GOLD PRICE FORECAST USING FUZZY LOGIC

By

ENGKU MARYAM BT ENGKU MOHAMED FATHILULLAH SUHAIMI

Dissertation submitted in partial fulfilment of

the requirements for the

Bachelor of Engineering (Hons)

(Electrical and Electronic Engineering)

JANUARY 2012

Universiti Teknologi Petronas
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

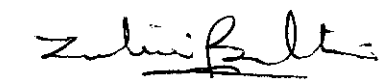
GOLD PRICE FORECAST USING FUZZY LOGIC

by

Engku Maryam bt Engku Mohamed Fathilullah Suhaimi

A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Approved:



Dr. Zuhairi Baharudin
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
JANUARY 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

ENGKU MARYAM BT

ENGKU MOHAMED FATHILULLAH SUHAIMI

ABSTRACT

Forecasting in management is to assist decision making. It is also described as the process of estimation in unknown future situations. In a more general term it is commonly known as prediction which refers to estimation of time series or longitudinal type data. Gold is a precious yellow commodity once used as money. 41 years ago it was made illegal in USA, but now once again accepted as a potential currency. The demand for this commodity is on the rise. People love gold. People love to own and keep gold. Gold is considered precious. People are always considering owning gold as a better option than paper currency. The reason behind it is that paper currency is a tool these days used by governments and those that influence them to control economies. However, this cannot be done with gold, hence the dropping of the gold standard. A currency will change and can be the subject of manipulation, inflation and depression. So it is crucial to invest in gold for future benefits and in order to be successful in gold investment, one have to master in gold price prediction. This is why the research for gold price forecasting to predict the next value of gold is crucial and important. Based on some research for prediction of gold price, the historic data of gold price as well as the exchange rate can be the most influential factor in determining the next gold price. Applying this knowledge, the inputs for next gold price prediction are mainly its historic gold price value and the exchange rate of world's major currency which are United States Dollar and British Pound. The research methodology to be used and implemented will be discussed further in next chapter.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATION

DoS : Degree of Support

MAPE : Mean Absolute Percentage Error

USD: United States Dollar

GBP: British pound

CHAPTER 1

PROJECT BACKGROUND

Project background will give a basic review about the background study of the project. It will state the main problem of this project that is to forecast the price of gold. To begin the research, there are some objective and scope of study to be understood.

1.1 Background Study

Forecasting is about predicting the future outcome. It is estimated based on our understanding and classification of the system. To be exact, it is the process of making predictions about future performance based on existing historic data. Forecasting is critically important for nowadays world as people use it to forecast the weather, earthquakes, stock market, and everything which people want to foresee. Like any other goods, gold's price depends on supply and demand. But the special thing about gold is, it is storable and the supply is accumulated over centuries. For example, in year 1998, the total world supply of gold is 125,000 metric tons and the annual ranges around 2,400 tons [1].

Since gold behaves less like other goods than long-lived assets such as stocks or bonds, gold prices are forward looking and today's price depends heavily on future supply and demand. Thus, to forecast the gold, it is depending a lot on the market's psychological perception of the future gold price based on countless variables, including inflation rates, currency variation and political turmoil [2].

This forecasting activity requires us to develop a forecasting model for predicting gold prices based on economic factors such as inflation, currency price movements and others. We have lots choices of approaches in order to forecast the future gold price but they are all requires us to basically have in depth understanding about the flow of the previous gold price and gather as much as data to use as inputs so the output can be can

be generate simply with the help of advance software nowadays. For this project, fuzzy logic software will be utilized to construct the model to forecast the next gold price.

This projects aims to help us to predict the next price of gold in order to make a good future investment plan, specifically in the gold investment field.

1.2 Problem Statement

1.2.1 Problem Identification

The gold prices are time series data of gold prices fixed twice a day in London [3]. Factors influencing gold prices are so many and we have to be selective in this study to ensure that the model developed is significant. It is a common practice in gold trade to use London PM Fix as the factor for pricing of gold and these become the published benchmark price used by the producers, consumers, investors and central banks. Many factors determine the price of gold, but basically, the price of gold is controlled by people's perceptions of the value of gold, world economic affairs, how much gold is being bought and sold and other external influences such as new discoveries, sudden large purchases and many more. We can see that the factors are not linear and subjective. Due to these conditions, it is complicated to mathematically formulate the gold price prediction problems.

In this study, the development of forecasting model for predicting future gold price is implemented using Fuzzy Logic. It is started by identifying the factors that influence the price of gold. Based on the hunch of experts, there are several economic factors which influence the gold prices such as Commodity Research Bureau future index (CRB); USD/Euro Foreign Exchange Rate (EUROUSD); Inflation rate (INF); Money Supply (M1); New York Stock Exchange (NYSE); Standard and Poor 500 (SPX); and US Dollar index (USDX) [4]. But remind that, these are not the only factors influencing gold prices.

This project will focus mainly on the relationship between the previous gold price and

exchange rate. For the relationship with previous gold price as seen from the all previous pattern, it always parallel. The higher previous gold price will result in increasing today gold price. As for exchange rate, it is said that the as a general rule, a country with a consistently lower inflation rate shows a rising currency value, as its purchasing power increases relative to other currencies[5]. During the last half of the twentieth century, the countries with low inflation included Japan, Germany and Switzerland, while the U.S. and Canada achieved low inflation only later[6].

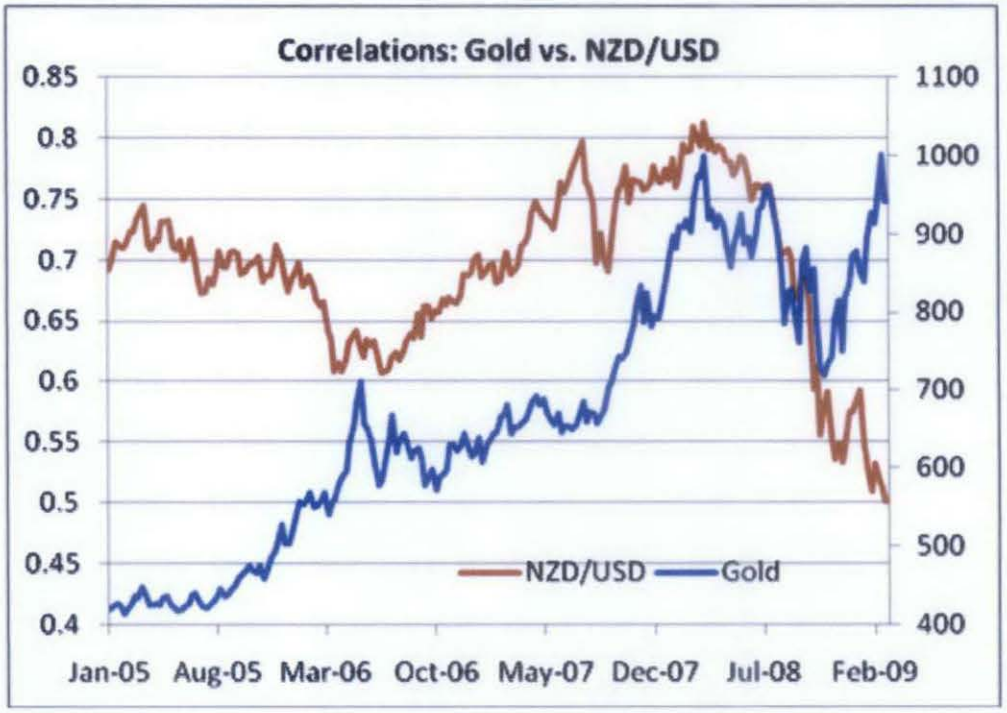


Figure 1.0: the correlation between the price of gold and the price action in the NZD/USD from January 2005 to March 2009[7].

From the figure, this project will apply an inverse relationship between gold price and exchange rate which is the higher the exchange rate gives a lower gold price.

To emerge this problem, the Fuzzy Set Theory introduced by Prof. Lotfi A. Zadeh in 1965 was applied as a tool to the mathematical approach in solving the gold prediction problems.

1.2.2 Significance of Project

It is undeniable that gold has been viewed as one of the oldest and most valuable commodity in the world. It is universally understood that not only does it look good when we wear it as precious jewelry, the habit of investing in gold can also bring the investor untold riches because gold is one of the most stable material in the category of precious metals. The gold market has always been steadier when compared to other investment means such as the stock market and the FOREX scene. Other commodities such platinum and palladium in the base metals category are not a preferred means of investment because they are too easily influenced by the state of the world economy. Gold is not affected easily because it is a universal currency recognized by every single bank across the globe. The international trade, foreign currency policy and fiscal deficit, the stock market, international political turmoil and war have a significant impact to the gold price directly or indirectly. Therefore, it is necessary to carry out the prediction research on gold price. [8]

Somehow due to the fact that some said the gold price is linearly increase so that, the forecast of gold price is unnecessary, is really not reliable. This is because, even though most of the time the price of gold is linearly increasing, but still it is not increasing all the time. There is still time when the gold price experiencing drop in value. So, in order to make sure that we will not fall into investment loss (for example: selling our gold during the dropping of gold price), we need to forecast the gold price.

Figure 1.1: Example of 1 year gold price trends from September 2010 to July 2011[9]

From September 2010, the price is kept on increasing but in January 2011, the price is suddenly dropped. If the forecast of the gold is not done properly, this can lead to wrong assumption that the price of the gold will keep on increasing and by taking this assumption to decide on the next action someone might sell their gold during the dropping price of gold (in January 2011) year. This will lead to losses in their investment.

On the other side, for the people who did gold price forecast successfully, might want to buy the gold on that time. This can help them to manage their investment or even plan for their future investment.

1.3 Objective & Scope of Study

1.3.1 Objectives

The main objective of the study is to construct a reliable forecast model of gold price prediction by using Fuzzy Logic method. The sub-objectives are stated as follows:

- To outline various types of forecasting methods.
- To outline the importance of gold prediction in doing future investment.
- To analyze the fundamental of fuzzy logic method

1.3.2 Scope of Study

Generally, the scope of study will cover the following areas:

- Gold demand in future.
- Historical data of gold price from international market.
- Exchange rate history.
- Fuzzy Logic as a technique used in the forecasting method.

1.4 Relevancy of the Project

Throughout this project, a forecasting model to predict gold prices will be forecast based on historic data of gold price and exchange rate. British Pound(GBP) and United States Dollar(USD) exchange rate are chosen in this model because they are among the most influential currency in the world. Due to the increase in demand for gold in Malaysian and other parts of the world, it is necessary to develop a model that reflects the structure and pattern of gold market and forecast movement of gold price.

1.5 Feasibility of the Project

This project will be conducted for two semesters. This includes research of gold price, development and improvement of data modeling. The required data for gold price forecasting was obtained from various source related to world gold price movement. Next, the model developed was tested on any random previous year which in this case it was tested on data of February and March 2005. After several times of simulation and reconstructing the rule block to achieve the lowest possible error, the model develop was saved and being applied to the recent gold price data which is November 2011. The result obtained was as expected and error is very small which is below 2 percent. The FuzzyTECH software should be able to fulfill the requirement in developing the gold forecasting model. Therefore, this project is feasible to be carried out within the time and scope.

CHAPTER 2
LITERATURE REVIEW

This chapter will elaborate in details about gold, the gold price pattern, forecasting and its various methodologies, relationship between exchange rate, gold and forecasting (gold price forecasting to be exact), the importance of gold price forecasting and its application in real world situation and last, the fuzzy logic systems.

2.1 Gold

2.1.1 Story of gold

Gold is a precious metal that has been treasured by people since ancient times. People use gold for coins, jewelry, ornaments, and many industrial purposes. Until recently, gold is treated as the basis of world monetary systems.

Gold is a very soft metal when it is pure.24 Kt. is pure gold. Gold is the most flexible metal to the extent that it can be made into wire. Gold is usually alloyed to make it less expensive and harder. Alloyed means that, it is mixed with other metals, often they used silver and copper to be mixed up with gold. The scientific abbreviation of gold is Au. The purity of gold jewelry is measured in karats. Some countries hallmark gold with a three-digit number that indicates the parts per thousand of gold. In this system, "750" means 750/1000 gold (equal to 18K); "500" means 500/1000 gold (equal to 12K) [10].The categorizations of gold colors are yellow, rose and white gold.

2.1.2 Gold trading

There are various methods of how people can trade the gold. A growing range of methods now allows investors to either buy gold, or simply gain exposure to gold price movements. From gold coins, online accounts, exchange traded funds and complex financial products, to mining stocks, the most appropriate gold investments will depend upon the investor's specific requirements and outlook. Below are some types of gold trading method [11]:

- Exchange Traded Funds (ETFs)
- Futures and options
- Warrants
- Gold accounts
- Coins and small bars
- Gold Accumulation Plans (GAP)
- Gold Mining stocks
- Gold Certificates
- Structured products

Some of the reasons why peoples nowadays choose to trade the gold are, because historically, gold has been considered a safe haven in times of economic, geopolitical and financial instability. Inflation and currency devaluation are also positive environments for gold, because it holds its value. Plus, gold investing allows investors to gain financially from increasing gold prices. They can gain unlimited benefits in gold trading if they are really understood and make a great effort in this field.

2.1.3 The importance of gold

Shown below are the historical gold price charts [12]:

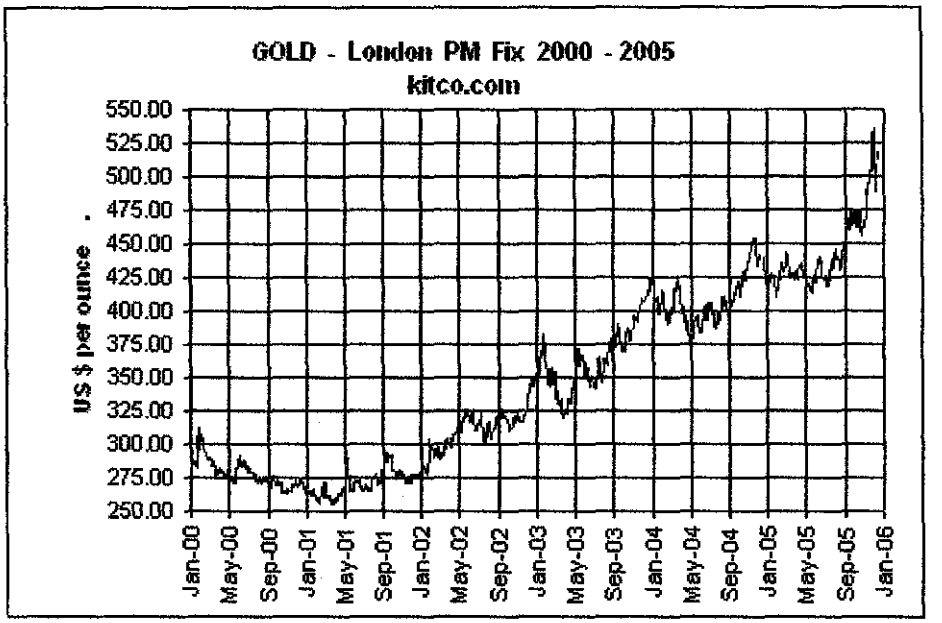


Figure 2.0: Gold price chart from year 2000 to 2005

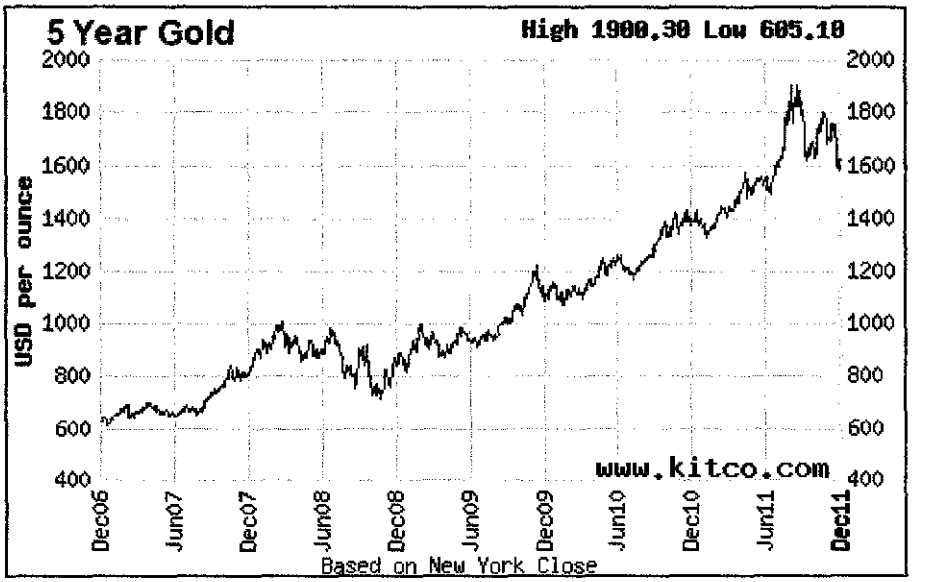


Figure 2.1: Gold price chart from year 2006 to present

Based from the observation of those two graphs above, it is obvious that gold price is kept on increasing from time to time. So, it is clear that people will benefits lots from gold investment and it was one of the strongest points about the importance of gold.

The other significance of gold are as follows:

- Gold is our wealth insurance during wars, natural disasters and political unrest

Even in the stock market or the FOREX market, we would realize that financial markets such as these are very easily affected by global happenings such as terrorism and war. The 9/11 disaster is a good example how financial markets can be at a standstill for extended periods of time and can cause billions of dollars of investment funds to be lost. Gold, on the other hand, will maintain its stability even when times are bad.

- Gold can protect us against the weakening currency

No matter which country we originate from, there is a chance that the country's currency will suffer a downfall at a particular point of time. Gold, on the other hand, retains its true value and can help us protect our assets because it does not rely on the state of the country's economic. Take the US dollar for example. For years now, terrorism and political rife have caused the dollar to appear very unstable and perhaps, increasingly undesirable. When the US dollar continued its decline between the years 2003 and 2004, the value of gold continued to ascend.

- Gold provides excellent price appreciation and untold profits

After the infamous stock market bubble burst during the early turn of the millennium, many investors realized that they are better off putting their equity in something more stable and enriching to their investment portfolio. And unlike other financial markets, investors can invest in gold for better peace of mind as they need not worry about the consequences that come with inflation.

To make it even clear about the importance of gold, here are some researches specifically about The Importance of Gold in a Portfolio for the Average Investor [13]:

- The stock market has lost a huge amount of value since the market high in late 2007.

- The economy has crashed due to failures in Washington and Wall Street.

- The Obama administration is printing money and running massive deficits to try and save the banks and rescue the economy. Both carry enormous risks for our long-term future.

- In the short term (6-18 months), this may head off a depression and limit a recession. Unemployment will continue to rise until the additional money hits the economy but will level off and start to decline once the economy begins to expand. The stock market recover some of its losses as the plan is understood and implemented. There will be a return to a 1970's style economy when commodity prices (oil, gas, electricity, food) will rise faster than workers' wages.

- In the longer term (18 months+), our situation will turn for the worse
  All of the money hitting the economy will lead to a dramatic increase in demand for goods and services. The price for these goods and services will rise dramatically (inflation). Inflation and a weak dollar will eat away at the value of our equity portfolio. All major commodities such as gold bullion, silver bullion, oil, and agricultural commodities will rise. Of the entire hedge against inflation, gold bullion and rare coins will protect our assets the best.

- Gold will experience a major run-up in price.

In the first phase, which is occurring now, professional money managers enter the market as a hedge against anticipated inflation down the road. In the second phase, when the initial sign of inflation start to become public and the stock market begins to fall, individual investors will enter the gold bullion market. In the third phase, after gold bullion has experienced a positive return the stragglers will enter the market and provide a last burst of growth. Smart investors will enter the market in phase one, and sell into the phase three wave, as it is going up.

2.2 Forecasting

By definition, forecasting means the process of analyzing current and historical data to determine future trends [14]. There are lots of forecasting methods but in order to solve specific problem, we need to find the most appropriate method for our problem. To be exact, the conditions for forecasting problems may vary, so, there is no single best method works for all situations.

Generally, the key point to all the forecasting methods are as stated below[15]:

- Use domain knowledge: based on managers and analysts knowledge about the situation
- Structure the problem: break a problem into manageable pieces, solve each piece, and then put things back together.
- Model experts' forecast: Organizations have expert systems to represent forecasts made by experts. They can reduce the costs of repetitive forecasts while improving accuracy.
- Represent the problem realistically: start with a model and attempt to generalize to the situation. This helps explain why game theory, a mathematical model used to model and predict the behavior of adversaries in a conflict, has had no demonstrable value for forecasting (Green, 2005).

2.2.1 Gold price forecasting

The term gold price forecasting referred to the act of making prediction on the future gold price using some forecasting method and taking into account the factors that may affect the forecasting result. Gold forecasting plays an important role to help public and investors in making decision for the gold investment. They can generate more profits and income if they are able to make an accurate forecast of future gold price.

Gold price forecasting can be divided into short and long term forecast. Short-term forecasting is the prediction of the gold price over an interval ranging from one hour to one week. Meanwhile, the long term gold forecasting is normally longer than a year and usually covers from one to next ten years [16].

Traditionally, forecaster only relied on technical analysis, looking at trends, moving averages, and certain graphical patterns, for performing predictions and making decisions. Somehow, the traditional forecasting methods cannot solve forecasting problems in which the historical data are linguistic values. So, Artificial intelligence (AI) method has been introduced to overcome this problem. Artificial intelligence (AI) is computerize human reasoning and has been widely used in many areas including financial time series forecasting. Plus, using this soft computing methodology, we do not need to specify the structure of a model a-priori, which is clearly needed in the traditional approach analysis. It is also non-linear in nature and can approximate complex dynamical systems more easily. Some types of AI that is widely used nowadays are:

- Artificial neural networks (ANNs)
- fuzzy logic, genetic algorithms (Gas)
- particle swarm optimization (PSO)

For this project, we will be doing short term forecasting(a day ahead) using fuzzy logic to forecast the next daily price of gold.

2.3 Fuzzy Logic

2.3.1 The Fuzzy Logic Concept

Fuzzy logic is not logic that is fuzzy, but logic that is used to describe fuzziness. Fuzzy logic is the theory of fuzzy sets, sets that calibrate vagueness. Fuzzy logic is based on the idea that all things admit of degrees. For example, temperature, height, speed, distance, beauty, all of them come on a sliding scale.

Many decision-making and problem-solving tasks are too complex to be understood quantitatively, however, people succeed by using knowledge that is imprecise rather than precise. Fuzzy set theory resembles human reasoning in its use of approximate information and uncertainty to generate decisions. It was specifically designed to mathematically represent uncertainty and vagueness.

Fuzzy, was first introduced in the 1930s by Jan Lukasiewicz, a Polish philosopher. While classical logic operates with only two values 1 (true) and 0 (false), Lukasiewicz introduced logic that extended the range of truth values to all real numbers in the interval between 0 and 1. In 1965, Lotfi Zadeh, published his famous paper "Fuzzy sets". Zadeh extended the work on possibility theory into a formal system of mathematical logic, and introduced a new concept for applying natural language terms. This new logic for representing and manipulating fuzzy terms was called fuzzy logic [17].

2.3.2 Fuzzy Representation

A Fuzzy Set has Fuzzy Boundaries. Let X be the universe of discussion and its elements be denoted as x. In the classical set theory, crisp set A of X is defined as function $f_A(x)$ called the characteristic function of A:

$f_A(x) : X \rightarrow \{0, 1\}$, where

$$f_A(x) = \begin{cases} 1, \text{if } x \in A \\ 0, \text{if } x \notin A \end{cases}$$

This set maps universe X to a set of two elements. For any element x of universe X, characteristic function $f_A(x)$ is equal to 1 if x is an element of set A, and is equal to 0 if x is not an element of A.

In the fuzzy theory, fuzzy set A of universe X is defined by function $\mu_A(x)$ called the membership function of set A

$\mu_A(x)$: X → {0, 1}, where $\mu_A(x) = 1$ if x is totally in A;

$\mu_A(x) = 0$ if x is not in A;

$0 < \mu_A(x) < 1$ if x is partly in A.

This set allows a range of possible choices. For any element x of universe X, membership function $\mu_A(x)$ equals the degree to which x is an element of set A. A value between 0 and 1, represents the degree of membership of element x in set A.

First, we determine the membership functions. For example, from our "tall men" case, we can obtain fuzzy sets of *tall*, *short* and *average* men.

The universe of discourse – the men's heights – consists of three sets: *short*, *average* and *tall* men. As you will see, a man who is 184 cm tall is a member of the *average* men set with a degree of membership of 0.1, and at the same time, he is also a member of the *tall* men set with a degree of 0.4.

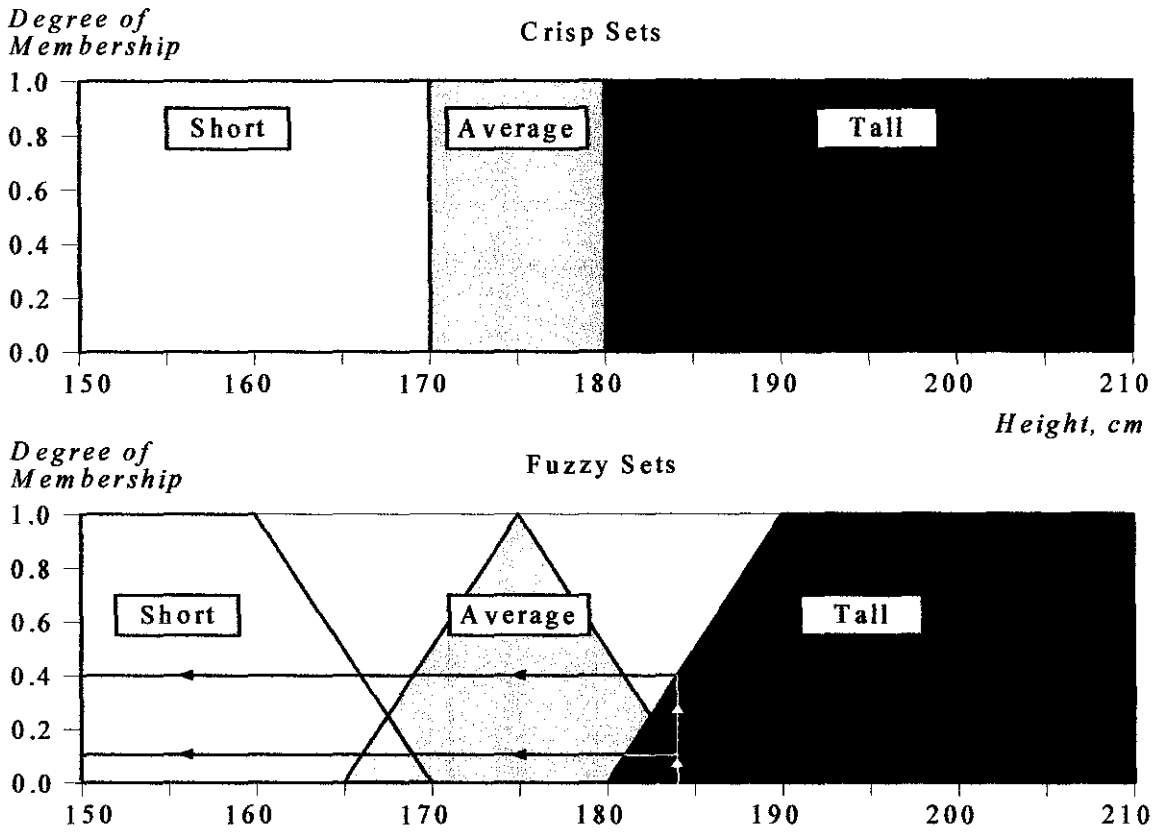


Figure 2.2: Example of membership function

The fuzzy logic is also applied for the non-numeric linguistic variables. It is often used for facilitating the expression of rules and facts. The Fuzzy Logic uses IF-THEN rules which employ the linguistic variables (fuzzy variables) whose values are in the linguistic terms.In fuzzy expert systems, linguistic variables are used in fuzzy rules. For example:

- IF wind is strong
  THEN sailing is good

- IF project_duration is long
  THEN completion_risk is high

- IF speed is slow
  THEN stopping_distance is short

2.3.3 Why choose fuzzy logic?

Fuzzy logic system provides an interesting tool for forecasting due to its capability to represent imperfect information. Fuzzy system has very strong functional capabilities to fit or map a function to a finite number of input output data. If Fuzzy Inference System (FIS) is properly constructed, then it can perform very complex operations, even more complex than those performed by a linear mapping. In the last decade a great deal of attention has been paid to the statistical analysis of data based on fuzzy clustering and it has been shown that clustering based function approximation is indeed the optimum methodology that has been widely and successfully applied in various areas like pattern recognition, machine learning, forecasting, share marketing, risk analysis, image analysis and bioinformatics [18, 19]

2.4 FuzzyTECH System Modeling Configurations

The structure of the fuzzy logic configurations can be represented as below:

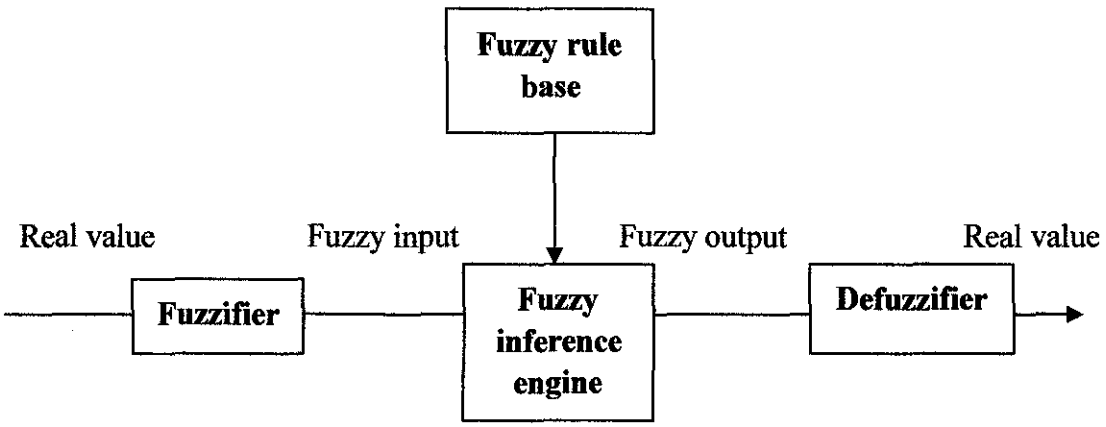


Figure 2.3: Basic Component of Fuzzy System

2.4.1 Fuzzification

Fuzzification is the process of relating crisp input values with the linguistic terms of corresponding input linguistic variables. First we enter the inputs to starts the modeling. The inputs are in terms of the crisp value. The Fuzzifier will then transforms the real valued input variables into fuzzy values. Next is fuzzy inference. The Fuzzy Inference engine will map the fuzzy inputs earlier to the fuzzy output based on the Fuzzy Rules. Now that all input variables have been converted to linguistic variable values, the fuzzy inference step can identify the rules that apply to the current situation and compute the value of the output linguistic variable. This inference system is used to evaluate the similarity between the previous forecast days and previous similar days resulting in correction factors. The computation of the fuzzy inference consists of three components:

- *Aggregation:* Computation of the 'IF' part of the rules. This step computes the support of the rule relative to the conditions.
- *Composition:* Computation of the 'THEN' part of the rules. This step computes the degree of truth for the rule.
- *Result Aggregation:* this step determines which rules will contribute to the Deffuzzified result

2.4.2 Rule base

Fuzzy rule base is a set of linguistic rules or conditional statements in the form of "IF a set of conditions is satisfied, THEN a set of consequences are inferred". These if-then rule statements are used to formulate the conditional statements that comprise fuzzy logic.

2.4.3Defuzzification

The result produced from the evaluation of fuzzy rules is fuzzy. Membership functions are used to retranslate the fuzzy output into a crisp value. This translation is known as *Defuzzification* and can be performed using several methods. Thus, the result of the fuzzy inference is retranslated from a linguistic concept to a crisp output value [20].

CHAPTER 3

METHODOLOGY

3.1 System Design Approach

This project consists of three main stages. The first stage is the construction phase, followed by expansion and modification on the earlier stage. The final part of the project is to test the system in stage 1 with real gold price in February and March of the year 2005.

3.2 Tools Required

For this project, two main software are required, the fuzzyTECH and Microsoft Excel. FuzzyTECH is the software for fuzzy logic-based solution. This software provides simple yet powerful user interface for developing the load forecasting model especially for beginners since all the fuzzy logic algorithm are embedded within the program.

However, fuzzyTECH does not provide the interface for data management. Alternatively, fuzzyTECH can be linked together with the software for data interfacing such as the Microsoft Excel. The Dynamic Data Exchange (DDE) Links function, which is embedded inside the fuzzyTECH, can be used to link the system with the worksheet of the Microsoft Excel.

3.3 Procedure Identification Stage 1: Construction

The construction stage starts with gathering the data of gold price and exchange rate in February and March 2005(Appendix A). Then, the input linguistic variables (real gold price and exchange rate for February and March 2005) and output linguistic variables (forecasted gold price) were identified. From the data obtained, the relationship between the input and output parameters was analyzed.

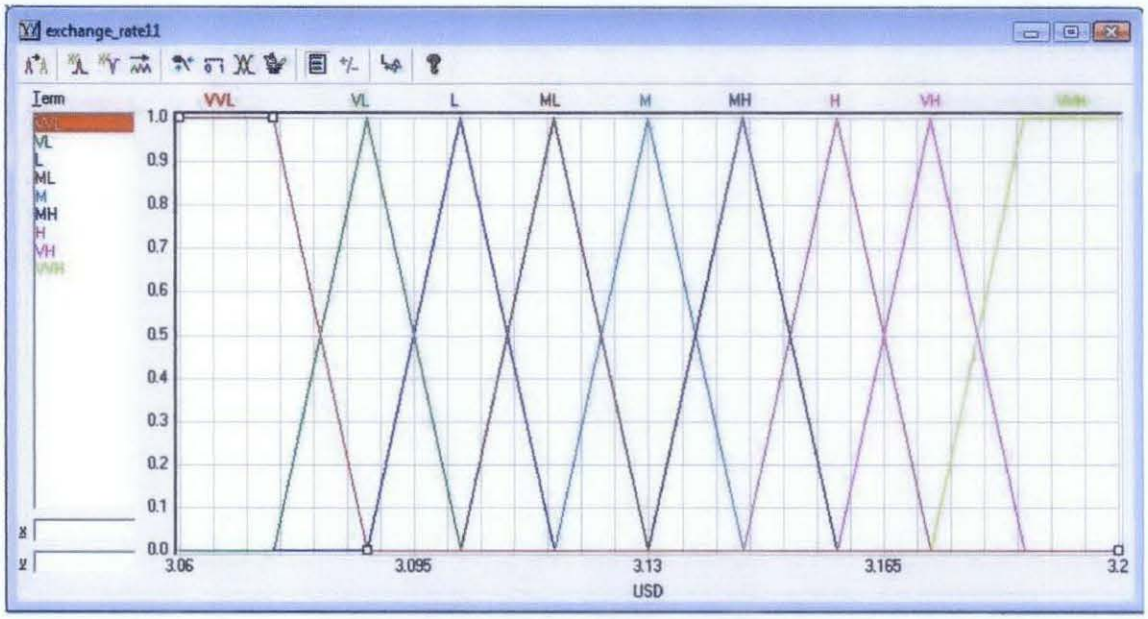


Figure 3.1: Membership function of Exchange Rate input variable

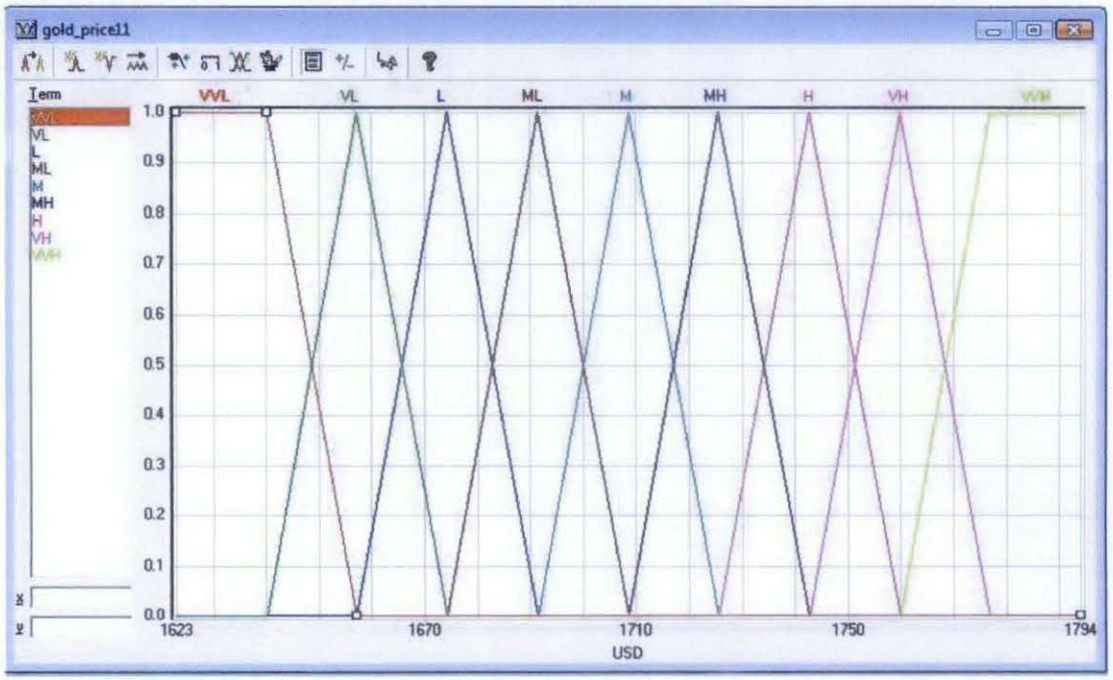


Figure 3.2: Membership function of Previous Gold Price input variable

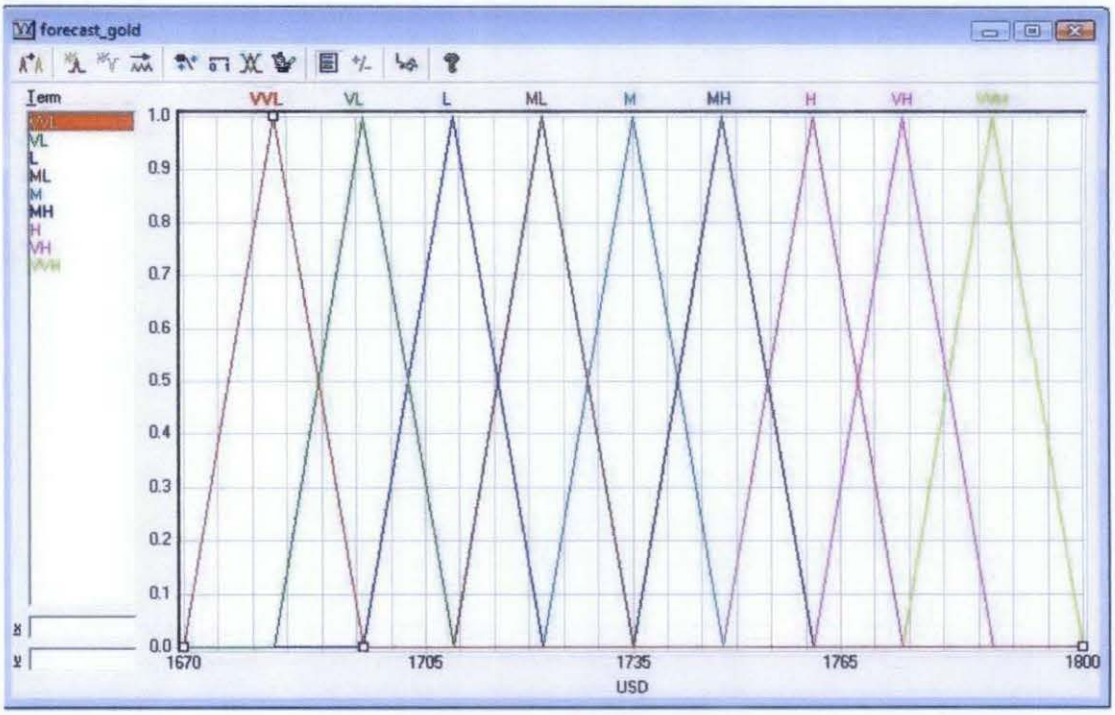


Figure 3.3: Membership function of Forecasted Gold price output variable

The next part is the construction of the fuzzy If-Then rule blocks. In fuzzyTECH individual rules are confined into rule blocks to build the system structure. The fuzzy rule block is the medium which connects between the system inputs with the system output based on the If-Then rules. The "IF" column on the left side shows the variables used in the precondition of fuzzy rules. The "THEN" column on the right shows the variables used for the conclusion of the condition.

#	IF		THEN	
	exchange_rate	gold_price	DoS	forecasted_price
1	very_low	very_low	1.00	very_low
2	very_low	low	1.00	low
3	very_low	medium_low	1.00	low
4	very_low	medium	1.00	medium_low
5	very_low	medium_high	1.00	medium
6	very_low	high	1.00	medium
7	very_low	very_high	1.00	medium_high
8	low	very_low	1.00	low
9	low	low	1.00	low
10	low	medium_low	1.00	medium_low
11	low	medium	1.00	medium_low
12	low	medium_high	1.00	medium
13	low	high	1.00	medium
14	low	very_high	1.00	medium_high
15	medium_low	very_low	1.00	low
16	medium_low	low	1.00	low
17	medium_low	medium_low	1.00	medium_low
18	medium_low	medium	1.00	medium
19	medium_low	medium_high	1.00	medium
20	medium_low	high	1.00	medium_high
21	medium_low	very_high	1.00	medium_high
22	medium	very_low	1.00	low
23	medium	low	1.00	medium_low
24	medium	medium_low	1.00	medium_low
25	medium	medium	1.00	medium
26	medium	medium_high	1.00	medium
27	medium	high	1.00	medium_high
28	medium	very_high	1.00	high
29	medium_high	very_low	1.00	low

Figure 3.4: Rule Blocks

After the model is completed, simulation can be performed to obtain the forecast gold price. Performing error analysis will determine the accuracy of the model. Retuning the system will be performed if the MAPE shows a value exceeding the previous percentage of MAPE. Figure 5 below shows the system design approach of this project.

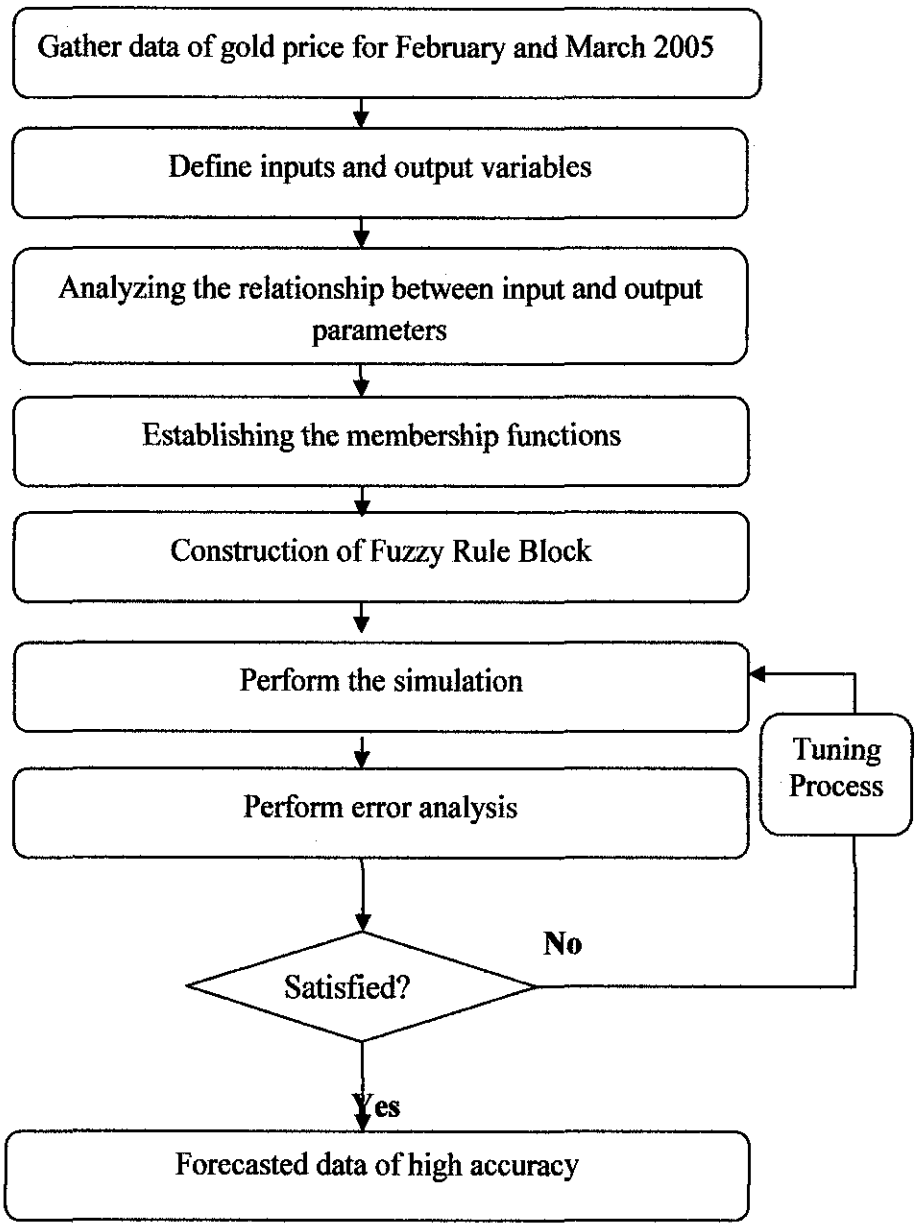


Figure 3.5: Flowchart for system design approach

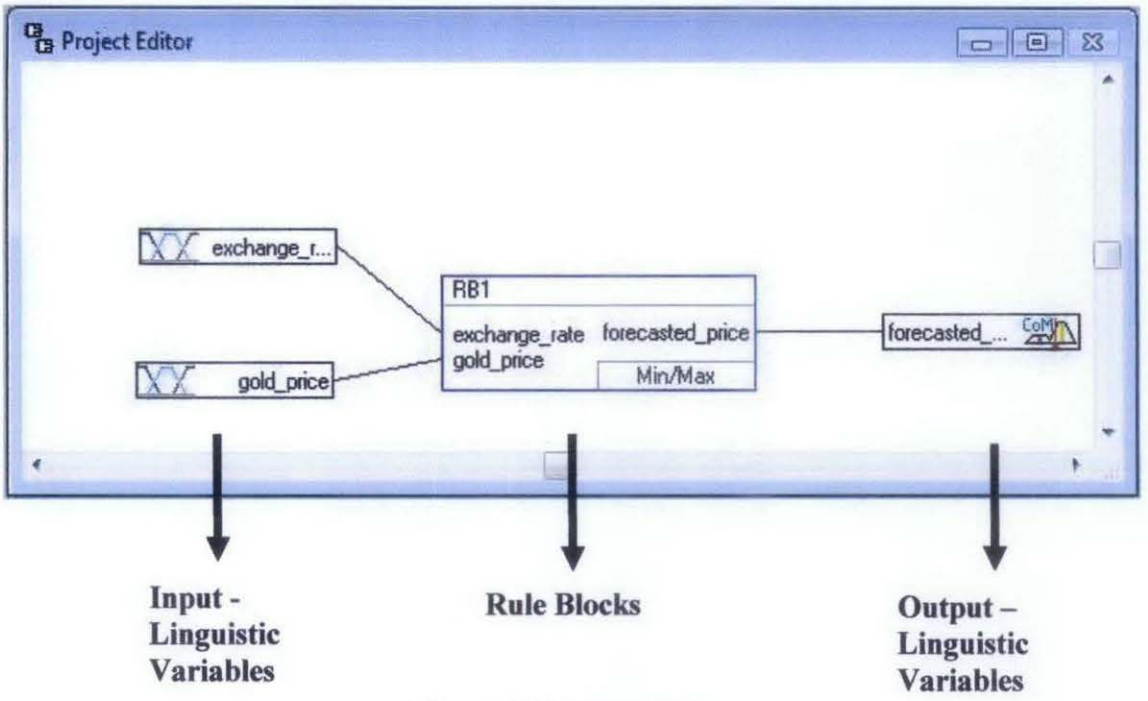


Figure 3.6: Project Editor

3.3.1 Error Calculation

The forecasted gold price was compared to the actual gold price data so that error can be calculated. The MAPE is computed in terms of daily MAPE. The MAPE calculation for daily gold price forecasting can be calculated as follows:

$$\%\ Absoluteerror = \frac{|Actualgold\ price - Forecastgold\ price|}{Actualgold\ price} x\ 100\%$$

$$MAPE = \frac{1}{N}\sum_{i=1}^{N}\left|\frac{P_A^i - P_F^i}{P_A^I}\right| X\ 100\% \qquad (3.1)$$

Where PA is actual gold price, PF is the forecasted gold price and N is the number of data points.

3.3.2 Program Simulation Process

Starting the simulation by activate the debug Interactive Mode button. Then, continue with inserting the input in the Data Input column in Microsoft Excel as shown in Table 3.1. The input which is in term of crisp value will be sent to the fuzzyTECH program through Data Dynamic Exchange (DDE) Link. Referring to the membership function values and the rule based, the value of the forecast output will be computed in fuzzyTECH program. The input value and the result of the computation are as shown in Table 3.1 and 3.2. For easier data management, the output of the computation can be sent back to the Microsoft Excel. All of these data exchange could be made possible by assigning the Excel column address in the DDE Links Window of fuzzyTECH program.

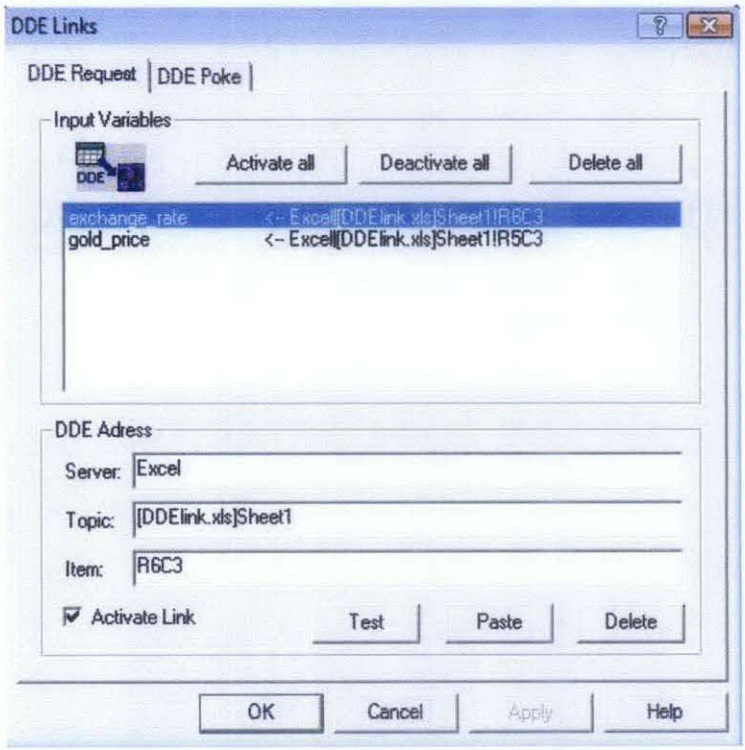


Figure 3.7: DDE Request for assigning Input location

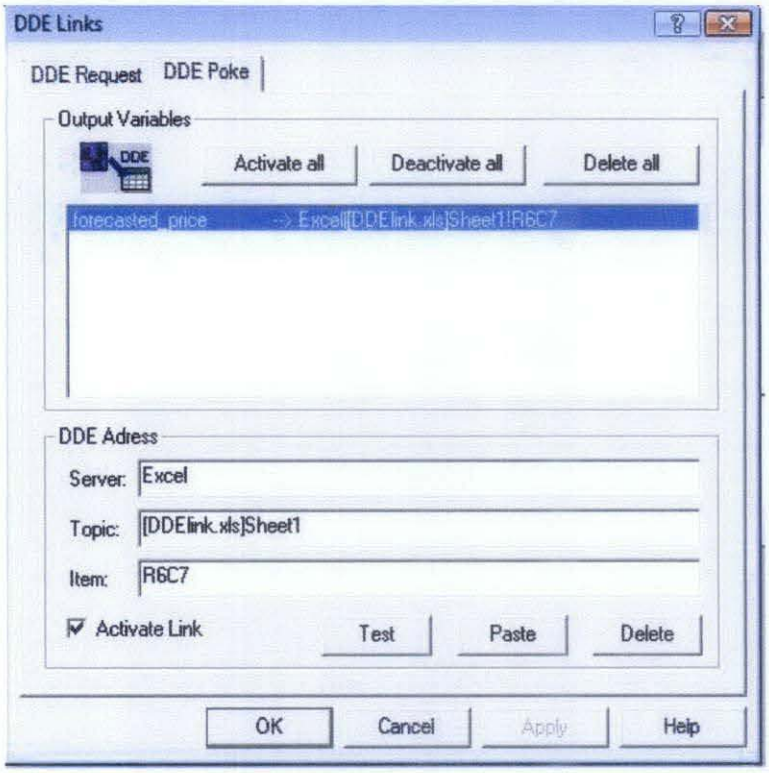


Figure 3.8: DDE Request for assigning Output location

Previous gold price	
Exchange rate	

Table 3.1: Example of Input Column in Microsoft Excel

Forecasted(F)	Actual(A)	F-A	ABS F-A	ERROR

Table 3.2: Example of Output Column in Microsoft Excel

3.3.3 Fine Tuning Process

During the first stage, the rules in each rule block were tested and modified as well as the DoS for each rules repeatedly. It is an error analysis process called fine-tuning process. The process was performed to obtain the lowest possible MAPE. The flow of the process is shown in the figure below.

If the forecasted result shows high MAPE, then a process called fine tuning needed to be done. The fine tuning process is a trial and error process, that is repeated during simulation until an optimal result or an accurate model is obtained. The fine tuning involves the process of specifying and editing the IF-THEN rules as well as the DoS for the rules.

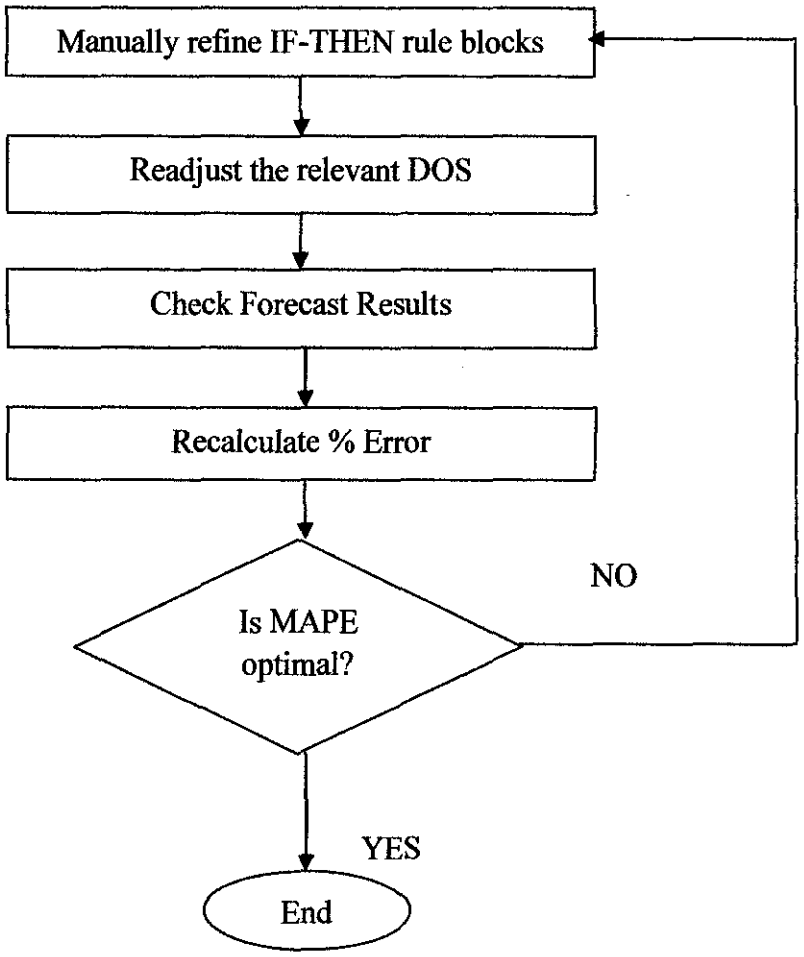


Figure 3.9: Fine tuning flow diagram

3.4 Procedure Identification Stage 2: Expansion

The second part of this project is to expand the membership function for the linguistic variables 'Previous Gold Price', and 'Forecasted Gold Price' in the system. As for 'Exchange Rate', no expanding of membership function had been done because it does not exist in previous system. The purpose of this expansion is a trial in designing a model with higher interpretability and accuracy.

An example of membership function expansion is shown below.

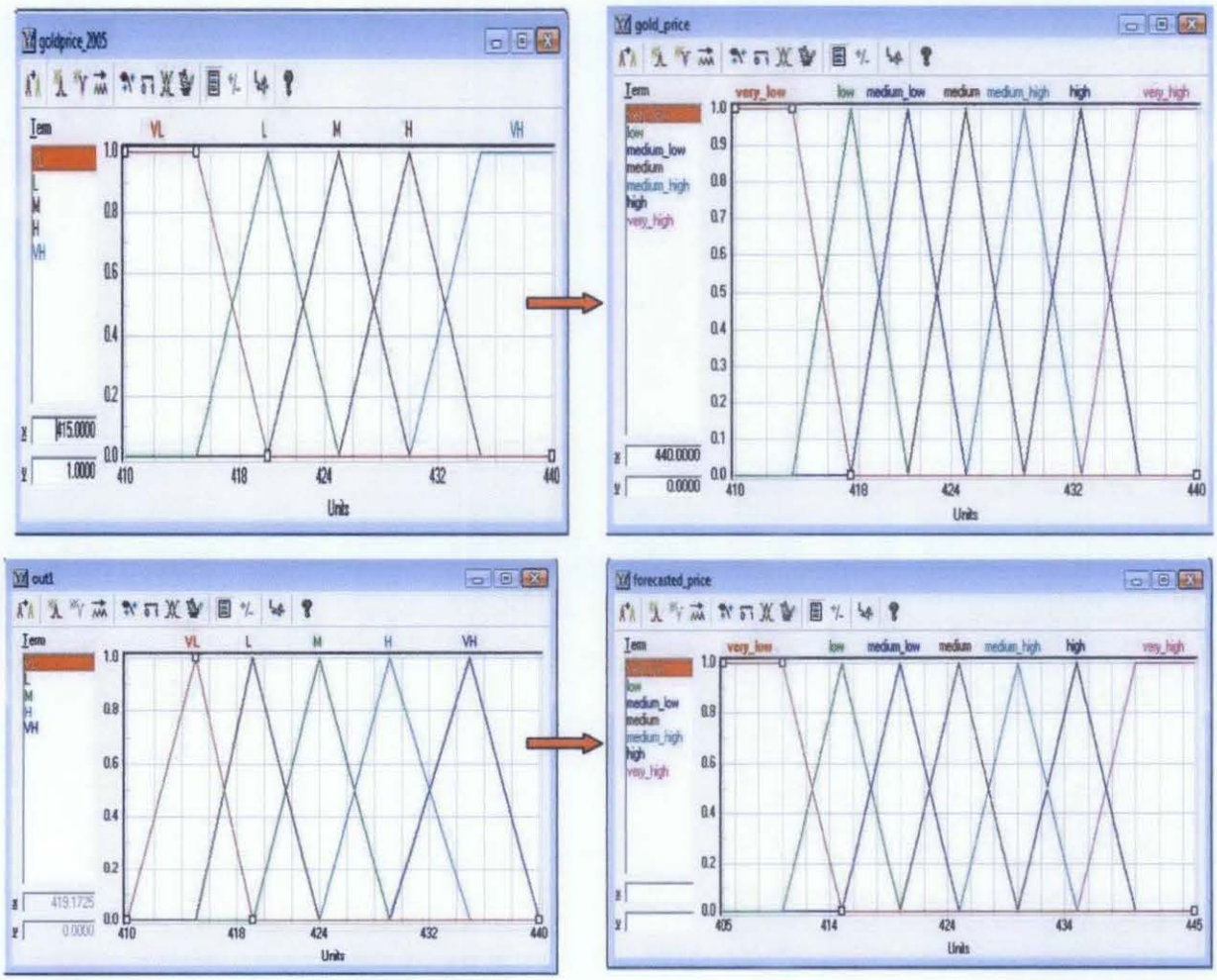


Figure 3.10: Expansion of membership function

As new terms has been added, the rule base were recreated based on the situation of the how the input affect the gold price. The fine tuning process was performed repeatedly until a smaller MAPE was obtained in the forecasting model. The new rule bases were shown in Appendix B.

3.5 Procedure Identification Stage 3: Testing

The final part of this project is to test the system that was built in Stage 1. This program was tested with the data of gold price and exchange rate in February and March 2005. During the testing stage, no further modification or changes were applied. The system was solely tested and checked for accuracy.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Simulation Result

Date	Forecast Gold Price(with exchange rate, $)	Forecast Gold Price(without exchange rate, $)	Actual Gold Price, $	MAPE(without exchange rate)	MAPE(with exchange rate)
1-Feb	427.07	430.11	421.15	2.13	1.40
2-Feb	427.00	433.06	421.90	2.65	1.21
3-Feb	427.00	431.00	419.80	2.67	1.72
4-Feb	425.79	429.76	416.50	3.18	2.23
7-Feb	425.12	428.29	414.50	3.33	2.56
8-Feb	423.60	427.40	411.50	3.86	2.94
9-Feb	423.70	426.88	413.20	3.31	2.54
10-Feb	422.62	424.34	413.50	2.62	2.21
11-Feb	422.01	424.15	417.05	1.70	1.19
14-Feb	422.57	423.05	422.80	0.06	0.06
15-Feb	422.77	422.70	424.60	0.45	0.43
16-Feb	422.89	421.19	424.15	0.70	0.30
17-Feb	424.41	425.78	426.60	0.19	0.51
18-Feb	425.31	429.83	426.55	0.77	0.29
21-Feb	425.04	429.88	427.10	0.65	0.48
22-Feb	426.85	430.05	430.75	0.16	0.91
23-Feb	426.01	432.18	433.25	0.25	1.67
24-Feb	427.14	432.35	434.75	0.55	1.75
25-Feb	428.07	433.71	432.40	0.30	1.00
28-Feb	427.82	434.87	436.55	0.38	2.00
Average MAPE=				1.4955	1.37

Table 4.1: Comparison MAPE of forecasted gold price with exchange rate and without exchange rate for February 2005

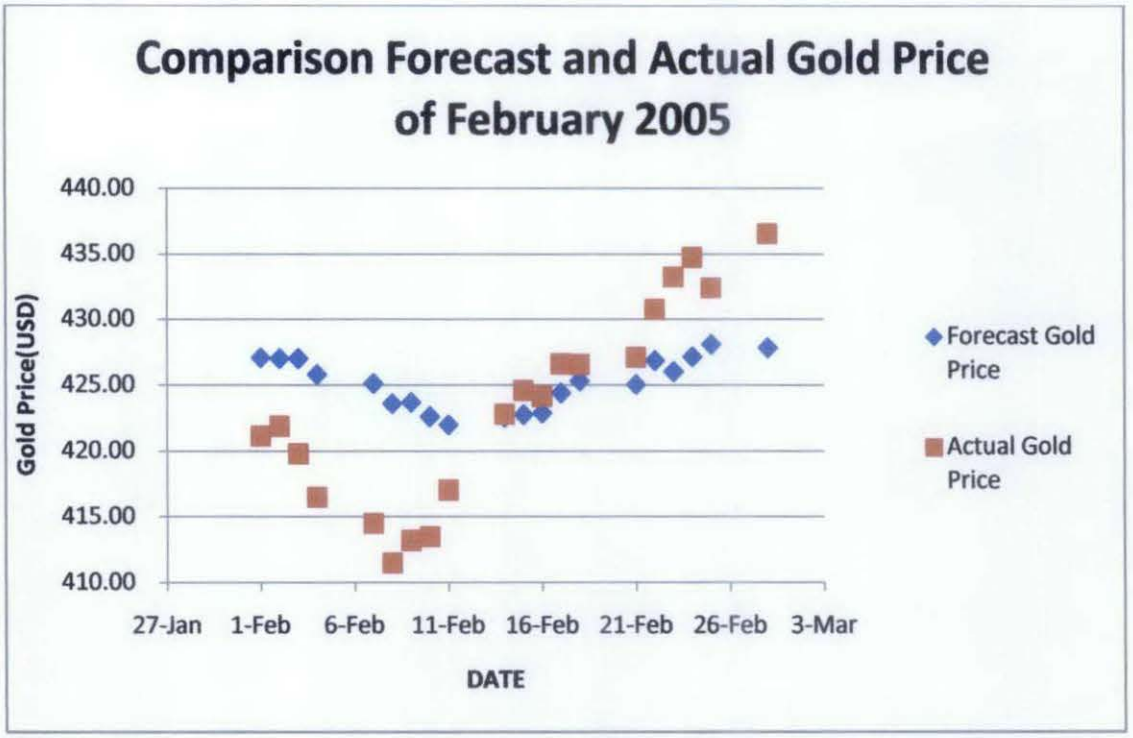


Figure 4.1: Comparison Forecast and Actual gold Price of February 2005

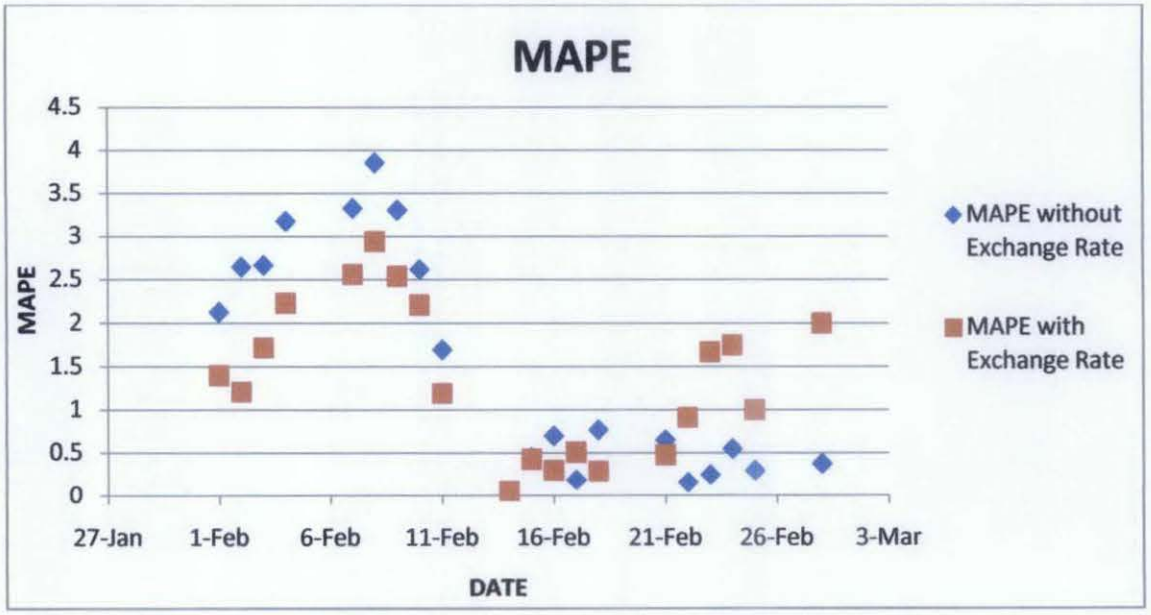


Figure 4.2: Comparison MAPE for Gold Price Forecast with Exchange Rate as input and without Exchange Rate of February 2005

Date	Forecast Gold Price(without exchange rate, $)	Forecast Gold Price(with exchange rate, $)	Actual Gold Price, $	MAPE(without exchange rate)	MAPE(with exchange rate)
1-Mar-05	425.55	428.13	434.65	2.09	1.50
2-Mar-05	425.67	428.95	429.15	0.81	0.05
3-Mar-05	426.03	428.49	433.25	1.67	1.10
4-Mar-05	426.34	428.26	429.65	0.77	0.32
7-Mar-05	427.15	428.20	433.60	1.49	1.25
8-Mar-05	428.77	427.83	434.85	1.40	1.61
9-Mar-05	429.36	427.65	439.90	2.40	2.78
10-Mar-05	427.00	427.44	440.20	3.00	2.90
11-Mar-05	425.58	427.28	440.95	3.49	3.10
14-Mar-05	431.65	428.96	442.75	2.51	3.11
15-Mar-05	430.18	430.41	442.00	2.67	2.62
16-Mar-05	430.96	431.58	441.20	2.32	2.18
17-Mar-05	435.74	432.27	442.65	1.56	2.34
18-Mar-05	435.18	432.22	436.65	0.34	1.02
21-Mar-05	435.65	432.50	436.25	0.14	0.86
22-Mar-05	436.11	432.89	430.65	1.27	0.52
23-Mar-05	436.13	432.00	427.25	2.08	1.11
24-Mar-05	436.83	430.40	424.90	2.81	1.29
29-Mar-05	432.37	430.40	426.95	1.27	0.81
30-Mar-05	434.44	431.40	426.50	1.86	1.15
31-Mar-05	429.10	429.66	427.50	0.37	0.74
Average MAPE:				1.72952381	1.54095238

Table 4.2: Comparison MAPE of forecasted gold price with exchange rate and without exchange rate for March 2005

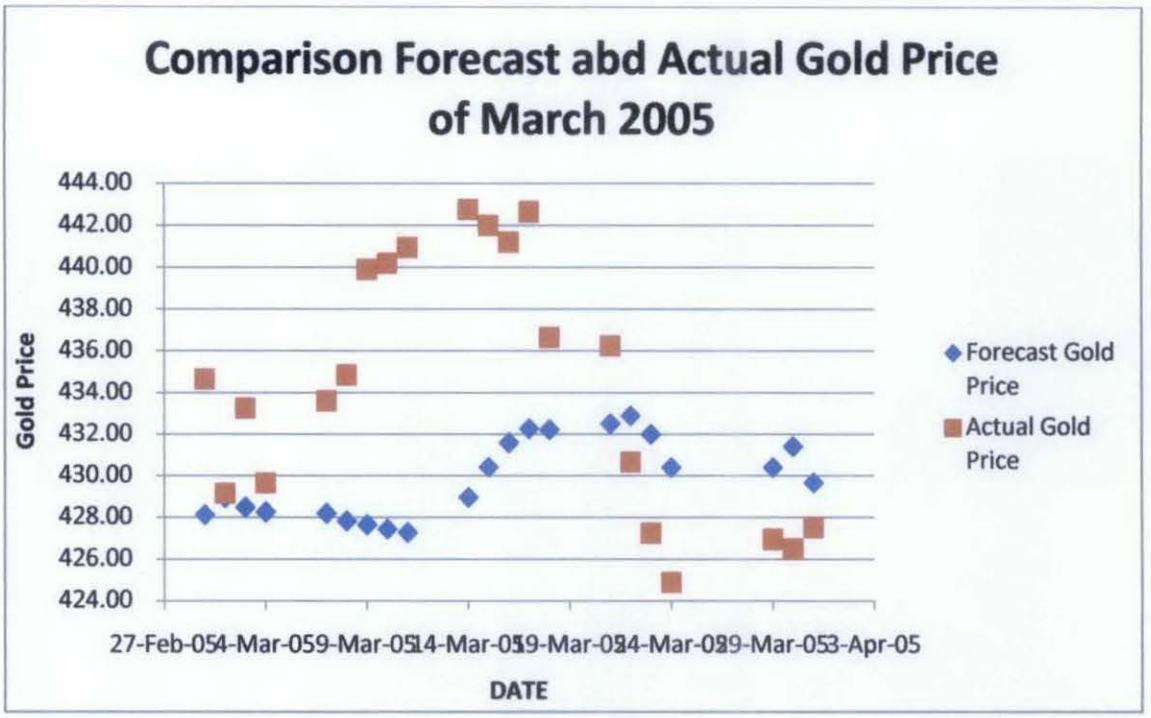


Figure 4.3: Comparison Forecast with Exchange Rate and Actual gold Price of March 2005

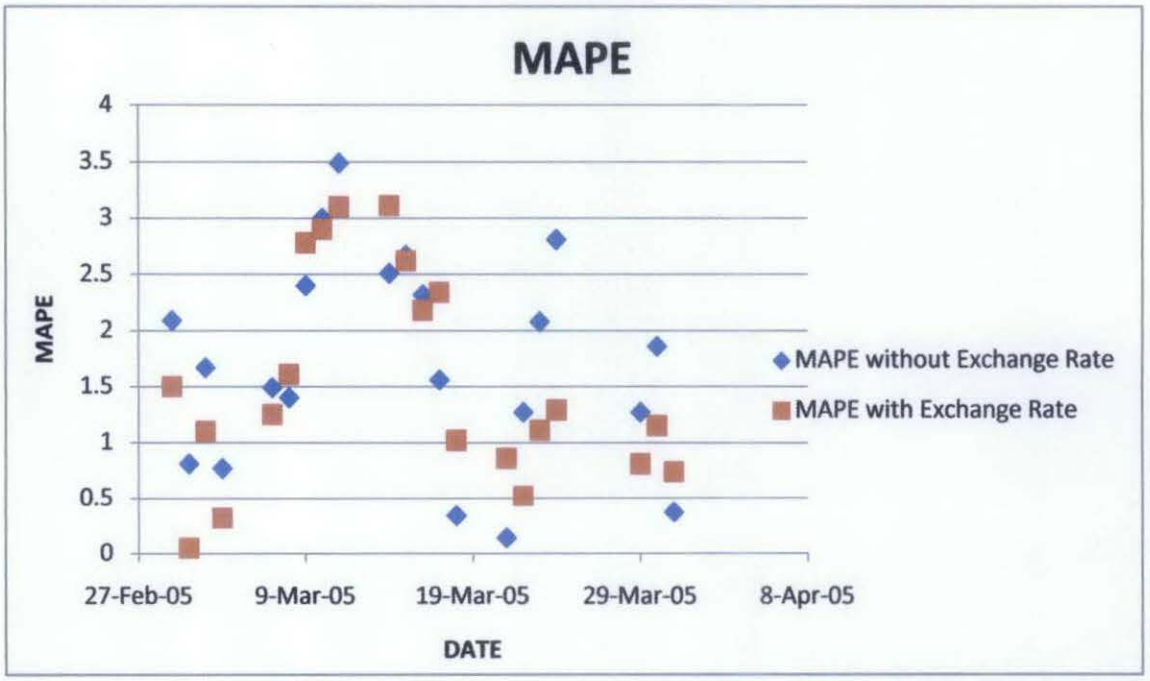


Figure 4.4: Comparison MAPE for Gold Price Forecast with Exchange Rate as input and without Exchange Rate of March 2005

After searching for the most suitable method that will result in the lowest error, the model was applied to forecast the gold price for recent data which is for November 2011.

Date	Actual gold price	Forecasted gold price	(MAPE)
1-Nov-11	1702	1,726.99	1.47
2-Nov-11	1731	1,735.00	0.23
3-Nov-11	1732.5	1,735.76	0.19
4-Nov-11	1756	1,742.82	0.75
7-Nov-11	1764	1,748.35	0.89
8-Nov-11	1794	1752.304	2.32
9-Nov-11	1780	1748	1.80
10-Nov-11	1766	1754.542	0.65
11-Nov-11	1764	1761	0.17
14-Nov-11	1780.5	1758.888	1.21
15-Nov-11	1765	1760.55	0.25
16-Nov-11	1773	1758.77	0.80
17-Nov-11	1756	1759.484	0.20
18-Nov-11	1730	1755.128	1.45
21-Nov-11	1704	1750.726	2.74
22-Nov-11	1697.5	1748	2.97
23-Nov-11	1686	1746.218	3.57
24-Nov-11	1699	1737.762	2.28
25-Nov-11	1676	1730.8	3.27
28-Nov-11	1714	1,720.90	0.40
29-Nov-11	1717	1,718.01	0.06
30-Nov-11	1704	1,715.49	0.67
		Average MAPE=	1.288181818

Table 4.3: Comparison of Forecasted and Actual Gold Price for November 2011.

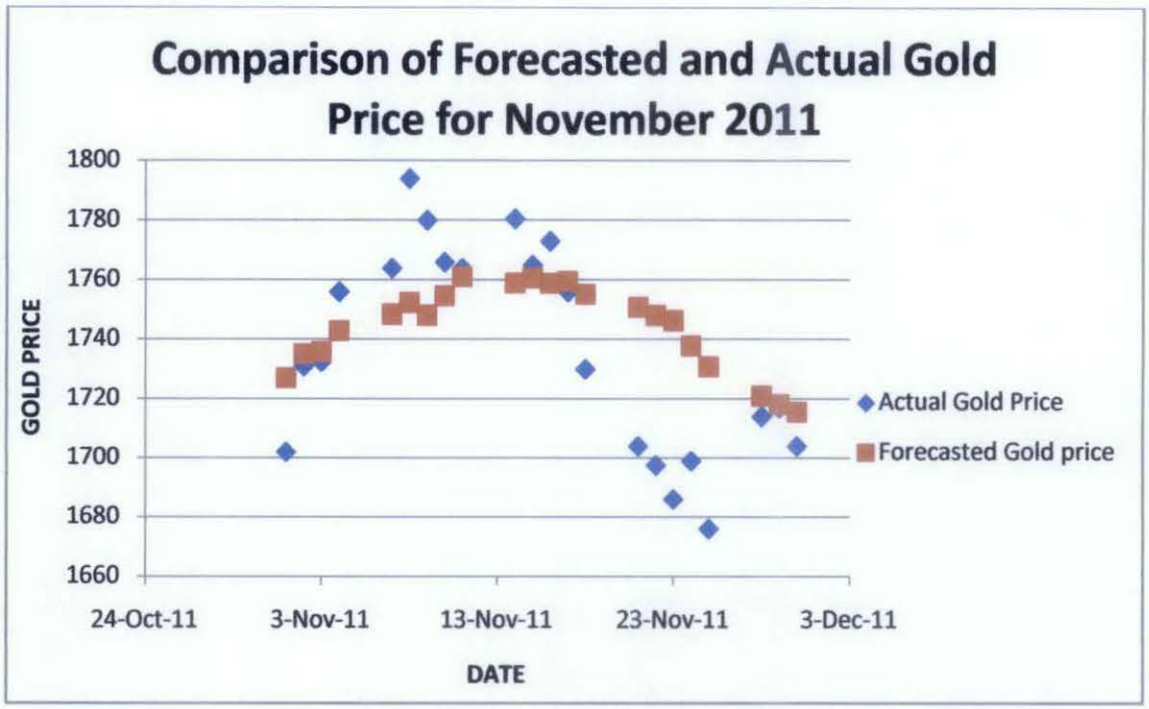


Figure 4.5: Chart Comparison of Forecasted and Actual Gold Price for November 2011

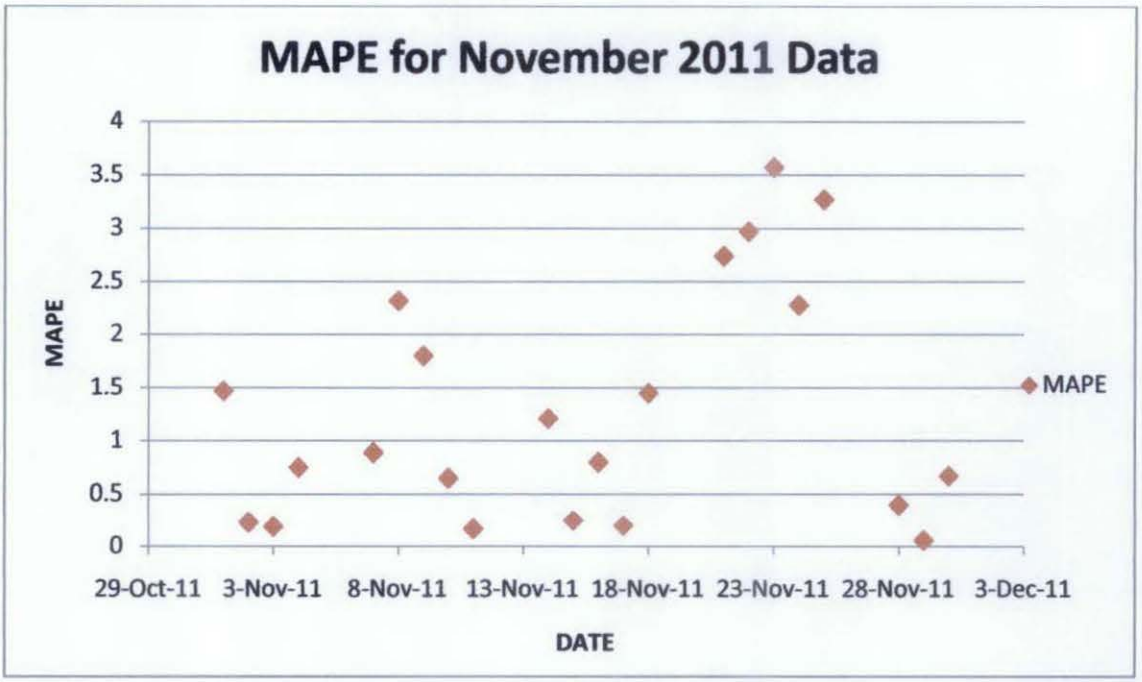


Figure 4.6: MAPE for November 2011 Data

4.2 Discussion

4.2.1 Output computation in FuzzyTECH

In the fuzzyTECH program, the result of the output computation will be shown in the *Watch: Interactive Debug Mode* window.

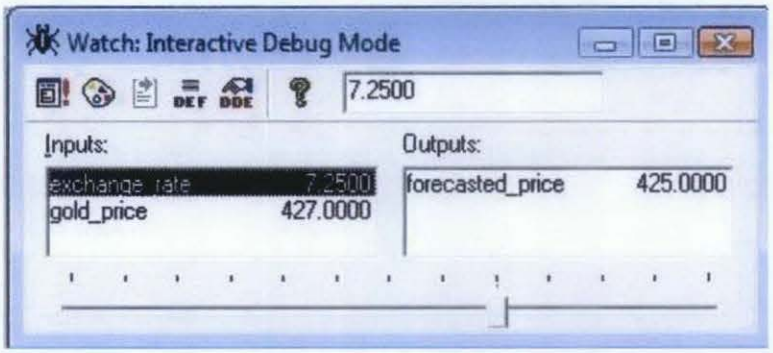


Figure 4.7: Watch: Interactive Debug Mode window

In the Center of Maximum (CoM) defuzzification method, the fuzzy logic controller first determines the typical numerical value for each scaled membership function. The typical numerical value is the mean of the numerical values corresponding to the degree of membership at which the membership function was scaled. The fuzzy logic controller then uses the following equation to calculate a weighted average of the typical values.

$$x_{final}=\frac{(x_1\mu_1+x_2\mu_2+\cdots+x_n\mu_n)}{(\mu_1+\mu_2+\cdots+\mu_n)} \quad (4.1)$$

Where x_n is the typical numerical value for the scaled membership function n, and μ_n is the degree of membership at which membership function n was scaled. Figure 4.7 illustrates how to use the CoM defuzzification method.

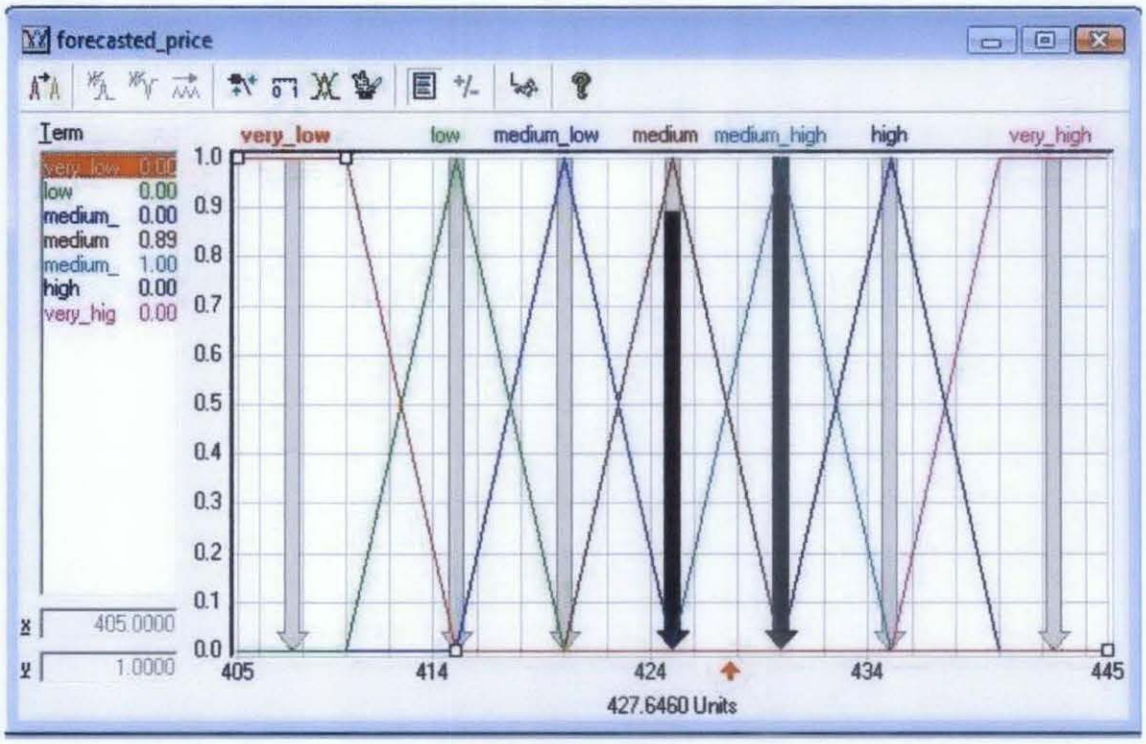


Figure 4.8: Example of Output variable for Forecast Gold Price

The values 425 and 430 are the typical values of the linguistic terms *medium* and *medium high*. The degrees of truth for these linguistic terms are 0.89 and 1.00, respectively. Therefore, the defuzzified crisp output value is calculated by the following equation:

$$x_{final} = \frac{((430)(1.00) + (425)(o.89)}{(1.00 + 0.89)} = 427.646$$

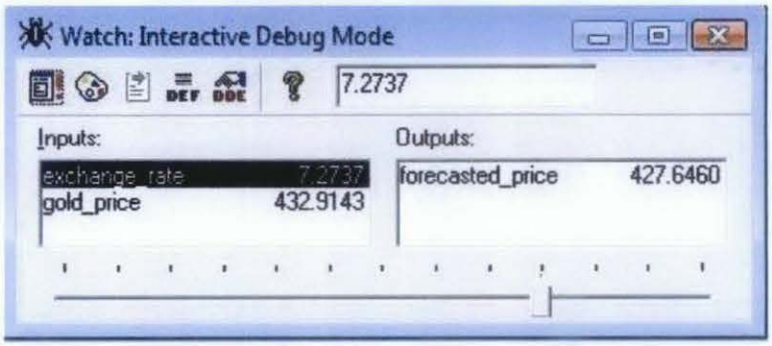


Figure 4.9: Output from Debug mode

In previous semester, the model only considered historic gold price as the input and the rule base was designated based on that factor only. The results based on that single factor are 1.495 averages MAPE for February 2005 and for March 2005 is 1.773. This shown that different month will result in different MAPE but they are still in the acceptable range of MAPE. Indeed, still a very small error.

However, for this semester some enhancement has been done that is adding exchange rate in the input variable. Referring to Table 4.1 and Table 4.2, MAPE for both months has improved with adding on exchange rate in input variable. MAPE for February is 1.370 and for March is 1.540. The MAPE when the model was applied to recent data which is November 2011 is 1.288.

Based on the analysis of above comparison graph and MAPE, it can be said that FuzzyTech is a very suitable tools to forecast the future gold price. The small error occur might due to other unconsidered inputs such as crude oil price, gold demand, etc. So, it can be said that daily forecasting gold price based on historic gold price and exchange rate data using FuzzyTech software is a success.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Throughout history, gold played the role as precious metals and usually considered as substitutes to reduce risks in portfolios. People can benefits lots from gold investment and it was one of the strongest points about the significance of gold. Thus, the short term gold price forecasting is needed as it can guide the investor who wants to do daily gold speculation. Short term gold price forecasting was performed for the daily historic gold price in month of February and March 2005. These two months was chosen arbitrarily of all the other previous gold price data.

The two most related factors which determined the forecasted gold price had also being decided. They are the historic gold price and the exchange rate. For the exchange rate, the GBP and USD value were chosen because they are the two major currencies in the world. The numbers of membership function in the fuzzy logic were also being expanded which resulting in lower error. Membership functions is the key in defining the values of input and output terms used in the rules. Expand the membership function lead to more accurate process in classifying the data into appropriate class based on their values.

The forecasting methodology with fuzzy parameters gives acceptable short term gold price forecasting results and they are below the range of 2% MAPE. The modification on DoS and IF-THEN rules on each rule blocks show significant decrement in the MAPE. Then, it is proven in this project that is by considering more factors in forecasting the gold price, resulting in more accurate forecasted value.

The fuzzyTECH software makes the implementation of fuzzy logic for the gold price forecasting model easier since fuzzy logic requires advanced in mathematical modeling. The overall steps taken to implement the model consist of finding the suitable inputs to forecast the gold price, construct reliable rule blocks and then test the rule blocks on any random historic year, reconstruct the rule block if the resulting error is big and finally, applied the method to recent data.

5.2 Recommendation

For enhancements, it is recommended to expand the membership function for both inputs and output. As there is no limitation number of membership function, then it should be increase until the error achieve is tremendously small. As for now, there are nine classes of membership function being employed for both output and inputs.

In addition, by further increase the number of rules and adding more input variables such as crude oil price and data of gold demand can also lead to a better system model. If the numbers of rules are increased, more inputs are being considered this may improve the system model accuracy. The inputs variable should be chosen based on the factors that affect the movement of gold price the most. Recent research should be done as the gold price is affected by the economics factors the most and the economic condition is always changes by time.

CHAPTER 6

PROJECT ACTIVITIES,GANTT CHART, KEY MILESTONE

6.1 Project Activities

There are quite number of activities in this project such as:

1. Reading and research material that could expand knowledge about gold, gold trading and forecasting.
2. Understanding the importance of gold price forecasting.
3. Compare different forecasting methods to help find the best result for forecasting.
4. Choose the suitable inputs with the numerical data which affect the gold price as the inputs of the fuzzy model system.
5. Understanding of fuzzy logic theory and its modeling configuration.
6. Construct Fuzzy logic model for gold price forecasting.
7. Study about the exchange rate mainly on the United States Dollar and British Pound.
8. Study the relationship between the exchange rate and gold price.
9. Do simulation using fuzzy logic system to forecast future gold price.
10. Analyze the result and try to enhance the current Fuzzy logic model

6.2Gantt chart

GANTT CHART FYP 1

No.	Detail/Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Selection of Project Topic															
2	Study about gold, gold trading and gold price forecasting															
3	Research on Fuzzy logic concept in forecasting field															
4	Familiarize and understand about Fuzzy logic software															
5	Submission of Extended Proposal						●									
6	Proposal Defense															
7	Simulate historic gold price data using fuzzy logic software															
8	Submission of Interim Draft Report														●	
10	Submission of Interim Report															●

Process ● Suggested Milestone

GANTT CHART FYP 2

No.	Detail/Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14	15
1	Project Work Continues	■	■	■	■	■	■	■									
2	Submission of Progress Report									●							
3	Project Work Continues									■	■	■	■	■			
4	Pre-EDX												●				
5	SSubmission of Draft Report													●			
6	Submission of Dissertation (soft bound)														●		
7	Submission of Technical Paper														●		
8	Oral Presentation															●	
10	Submission of Project Dissertation (Hard Bound)																●

■ Process ● Suggested Milestone

6.3Key Milestone

The key milestones of this project are:

1. Summary of gold price and literature review of gold, gold trading and forecasting to be completed at week3 of FYP I.
2. Summary about the importance of gold price forecasting to be completed at week 4 of FYP I.
3. Comparisonbetween different forecasting methods and come out with the best method for gold price forecasting to be completed at week6 of FYP I.
4. Simulation to forecast future gold price using fuzzy logic system to be completed at week 12 of FYP I.
5. Enhancement of fuzzy logic model to be completed at week 3 of FYP II.
6. Summary of fuzzy logic theory and its modeling configuration to be completed at week3 of FYP II.
7. Simulation to forecast future gold price using fuzzy logic system to be completed at week7 of FYP II.

REFERENCES

[1] Lorie, J.H., D. Peter and K.M. Hamilton 1985. The Stock Market: Theories and Evidence. 2nd Edn., Dow Jones-Irwin, Homewood, ISBN: 10: 0870946188, pp: 192.

[2] Ismail, Z., F. Jamaluddin and F. Jamaludin, 2008. Time series regression model for forecasting Malaysian electricity load demand.Asian J. Math. Stat., 1: 139-149. DOI: 10.3923/ajms.2008.139.149.

[3] Michael Moore, (2007), London Gold Price, http://buying-gold.goldprice.org/2007/04/london-gold-prices.html, 13 March 2011.

[4] American Journal of Applied Sciences 6. Forecasting Gold Prices Using Multiple Linear Regression Method. Z. Ismail,A. Yahya and A. Shabri Department of Mathematics, Faculty of Science Department of Basic Education, Faculty of Education University Technology Malaysia.

[5] Jason Van Bergen, (2010), 6 Factors That Influence Exchange Rates, http://www.investopedia.com/articles/basics/04/050704.asp#axzz1hJwZQzmo, 15 October 2011.

[6] Reem Heakal, (2005), Cost-Push Inflation Versus Demand-Pull inflation, http://www.investopedia.com/articles/05/012005.asp#axzz1hJwZQzmo, 13 November 2011.

[7] Jon Kicklighter, (2011), Dollar Will Keep Its Bid as Fear Continues to Win Out Againts Hope, http://www.dailyfx.com, 20 November 2011.

[8] M. C. Lineesh, K. K. Minu and C. Jessy John (2010), Analysis of nonstationary Nonlinear Economic Time Series of Gold Price: A Comparative Study, International Mathematical Forum, 5, no. 34, 1673 – 1683.

[9] [12]World Gold Council, http://www.gold.org/about_gold/story_of_gold/, 3 June 2011.

[10] Gold Yabz, (2007), Facts about Gold, http://gold.yabz.com/facts.htm, 27 May 2011.

[11] Kitco, Historical Gold Charts, http://www.kitco.com/scripts/hist_charts/yearly_graphs.plx, 22 July 2011.

[13] Blanchard and Company Inc, Investing in Gold:New Investors, http://www.blanchardonline.com, 24 July 2011.

[14] Investopedia, Forecasting, http://www.investopedia.com/terms/f/forecasting.asp#ixzz1Q0TfBS6d, 17 July 2011.

[15] Armstrong, J. S. (2001b), Combining Forecasts. In: J. S.Armstrong (Ed.), Principles of Forecasting. Boston: Kluwer Academic Publishers.

[16] SeekinGold, Short and Long Term Gold Forecast, http://seekingold.com/index.php/Gold-Price-Trend/Long-Term-Forecast-of-Gold-Price.htm, 16 July 2011.

[17] Mukaidono, Masao, (2001), Fuzzy Logic for Beginners, http://mathematica.ludibunda.ch/fuzzy-logic7.html, 25 May 2011.

[18] Amine Trabelsi, Frederic Lafont, Mohamed Kamoun, Gilles Enea (2007), Fuzzy identification of a greenhouse, Applied Soft Computing, 1092–1101.

[19] Y. Nakamori and M. Ryoke (1994), "Identification of fuzzy prediction models through hyperellipsoidal clustering," IEEE Trans. Syst., Man, Cybern., vol. 24, 1153–1173.

[20] Fuzzy genomes by KazemSadegh-Zadeh. *Theory of Medicine Department, University of Mu¨nster Medical Institutions, Waldeyer Street* 27, *Mu¨nster*48149, *Germany.* www.elsevier.com:locate:artmed.

APPENDICES

APPENDIX A

Data of gold price(USD).

February 2005

1-Feb	2-Feb	3-Feb	4-Feb	7-Feb	8-Feb	9-Feb	10-Feb	11-Feb
21Jan-31Jan	24Jan-1Feb	25Jan-2Feb	26Jan-3Feb	27Jan-4Feb	28Jan-7Feb	31Jan-8Feb	1-9Feb	2-10Feb
423.3	427.6	426.2	423.7	426.3	426.4	423.8	421.15	421.9
427.6	426.2	423.7	426.3	426.4	423.8	421.15	421.9	419.8
426.2	423.7	426.3	426.4	423.8	421.15	421.9	419.8	416.5
423.7	426.3	426.4	423.8	421.15	421.9	419.8	416.5	414.5
426.3	426.4	423.8	421.15	421.9	419.8	416.5	414.5	411.5
426.4	423.8	421.15	421.9	419.8	416.5	414.5	411.5	413.2
423.8	421.15	421.9	419.8	416.5	414.5	411.5	413.2	413.5
425.328571	425.021429	424.207143	423.292857	422.264286	420.5786	418.45	416.9357	415.8429

14-Feb	15-Feb	16-Feb	17-Feb	18-Feb	21-Feb	22-Feb	23-Feb	24-Feb	25-Feb	28-Feb
3-11Feb	4-14Feb	7-15Feb	8-16Feb	9-17Feb	10-18Feb	11-21Feb	14-22Feb	15-23Feb	16-24Feb	17-25Feb
419.8	416.5	414.5	411.5	413.2	413.5	417.05	422.8	424.6	424.15	426.6
416.5	414.5	411.5	413.2	413.5	417.05	422.8	424.6	424.15	426.6	426.55
414.5	411.5	413.2	413.5	417.05	422.8	424.6	424.15	426.6	426.55	427.1
411.5	413.2	413.5	417.05	422.8	424.6	424.15	426.6	426.55	427.1	430.75
413.2	413.5	417.05	422.8	424.6	424.15	426.6	426.55	427.1	430.75	433.25
413.5	417.05	422.8	424.6	424.15	426.6	426.55	427.1	430.75	433.25	434.75
417.05	422.8	424.6	424.15	426.6	426.55	427.1	430.75	433.25	434.75	432.4
415.15	415.578571	416.735714	418.114286	420.271429	422.1786	424.1214	426.0786	427.5714	429.0214	430.2

1-Mar	2-Mar	3-Mar	4-Mar	7-Mar	8-Mar	9-Mar	10-Mar	11-Mar	14-Mar	15-Mar
18-28Feb	21Feb-1Mar	22Feb-2Mar	23Feb-3Mar	24Feb-4Mar	25Feb-7Mar	28Feb-3Mar	1-9Mar	2-10Mar	3-11Mar	4-14Mar
426.55	427.1	430.75	433.25	434.75	432.4	436.55	434.65	429.15	433.25	429.65
427.1	430.75	433.25	434.75	432.4	436.55	434.65	429.15	433.25	429.65	433.6
430.75	433.25	434.75	432.4	436.55	434.65	429.15	433.25	429.65	433.6	434.85
433.25	434.75	432.4	436.55	434.65	429.15	433.25	429.65	433.6	434.85	439.9
434.75	432.4	436.55	434.65	429.15	433.25	429.65	433.6	434.85	439.9	440.2
432.4	436.55	434.65	429.15	433.25	429.65	433.6	434.85	439.9	440.2	440.95
436.55	434.65	429.15	433.25	429.65	433.6	434.85	439.9	440.2	440.95	442.75
431.621429	432.778571	433.071429	433.428571	432.914286	432.75	433.1	433.5786	434.3714	436.0571	437.4143

16-Mar	17-Mar	18-Mar	21-Mar	22-Mar	23-Mar	24-Mar	29-Mar	30-Mar	31-Mar
7-15Mar	8-16Mar	9-17Mar	10-18Mar	11-21Mar	14-22Mar	15-23Mar	16-24Mar	17-29Mar	18-30Mar
433.6	434.85	439.9	440.2	440.95	442.75	442	441.2	442.65	436.65
434.85	439.9	440.2	440.95	442.75	442	441.2	442.65	436.65	436.25
439.9	440.2	440.95	442.75	442	441.2	442.65	436.65	436.25	430.65
440.2	440.95	442.75	442	441.2	442.65	436.65	436.25	430.65	427.25
440.95	442.75	442	441.2	442.65	436.65	436.25	430.65	427.25	424.9
442.75	442	441.2	442.65	436.65	436.25	430.65	427.25	424.9	426.95
442	441.2	442.65	436.65	436.25	430.65	427.25	424.9	426.95	426.5
439.178571	440.264286	441.378571	440.914286	440.35	438.8786	436.6643	434.2214	432.1857	429.8786

November 2011

1-Nov	2-Nov	3-Nov	4-Nov	7-Nov	8-Nov	9-Nov	10-Nov	11-Nov	14-Nov	15-Nov	16-Nov
21Oct-31oct	24oct-1nov	25oct-2nov	26oct-3nov	27Oct-4Nov	28Oct-7Nov	31Oct-8Nov	1-9Nob	2-10Nov	3-11Nov	4-14Nov	7-15Nov
1623	1651	1656.25	1713	1708	1735	1718	1702	1731	1732.5	1756	1764
1651	1656.25	1713	1708	1735	1718	1702	1731	1732.5	1756	1764	1794
1656.25	1713	1708	1735	1718	1702	1731	1732.5	1756	1764	1794	1780
1713	1708	1735	1718	1702	1731	1732.5	1756	1764	1794	1780	1766
1708	1735	1718	1702	1731	1732.5	1756	1764	1794	1780	1766	1764
1735	1718	1702	1731	1732.5	1756	1764	1794	1780	1766	1764	1780.5
1718	1702	1731	1732.5	1756	1764	1794	1780	1766	1764	1780.5	1765
1686.321	1697.607	1709.036	1719.929	1726.071	1734.071	1742.5	1751.357	1760.5	1765.214	1772.071	1773.357

17-Nov	18-Nov	21-Nov	22-Nov	23-Nov	24-Nov	25-Nov	28-Nov	29-Nov	30-Nov
8-16Nov	9-17Nov	10-18Nov	11-21Nov	14-22Nov	15-23Nov	16-24Nov	17-25Nov	18-28Nov	21-29Nov
1794	1780	1766	1764	1780.5	1765	1773	1756	1730	1704
1780	1766	1764	1780.5	1765	1773	1756	1730	1704	1697.5
1766	1764	1780.5	1765	1773	1756	1730	1704	1697.5	1686
1764	1780.5	1765	1773	1756	1730	1704	1697.5	1686	1699
1780.5	1765	1773	1756	1730	1704	1697.5	1686	1699	1676
1765	1773	1756	1730	1704	1697.5	1686	1699	1676	1714
1773	1756	1730	1704	1697.5	1686	1699	1676	1714	1717
1774.643	1769.214	1762.071	1753.214	1743.714	1730.214	1720.786	1706.929	1700.929	1699.071

▭ Average 7 days value of gold price

Data of Exchange Rate

The exchange rate for month February and March 2005 were in British Pound currency(GBP).

February 2005

1-Feb	2-Feb	3-Feb	4-Feb	7-Feb	8-Feb	9-Feb	10-Feb	11-Feb	14-Feb
20Jan-31Jan	24Jan-1Feb	25Jan-2Feb	26Jan-3Feb	27Jan-4Feb	28Jan-7Feb	31Jan-8Feb	1-9Feb	2-10Feb	3-11Feb
7.1157	7.1305	7.1402	7.1039	7.1522	7.1716	7.1716	7.1617	7.1611	7.1586
7.1305	7.1402	7.1039	7.1522	7.1716	7.1716	7.1617	7.1611	7.1586	7.1467
7.1402	7.1039	7.1522	7.1716	7.1716	7.1617	7.1611	7.1586	7.1467	7.1166
7.1039	7.1522	7.1716	7.1716	7.1617	7.1611	7.1586	7.1467	7.1166	7.0574
7.1522	7.1716	7.1716	7.1617	7.1611	7.1586	7.1467	7.1166	7.0574	7.0574
7.1716	7.1617	7.1617	7.1611	7.1586	7.1467	7.1166	7.0574	7.0574	7.0574
7.1617	7.1617	7.1611	7.1586	7.1467	7.1166	7.0574	7.0574	7.0574	7.0574
7.1394	7.145971	7.151757	7.154386	7.1605	7.155414	7.1391	7.122786	7.107886	7.093071

15-Feb	16-Feb	17-Feb	18-Feb	21-Feb	22-Feb	23-Feb	24-Feb	25-Feb	28-Feb
4-14Feb	7-15Feb	8-16Feb	9-17Feb	10-18Feb	11-21Feb	14-22Feb	15-23Feb	16-24Feb	17-25Feb
7.1467	7.1166	7.0574	7.0574	7.0574	7.0574	7.1349	7.1659	7.1974	7.1636
7.1166	7.0574	7.0574	7.0574	7.0574	7.1349	7.1659	7.1974	7.1636	7.1966
7.0574	7.0574	7.0574	7.0574	7.1349	7.1659	7.1974	7.1636	7.1966	7.1913
7.0574	7.0574	7.0574	7.1349	7.1659	7.1974	7.1636	7.1966	7.1913	7.2261
7.0574	7.0574	7.1349	7.1659	7.1974	7.1636	7.1966	7.1913	7.2261	7.251
7.0574	7.1349	7.1659	7.1974	7.1636	7.1966	7.1913	7.2261	7.251	7.255
7.1349	7.1659	7.1974	7.1636	7.1966	7.1913	7.2261	7.251	7.255	7.2601
7.089686	7.092429	7.103971	7.119143	7.139029	7.158157	7.182257	7.198843	7.211571	7.220529

March 2005

1-Mar	2-Mar	3-Mar	4-Mar	7-Mar	8-Mar	9-Mar	10-Mar	11-Mar	14-Mar	15-Mar
18-28Feb	21Feb-1Mar	22Feb-2Mar	23Feb-3Mar	24Feb-4Mar	25Feb-7Mar	28Feb-8Mar	1-9Mar	2-10Mar	3-11Mar	4-14Mar
7.1966	7.1913	7.2261	7.251	7.255	7.2601	7.3065	7.2943	7.2871	7.2664	7.2464
7.1913	7.2261	7.251	7.255	7.2601	7.3065	7.2943	7.2871	7.2664	7.2464	7.3013
7.2261	7.251	7.255	7.2601	7.3065	7.2943	7.2871	7.2664	7.2464	7.3013	7.2781
7.251	7.255	7.2601	7.3065	7.2943	7.2871	7.2664	7.2464	7.3013	7.2781	7.3253
7.255	7.2601	7.3065	7.2943	7.2871	7.2664	7.2464	7.3013	7.2781	7.3253	7.3253
7.2601	7.3065	7.2943	7.2871	7.2664	7.2464	7.3013	7.2781	7.3253	7.3253	7.3101
7.3065	7.2943	7.2871	7.2664	7.2464	7.3013	7.2781	7.3253	7.3253	7.3101	7.308
7.240943	7.2549	7.268586	7.274343	7.273686	7.2803	7.282871	7.285557	7.289986	7.293271	7.299214

16-Mar	17-Mar	18-Mar	21-Mar	22-Mar	23-Mar	24-Mar	29-Mar	30-Mar	31-Mar
7-15Mar	8-16Mar	9-17Mar	10-18Mar	11-21Mar	14-22Mar	15-23Mar	16-24Mar	17-29Mar	18-30Mar
7.3013	7.2781	7.3253	7.3253	7.3101	7.308	7.2795	7.2677	7.269	7.2115
7.2781	7.3253	7.3253	7.3101	7.308	7.2795	7.2677	7.3118	7.2115	7.1685
7.3253	7.3253	7.3101	7.308	7.2795	7.2677	7.3118	7.3076	7.1685	7.1087
7.3253	7.3101	7.308	7.2795	7.2677	7.3118	7.3076	7.269	7.1087	7.1037
7.3101	7.308	7.2795	7.2677	7.3118	7.3076	7.269	7.2115	7.1037	7.0798
7.308	7.2795	7.2677	7.3118	7.3076	7.269	7.2115	7.1685	7.0798	7.1014
7.2795	7.2677	7.3118	7.3076	7.269	7.2115	7.1685	7.1087	7.1014	7.137
7.303943	7.299143	7.303957	7.301429	7.293386	7.2793	7.259371	7.234971	7.148943	7.130086

The exchange rate for month November are in term of United States Dolar(USD)

November 2011

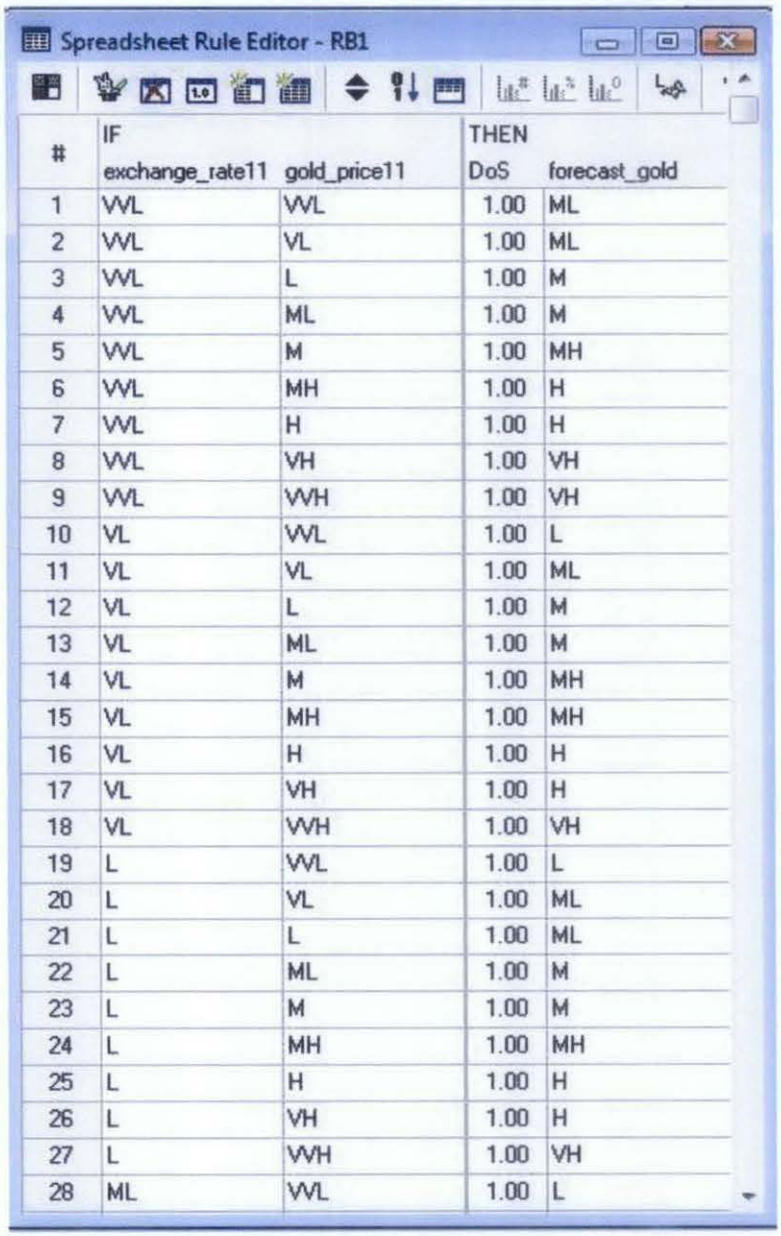
1-Nov	2-Nov	3-Nov	4-Nov	7-Nov	8-Nov	9-Nov	10-Nov	11-Nov	14-Nov	15-Nov
21Oct-31oct	24oct-1nov	25oct-2nov	26oct-3nov	27Oct-4Nov	28Oct-7Nov	31Oct-8Nov	1-9Nov	2-10Nov	3-11Nov	4-14Nov
3.158	3.1288	3.1267	3.1267	3.1315	3.0735	3.0735	3.0965	3.1275	3.147	3.1225
3.158	3.1267	3.1267	3.1315	3.0735	3.0735	3.0965	3.1275	3.147	3.1225	3.1225
3.1288	3.1267	3.1315	3.0735	3.0735	3.0965	3.1275	3.147	3.1225	3.1225	3.126
3.1267	3.1315	3.0735	3.0735	3.0965	3.1275	3.147	3.1225	3.1225	3.126	3.1105
3.1315	3.0735	3.0735	3.0965	3.1275	3.147	3.1225	3.1225	3.126	3.1105	3.1515
3.0735	3.0735	3.0965	3.1275	3.147	3.1225	3.1225	3.126	3.1105	3.1515	3.149
3.0735	3.0965	3.1275	3.147	3.1225	3.1225	3.126	3.1105	3.1515	3.149	3.1315
3.121429	3.108171	3.10799	3.110886	3.110286	3.109	3.1165	3.121786	3.129643	3.132714	3.1305

16-Nov	17-Nov	18-Nov	21-Nov	22-Nov	23-Nov	24-Nov	25-Nov	28-Nov	29-Nov	30-Nov
7-15Nov	8-16Nov	9-17Nov	10-18Nov	11-21Nov	14-22Nov	15-23Nov	16-24Nov	17-25Nov	18-28Nov	21-29Nov
3.1225	3.126	3.1105	3.1515	3.149	3.1315	3.143	3.1658	3.159	3.1612	3.1725
3.126	3.1105	3.1515	3.149	3.1315	3.143	3.1658	3.159	3.1612	3.1725	3.188
3.1105	3.1515	3.149	3.1315	3.143	3.1658	3.159	3.1612	3.1725	3.188	3.1825
3.1515	3.149	3.1315	3.143	3.1658	3.159	3.1612	3.1725	3.188	3.1825	3.1865
3.149	3.1315	3.143	3.1658	3.159	3.1612	3.1725	3.188	3.1825	3.1865	3.192
3.1315	3.143	3.1658	3.159	3.1612	3.1725	3.188	3.1825	3.1865	3.192	3.192
3.143	3.1658	3.159	3.1612	3.1725	3.188	3.1825	3.1865	3.192	3.192	3.1835
3.133429	3.139614	3.144329	3.151571	3.154571	3.160143	3.167429	3.173643	3.17739	3.1821	3.185286

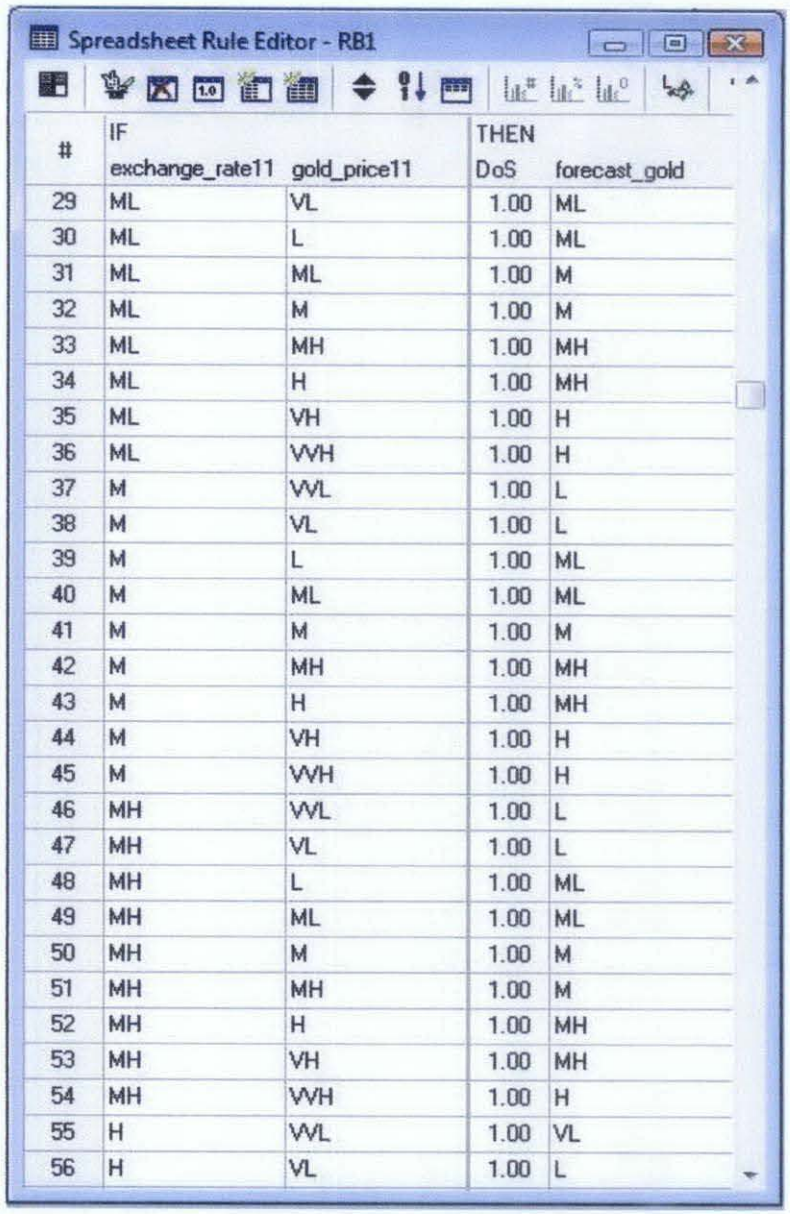
Average 7 days value of exchange rate

APPENDIX B

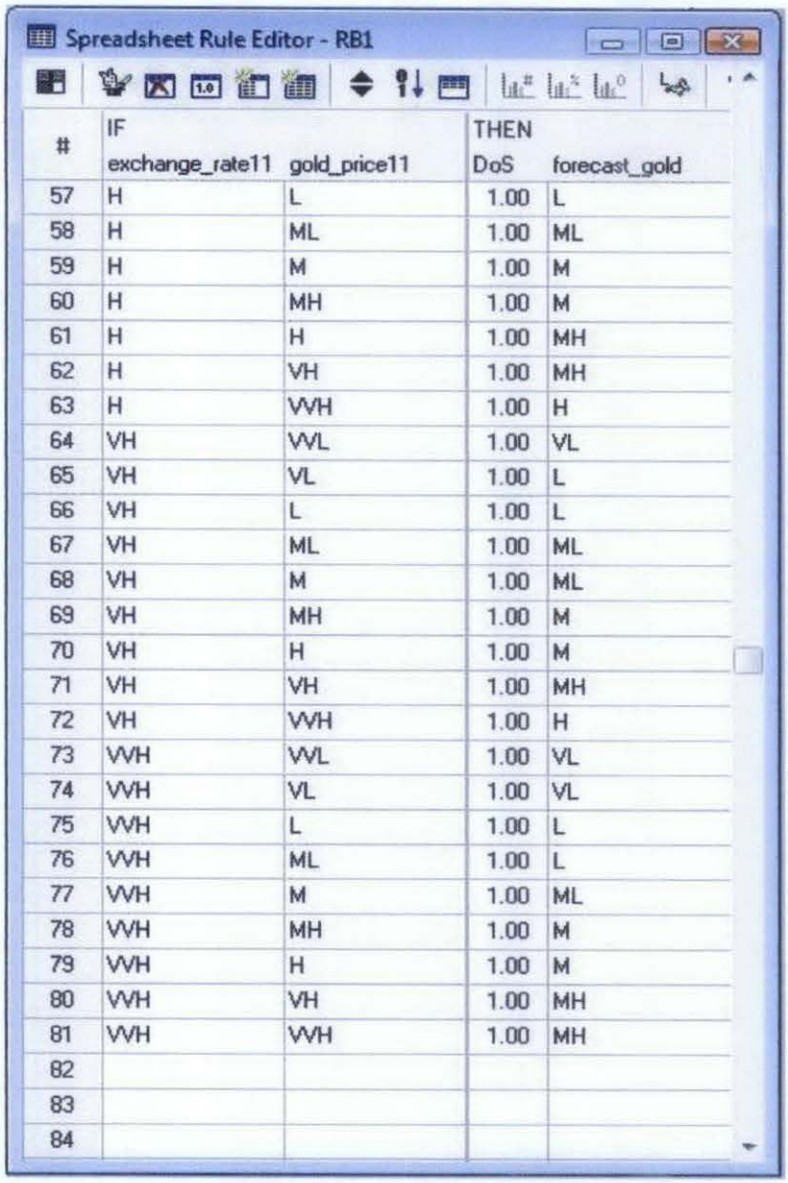
New Rule Base



#	IF		THEN	
	exchange_rate11	gold_price11	DoS	forecast_gold
1	VVL	VVL	1.00	ML
2	VVL	VL	1.00	ML
3	VVL	L	1.00	M
4	VVL	ML	1.00	M
5	VVL	M	1.00	MH
6	VVL	MH	1.00	H
7	VVL	H	1.00	H
8	VVL	VH	1.00	VH
9	VVL	VVH	1.00	VH
10	VL	VVL	1.00	L
11	VL	VL	1.00	ML
12	VL	L	1.00	M
13	VL	ML	1.00	M
14	VL	M	1.00	MH
15	VL	MH	1.00	MH
16	VL	H	1.00	H
17	VL	VH	1.00	H
18	VL	VVH	1.00	VH
19	L	VVL	1.00	L
20	L	VL	1.00	ML
21	L	L	1.00	ML
22	L	ML	1.00	M
23	L	M	1.00	M
24	L	MH	1.00	MH
25	L	H	1.00	H
26	L	VH	1.00	H
27	L	VVH	1.00	VH
28	ML	VVL	1.00	L



#	IF		THEN	
	exchange_rate11	gold_price11	DoS	forecast_gold
29	ML	VL	1.00	ML
30	ML	L	1.00	ML
31	ML	ML	1.00	M
32	ML	M	1.00	M
33	ML	MH	1.00	MH
34	ML	H	1.00	MH
35	ML	VH	1.00	H
36	ML	VVH	1.00	H
37	M	VVL	1.00	L
38	M	VL	1.00	L
39	M	L	1.00	ML
40	M	ML	1.00	ML
41	M	M	1.00	M
42	M	MH	1.00	MH
43	M	H	1.00	MH
44	M	VH	1.00	H
45	M	VVH	1.00	H
46	MH	VVL	1.00	L
47	MH	VL	1.00	L
48	MH	L	1.00	ML
49	MH	ML	1.00	ML
50	MH	M	1.00	M
51	MH	MH	1.00	M
52	MH	H	1.00	MH
53	MH	VH	1.00	MH
54	MH	VVH	1.00	H
55	H	VVL	1.00	VL
56	H	VL	1.00	L



#	IF		THEN	
	exchange_rate11	gold_price11	DoS	forecast_gold
57	H	L	1.00	L
58	H	ML	1.00	ML
59	H	M	1.00	M
60	H	MH	1.00	M
61	H	H	1.00	MH
62	H	VH	1.00	MH
63	H	VVH	1.00	H
64	VH	VVL	1.00	VL
65	VH	VL	1.00	L
66	VH	L	1.00	L
67	VH	ML	1.00	ML
68	VH	M	1.00	ML
69	VH	MH	1.00	M
70	VH	H	1.00	M
71	VH	VH	1.00	MH
72	VH	VVH	1.00	H
73	VVH	VVL	1.00	VL
74	VVH	VL	1.00	VL
75	VVH	L	1.00	L
76	VVH	ML	1.00	L
77	VVH	M	1.00	ML
78	VVH	MH	1.00	M
79	VVH	H	1.00	M
80	VVH	VH	1.00	MH
81	VVH	VVH	1.00	MH
82				
83				
84				