stocks[17].

5.3 Fuzzy Rules and Decision Trees

The key determinants of financial market in terms of fuzzy rules are[18] :

1. Fuzzification
   - Set of indicators chose by Solicitors Regulation Authority [SRA] fed into data fuzzification module.
   - This module changes technical indicators into fuzzy values.
   - Triangular and trapezoidal membership functions for the module are adopted.
   - Output decision is obtained in terms of a Gaussian membership function.
2. Defuzzification
   - Output that is obtained from fuzzy inference scheme is changed into a meaningful decision.
   - Popular Center of Area[COA] methods in the Fuzzy Control Module's algorithm is used to implement it.

The examples of Fuzzy decision rules

- If m**oving average convergence divergence[**MACD] is above the signal line, then BUY
- If **Relative Strength Index** [RSI] increases above 70, then market is BULLISH
- If Price increases above BBupper then market is BULLISH
- If MACD is LOW and RSIupper goes HIGH to LOW, then SELL
- If MACD is HIGH and CCIupper goes LOW to HIGH, then BUY

6. RESULTS and DISCUSSION

- Decision of Stock transaction and price and will be determined by the decision tree basedon the trends and indicators:
- Uptrend is marked by hike in price greater than 0.5%.
- Downtrend is marked by fall in price less than -0.5%.
- Steady state/hold is marked if *'y'* is between -0.5% and 0.5% .

7. LIMITATIONS AND IMPLICATIONS

Expansive number of elements impacts the advancements on the financial market every day. The dependability of the model would diminish significantly if it is used for short-term investing [15].

It's dependability diminishes significantly when it would be utilized for investing in a single company owing to the fact that events such as changes in firms focus, sudden changes in management, mergers and similar changes have significant impact on the stock price of the individual company but not on the whole index that is composed of hundreds of companies. This basic model is intended to utilize specific combination of input variables. It will give altogether less reliable recommendations when it would be utilized for other indexes due to the large change in conditions [13].

No simple fuzzy model can be of any use for the investor to recognize all the short-term irregularities that can be used for investing; this is due to the current financial markets are prohibitively complex due to globalization and is interconnected. Regardless of this it is conceivable to reliably detect the long-term major irregularities of the financial markets which can then be utilized by investors to create profit as well as maintaining low risk [14] [19][20].

8. CONCLUSION

Investment decision making support that is based on the fuzzy model can be very useful especially for the investors who are searching for the path to minimize the risk while dealing with their long-term investment portfolio. The aim of this research is obviously to minimize the risk and securely recognize opportunities. This research does not advocate short-term speculations that are risky. In this paper a designed model has been tested and scrutinized thoroughly on the historical data and it has demonstrated to provide

correct investment recommendations with high statistical probability.

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