# Fuzzy Logic Expert Advisor Topology for Foreign Exchange Market

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**Abstract.** The Foreign Exchange Market attracts over $1.8 trillion trading volume everyday. It is the world's largest financial market and still claims to be one of the most challenging areas of research. In this paper, we present the topology of an Expert Advisor that serves as a robot for Foreign Exchange trading, using fuzzy logic. Our result shows that the fuzzy logic based expert advisor robot is capable of making up to 80% consecutive profitable trades. This indicates that developing Expert Advisors that could achieve a higher percentage of profitable trades, based on this topology, is worth the effort.

**Keywords:** Foreign Exchange, Expert Advisor, Fuzzy logic.

## 1 Introduction

The Foreign Exchange Market attracts over 1.8 trillion USD trading volume everyday. It is the world's largest financial market and perhaps no other industry has been affected by e-commerce revolution more than financial services, under which foreign exchange is classified. Foreign exchange may represent the highest e-commerce opportunity yet [4]. However, it claims to be one of the most challenging areas of research.

The financial time series especially the Foreign Exchange market is characterized by a nonlinear and non stationary behavior and as it has been suggested in many researches before that most of the financial markets are not predictable and it follows a random walk hypothesis. Many attempts have been made to crack the codes of the financial markets especially the Foreign Exchange market but unfortunately none of them has made a good percentage of success [1]. The impreciseness, vagueness and fluctuations of prices used for foreign exchange forecasting make the application of Fuzzy Logic appropriate for foreign exchange trading. However, this is best done using an Expert Adviser robot that replaces or supports manual trading.

The advantages of employing an Expert Advisor for foreign exchange trading are promptness and accuracy. Other advantages are trading and forecasting without emotion or stress. It is a highly cost and time saving approach. We demonstrate in this paper through empirical study that Fuzzy Logic can be applied profitably for forecasting and trading in the foreign exchange market.

This paper is organized as follows. In section 2, we give the background of Foreign Exchange Market. We describe the realated work in section 3. Section 4 is a description of the overview of Fuzzy Logic; its application to the Foreign Exchange Market is explained in section 5. Finally, section 6, 7.1 and 7.2 state the tests and results, future work/recommendation and the conclusion respecively.

## 2 Background

Foreign exchange market is an international financial market, where money is sold and bought freely and it was launched in the 1970s.

Currency is traded in pairs and each currency has an assigned symbol. For illustration, JPY is the symbol assigned for the Japanese Yen, for the Pound Sterling it is GBP, for Euro it is EUR and for the Swiss Frank it is CHF. There are four terminology related currency marker, which are: high, low, open and close. High and low indicate the highest traded price and the lowest traded price, while open and close indicate the price recorded during the period designated by the exchange at the official opening or closing. A rise in the rate between a currency pair (GBP/USD) means that the first named currency has strengthened against the second named currency and that is why when someone is selling a currency rate; he is selling the first-named currency and buying the second-named currency [1].

The Foreign Exchange (FOREX or FX) market is associated with some terms such as Spread (currency quote received from a dealer or broker), Lot size (the size of the currency unit to be traded and each lot is worth 100,000 units of the base currency), and Pips (the smallest unit in which a currency price is normally quoted or the last decimal place of a currency). Ask Price is the price a foreign exchange broker is willing to sell to a trader. Bid Price is the price a Foreign Exchange broker is willing to buy from a trader. Tick is an event that is characterized by a new price of the symbol at some instant. “Going long” is another term for buying, while “going short” is the equivalent term for “selling” from the perspective of the trader.

Two types of analysis are used for the market movements forecasting Fundamental and technical dataset. The technical analysis is the chart study of past behavior of the prices while the fundamental one focuses on the theoretical models of exchange rate determination and on the major economic factors and their likelihood of affecting the foreign exchange rates [3].

Expert Advisor (EA) is a program coded in Meta Quote Language (MQL) and called by the client terminal to be executed at every tick. The main purpose of Expert Advisors is the programmed control over trades.

The three popular types of chart used for modeling the interfaces of FOREX trading platforms are the Bar chart, Line Chart and the Candle stick chart. The Expert Advisor presented in this paper manipulates the financial time series of the foreign exchange market using the bar properties of the Meta Quote Language.

## 3 Related Work

The evolution of the Internet has drawn the attention of economists and traders to the prediction of the financial markets.

Emam [1] showed that Artificial Neural Network (ANN) can be used to predict the Foreign Exchange market. However, he pointed out that it is not easy to implement a successful neural network model for predicting the FOREX market because of the various factors influence such as political events that generally take place over a period of time; such political crises strike suddenly and prices dry out quickly, and sometimes the spreads between bid and offer jump from 5 pips to 100 pips. In foreign currency exchange data stream, the number of real-time transactions is normally very large and distributed in high-density [7]. Furthermore, ANN will not evolve a good result without a good data preparation, input selections, variable selection, training algorithms and a predefined model for validation.

Slany proposed a self-adapting architecture for FOREX market prediction using genetic programming (GP) for predictor representation. The goal of the system is the design and adaptation of simple predictors which can either be used by the system itself or be ’manually’ used by a human trader. However, this system has a major drawback high ratio of wrongly predicted turning points [13].

Wedding and CIO proposed a hybrid model of radial basis function (RBF) networks and AutoRegression Moving Average (ARMA) models [15]. This methodology employs model combination.

Kablan extended the Adaptive Neuro-Fuzzy Inference System to create an expert system that is capable of using fuzzy reasoning combined with the pattern recognition capability of neural networks to be used in financial forecasting and trading. However, this is another instance of a hybrid system [5].

The Penn-Lehman Automated Trading (PLAT) project is a broad investigation of genetic algorithms and strategies for automated trading in financial markets. Subramanian et al presented the results of experiments conducted within this project and demonstrated that autonomous agents can achieve consistent profitability in a variety of market conditions,

in ways that are human competitive. They also showed that show that it is possible to use qualitative characterizations of stochastic dynamics to improve the performance of these agents [14]. The experiments were however limited to the stock market.

Conclusively, most of the previously used models for foreign exchange forecasting are hybrid. None of the methodologies has explored a pure application of fuzzy logic inference to foreign exchange trading in open literature, to our knowledge.

## 4 Overview of Fuzzy Logic

Fuzzy logic is a form of multi-valued logic derived from fuzzy set theory to deal with reasoning that is approximate rather than precise. In contrast with "crisp logic", where binary sets have binary logic, fuzzy logic variables may have a truth value that ranges between 0 and 1 and is not constrained to the two truth values of classic propositional logic [10]. Fuzzy logic is a form of soft computing, which mimics human decision-making. Unlike classical set theory where there are crisp boundaries, a fuzzy system allows for imprecision and flexibility in a decision-making system.

Fuzzy Logic permits the manipulation and exploitation of incomplete data or with a grade of uncertainty [16, 2].

Two terms are commonly associated with Fuzzy Logic: fuzzy set and fuzzy numbers.

A fuzzy set could be represented by Equation (1). If X is the universe of discourse (all possible values for a specific feature within the system) and its elements are denoted by x, then the fuzzy set F in X is defined as a set of ordered pairs.

$$F = \{x, \mu F(x) \mid x \square X\} . \quad (1)$$

$\mu F(x)$ is called the membership function (or MF) of x in F and with fuzzy logic F can either be totally true like the traditional set theory when $\mu = 1$ or not true when $\mu = 0$ or partially true or not true when $0 < \mu < 1$ [5].

A fuzzy number is a quantity whose value is imprecise, rather than exact as in the case of ordinary single valued numbers. Fuzzy numbers are a way of describing data vagueness. Any fuzzy number can be thought of as a function, called membership function, whose domain is specified, usually the set of real numbers, and whose range is the span of positive numbers in the closed interval [0,1]. Each numerical value of the domain is assigned a specific value and 0 represents the smallest possible value of the membership function, while the largest possible value is 1. The membership function is increasing towards the mean and decreasing away from it. The Fuzzy number can be of three types: Triangular fuzzy Number, Trapezoidal fuzzy number, and Bell shaped fuzzy number. The three curves are shown in Figure 1 below [8].

Fuzzy numbers actually depicts the real world which rarely operates on a single-valued number [10]. For example, when driving in a busy traffic where the speed limit is 50 km/h, many factors exist that will make the actual speed to fluctuate around 50 km/h.

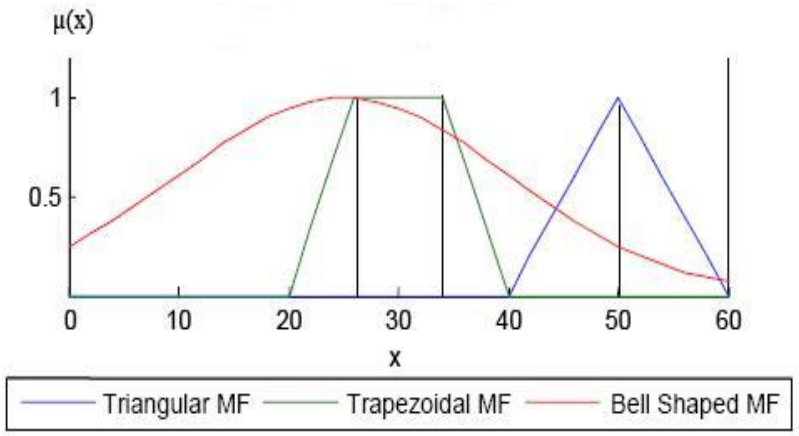


**Figure 1:** Membership Functions

## 5 Fuzzy Logic and the Foreign Exchange Market

The uncertainty, vagueness, instability and fluctuations of foreign exchange prices and quotes, on which traders depend, make the application of fuzzy logic relevant to the foreign exchange market.

In FOREX, prices and quotes can either go up or down. You either make a profit or a loss. A trader either buys or sells; he either goes long or short. Trade position can either be open or close. FOREX brokers give either the bid price or the ask price.

Consequently, identifiable Fuzzy sets in FOREX are: high bid price, low bid price, high ask price, low ask price, high loss, low loss, high profit, and low profit. Diverse factors affect the degree of membership placement between profit and no profit, and between loss and no loss. These factors, no matter how minute, must be captured by some programmable functions, to minimize loss or maximize profit. Within a period, prices can fluctuate, accumulate, increase or decrease progressively. The functions developed should accommodate these fluctuation, accumulation and progression of prices.

Fuzzy set theory defines fuzzy operators on fuzzy sets. The problem in applying this is that the appropriate fuzzy operator may not be known. For this reason, fuzzy logic usually

uses linguistically stated IF-THEN rules, or constructs that are equivalent, such as fuzzy associative matrices. The AND, OR, and NOT operators of Boolean logic exist in fuzzy logic. ELSE is not used. Figure 2 shows the Fuzzy set and membership functions for the expert advisor topology.

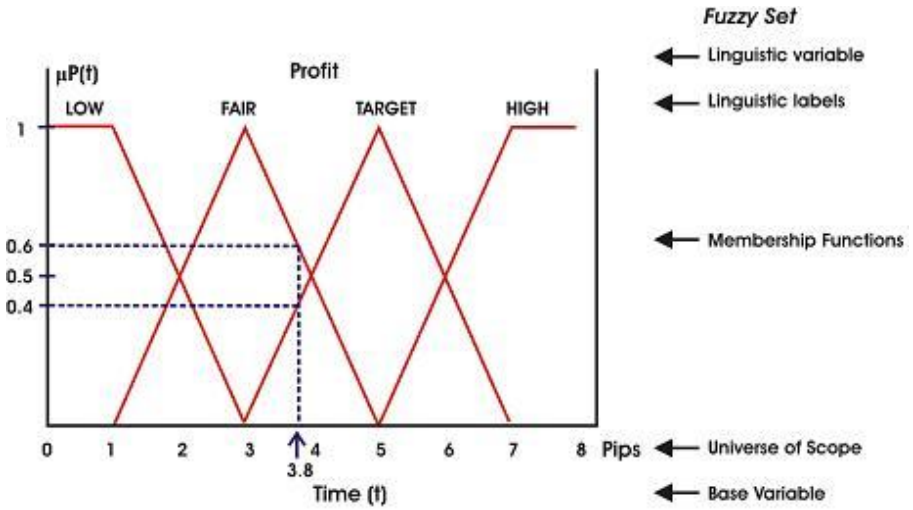


**Figure 2:** Expert Advisor Fuzzy Set and Membership Functions

A segment of the implementation is shown below for our Fuzzy Logic based Expert Advisor, written in Meta Quote Language (MQL) 4. The Expert Advisor employs two systems namely: System5A and System5B. The first places a trade in the direction of the market trend while the second places a trade contrary to the direction of the trend. dBysPip5M and dSlsPip5M are double typed array linguistic variables initially declared and initialized using MQL4 time series functions. They stand for BuysPips and SellsPips of 5-Minute Trading Period. b_f_factor stands for Broker's factor; it was declared with extern keyword and it can be globally set to 1 or 10. The Expert Adviser targets a Take Profit of 5 pips. Therefore, the number 3, when compared with 5 as our profit level, identifies with our fuzzy number, which incidentally in this case is a Fibonacci number. It belongs to a degree of membership 1 for Fair profit. The value 3.8 pips belongs to Fair with a degree of membership 0.6 and it belongs to Moderate with a degree of membership 0.4 as shown in Figure 2. The user function fnOpenTrade, with six arguments, is used for placing the trade order. The expert adviser was designed for short term trading to make profit in both directions of the trade.

The algorithm for trade order placement is shown below.

**Algorithm for Order Placement**

1) Determine and capture the inputs to be fuzzified by setting four of the most recent bars of bid and ask quotes into two different sets of 5-minute arrays such as:
5MinutesBuysPip[1], 5MinutesBuysPip[2], 5MinutesBuysPip[3], 5MinutesBuysPip[4]; and 5MinutesSalesPip [1], 5MinutesSalesPip [2], 5MinutesSalesPip [3], 5MinutesSalesPip [1].

2) Establish the fuzzy inference by computing the degree of truth and membership function based on the target profit. For example, for a profit target of 5 pips, we can choose 3 as fuzzy number. We can also choose 3.8 which will result in a degree of membership of 0.6 and 0.4 for Fair and Moderate profits respectively.
3) Compose fuzzification rules by using the intersection of the first two array elements and the union of the third or fourth array elements, to place a trade in their direction of the first two array elements if the conditions are satisfied.
4) To get output, defuzzify by reversing the condition of step 3 to place a trade in this direction only if the condition is satisfied
5) Place a trade in the appropriate direction, using one of the named systems, say, “System 5A” using the output in step 4.
6) Apply steps 3 to 5 above for the second set of 5-minute array to place a trade in the direction of a reversed trend, using the second system which can be named “System 5B”.

**Order Placement Code Segment**

```
// Declare the input arrays globally. That is,

// double dSlsPip5M[4];

// double dBysPip5M[4];


// SYSTEM 5A

if( (bSys5AClosed == true) ) //Ensure system 5A //is closed so that it places only one trade at a time
```

```
{

// Set the rules by using the AND operator on the first //two array elements and the OR operator on the third and //fourth array elements using our fuzzy number

if( (dBysPip5M[1] >= 3 * b_f_factor) && ( (dSlsPip5M[2] >= 3 * b_f_factor) || (dSlsPip5M[3] >= 3 * b_f_factor) || (dSlsPip5M[4] >= 3 * b_f_factor) ) )

{

//Place a trade for a take-profit of 5 pips //to BUY only //if the condition for buying is met

fnOpenTrade(Symbol(), OP_BUY, magic_number5A, Remarks5A, sys5A_stoploss, sys5A_takeprofit);

bSys5AClosed = false; //reassign.

return(0);

}

//Similarly set the rules and place a trade for a take-//profit of 5 pips to SELL only if the condition below //for selling is met

if( (dSlsPip5M[1] >= 3 * b_f_factor) && ( (dBysPip5M[2] >= 3 * b_f_factor) || (dBysPip5M[3] >= 3 * b_f_factor) || (dBysPip5M[4] >= 3 * b_f_factor) ) )

{

fnOpenTrade(Symbol(), OP_SELL, magic_number5A, Remarks5A, sys5A_stoploss, sys5A_takeprofit);

bSys5AClosed = false; //reassign.

return(0);

}

}


//For SYSTEM 5B, use the same conditions as in SYSTEM 5A but place a trade against the direction of the trend
```

```
if( (bSys5BClosed == true)  ) //Ensure system 5A and 5B is closed

{

 if(  (dBysPip5M[1]  >= 3 * b_f_factor) && ( (dSlsPip5M[2] >= 3 * b_f_factor)
|| (dSlsPip5M[3] >= 3 * b_f_factor) ||  (dSlsPip5M[4] >= 3 * b_f_factor) ) )

 {

// Place a trade of a reversed trend.

  fnOpenTrade(Symbol(),  OP_SELL,  magic_number5B,  Remarks5B,
sys5B_stoploss, sys5B_takeprofit);

   bSys5BClosed = false; //reassign.

  return(0);

 }


 if(  (dSlsPip5M[1]  >= 3 * b_f_factor) && ( (dBysPip5M[2] >= 3 * b_f_factor)
|| (dBysPip5M[3] >= 3 * b_f_factor) || (dBysPip5M[4] >= 3 * b_f_factor) ) )

 {

// Place a trade of a reversed trend.

  fnOpenTrade(Symbol(),  OP_BUY,  magic_number5B,  Remarks5B,
sys5B_stoploss, sys5B_takeprofit);

   bSys5BClosed = false; //reassign.

  return(0);

 }

}
```

**Table 1: Test Result**

| **Alpari (UK) Ltd.** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| **Account: 1676941** | | **Name: Dave Monitor Demo** | | | | | | **Currency: USD** | | |
| **Closed Transactions:** | | | | | | | | | | |
| Ticket | Open Time | Type | Size | Item | Price | S / L | T / P | Close Time | Price | Profit |
| 108000000 | 2010.04.23 19:40 | balance | Deposit | | | | | | | 5 000.00 |
| 111000000 | 2010.05.06 15:53 | buy | 1.00 | gbpusd | 1.50394 | 1.50114 | 1.50444 | 2010.05.06 15:55 | 1.50444 | 50.00 |
| 111000000 | 2010.05.06 15:54 | buy | 1.00 | gbpusd | 1.50387 | 1.50087 | 1.50437 | 2010.05.06 15:55 | 1.50437 | 50.00 |
| 111000000 | 2010.05.06 16:01 | sell | 1.00 | usdchf | 1.10321 | 1.10601 | 1.10277 | 2010.05.06 16:23 | 1.10601 | -253.16 |
| 111000000 | 2010.05.06 16:16 | sell | 1.00 | usdchf | 1.10519 | 1.10819 | 1.10477 | 2010.05.06 16:19 | 1.10477 | 38.02 |
| 111000000 | 2010.05.06 16:20 | buy | 1.00 | usdchf | 1.10492 | 1.10192 | 1.10542 | 2010.05.06 16:21 | 1.10542 | 45.23 |
| 111000000 | 2010.05.06 16:22 | buy | 1.00 | usdchf | 1.10547 | 1.10247 | 1.10597 | 2010.05.06 16:23 | 1.10597 | 45.21 |
| 111000000 | 2010.05.06 16:24 | sell | 1.00 | usdchf | 1.10579 | 1.10859 | 1.10536 | 2010.05.06 16:56 | 1.10859 | -252.57 |
| 111000000 | 2010.05.06 16:24 | buy | 1.00 | usdchf | 1.10605 | 1.10305 | 1.10655 | 2010.05.06 16:26 | 1.10655 | 45.19 |
| 111000000 | 2010.05.06 16:26 | sell | 1.00 | usdchf | 1.10669 | 1.10969 | 1.10629 | 2010.05.06 16:49 | 1.10629 | 36.16 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 111000000 | 2010.05.06 16:51 | buy | 1.00 | usdchf | 1.10655 | 1.10355 | 1.10705 | 2010.05.06 16:52 | 1.10705 | 45.17 |
| 111000000 | 2010.05.06 16:52 | buy | 1.00 | usdchf | 1.10708 | 1.10408 | 1.10758 | 2010.05.06 16:52 | 1.10758 | 45.14 |
| 111000000 | 2010.05.06 16:52 | buy | 1.00 | usdchf | 1.10769 | 1.10469 | 1.10819 | 2010.05.06 16:55 | 1.10819 | 45.12 |
| 111000000 | 2010.05.06 16:59 | buy | 1.00 | usdchf | 1.10802 | 1.10522 | 1.10852 | 2010.05.06 17:02 | 1.10852 | 45.11 |
| 111000000 | 2010.05.06 16:59 | sell | 1.00 | usdchf | 1.10762 | 1.11062 | 1.10716 | 2010.05.06 16:59 | 1.10716 | 41.55 |
| 111000000 | 2010.05.06 17:02 | buy | 1.00 | usdchf | 1.10829 | 1.10529 | 1.10879 | 2010.05.06 17:02 | 1.10879 | 45.09 |
| 111000000 | 2010.05.06 17:02 | sell | 1.00 | usdchf | 1.10854 | 1.11134 | 1.10808 | 2010.05.06 17:09 | 1.10808 | 41.51 |
| 111000000 | 2010.05.06 17:02 | buy | 1.00 | usdchf | 1.10929 | 1.10629 | 1.10979 | 2010.05.06 17:02 | 1.10979 | 45.05 |
| 111000000 | 2010.05.06 17:02 | buy | 1.00 | usdchf | 1.10982 | 1.10682 | 1.11032 | 2010.05.06 17:28 | 1.10682 | -271.05 |
| 111000000 | 2010.05.06 17:09 | buy | 1.00 | usdchf | 1.10804 | 1.10524 | 1.10854 | 2010.05.06 17:11 | 1.10854 | 45.10 |
| 111000000 | 2010.05.06 17:12 | sell | 1.00 | usdchf | 1.10855 | 1.11135 | 1.10812 | 2010.05.06 17:14 | 1.10812 | 38.80 |
| 111000000 | 2010.05.06 17:14 | sell | 1.00 | usdchf | 1.10796 | 1.11076 | 1.10757 | 2010.05.06 17:24 | 1.10757 | 35.21 |
| 112000000 | 2010.05.06 17:24 | buy | 1.00 | usdchf | 1.10755 | 1.10475 | 1.10805 | 2010.05.06 17:25 | 1.10805 | 45.12 |
| 112000000 | 2010.05.06 17:28 | sell | 1.00 | usdchf | 1.10745 | 1.11025 | 1.10701 | 2010.05.06 17:28 | 1.10701 | 39.75 |
| 112000000 | 2010.05.06 18:23 | sell | 1.00 | usdchf | 1.10795 | 1.11075 | 1.10760 | 2010.05.06 18:23 | 1.10760 | 31.60 |
| 112000000 | 2010.05.06 18:23 | sell | 1.00 | usdchf | 1.10786 | 1.11086 | 1.10753 | 2010.05.06 18:23 | 1.10753 | 29.80 |
| 112000000 | 2010.05.06 18:23 | buy | 1.00 | usdchf | 1.10748 | 1.10468 | 1.10798 | 2010.05.06 18:28 | 1.10798 | 45.13 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 112000000 | 2010.05.06 18:29 | sell | 1.00 | usdchf | 1.10792 | 1.11072 | 1.10754 | 2010.05.06 18:30 | 1.10754 | 34.31 |
| | | | | | | | | | | |
| **Closed P/L:** | | | | | | | | | | **231.59** |

## 6 Tests and Results

Meta Quote Language (MQL) 4 was chosen as the implementation programming language because it the widely accepted language for programming Meta Trader 4, the most popular trading platform for Foreign Exchange. Furthermore, its syntax and semantics have much resemblance to C programming language and it is sourced free.

The Expert Advisor was tested using Alpari (UK) server on a Demo Account, hosted on the Web. Alpari (UK) is a reputable Foreign Exchange market vendor. The result is shown in Table 1 below. The result demonstrates that the Expert Advisor is capable of making up to 80 % profitable trades.

## 7 Future Work/Recommendation

Future work will concentrate on reducing or eliminating the trade that resulted in the losses.

## 8 Conclusion

A Fuzzy Logic based expert advisor shows a good promise of success for the foreign exchange market for short term trading. This empirical study has demonstrated that Fuzzy Logic can be applied profitably for forecasting and trading in the foreign exchange market.

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