Fuzzy Logic Decision Support for Long-Term Investing in the Financial Markets

Zdeněk Brož and Petr Dostál

Brno University of Technology, Faculty of Business and Management,
Institute of Informatics, Kolejní 2906/4, 612 00 Brno, Czech Republic

Abstract. This paper discusses the use of fuzzy logic and modeling as a decision support for long-term investment decisions in the financial markets. A simple model is proposed to calculate recommendations for investors. This research required thorough analysis of historical data that lead to the discovery of interesting dependencies between the Dow Jones index, currency pairs, oil price and the VIX volatility index. The fuzzy model uses several input variables that are used to simplify the complex conditions in the financial markets. The purpose of the model is to evaluate the current market situation, compare the current situation to similar situations in the past and to provide investment recommendations for long-term future investing.

1 Introduction

This paper researches the use of soft computing as a decision making support for long-term investment in the financial markets. It is very difficult to predict the development of financial markets [4], [11], [13] and [14]. Markets are dynamic and there are many complex factors and complicated relationships that influence indexes, currencies and commodities these makes investing complicated and risky [7]. The processes in economy are nonlinear. If the system is nonlinear and dynamic, it can generate randomly looking behaviour but it can include the permanent trends and cycles [6] and [16]. Investing in the financial markets is difficult because of globalized economies - there are different crises, bubbles, rising debts and prices of commodities, energy etc. These problems randomly escalate and create extreme imbalances in the market. These imbalances are both great opportunities and threats for the investors. Psychology also plays an important role in the financial markets - investors often do not recognize these opportunities because they are afraid of the future development [9] and [10]. This research is facing very actual and yet at the same time classic problem of investing – when to buy and sell stocks while minimizing the risk [8]. Understanding the markets and being able to predict what will happen in the near future are the key skills that every successful investor has to have. This research uses a simple model with a few variables that simplifies the complex market environment to make reliable recommendations for the investors and so provides a valuable decision making support tool.

   This research has several objectives. The first objective is to analyse the past development of the Dow Jones index and to find extreme imbalances that occurred

in the past. These situations are opportunities for the investors. The second objective is to define a set of variables that reliably describe the situation in the market. The third objective is to research the dependencies and relationships between these variables. The final objective is to design a very simple and reliable fuzzy model that uses these variables to calculate recommendations for the investor.

This research focuses on the use of soft computing and fuzzy logic in finance. Investors and decision makers have to decide when, where and how to invest. This problem is very complex and decision makers always try to use methods, tools and algorithms that allow them to limit risk [7]. Fuzzy model designed in this research is intended as a decision making support tool for investors in the financial markets [12]. This research deals with extreme situations that occur in the financial markets and that are very difficult to predict [24], [25] and [26]. Many researchers in the past used soft computing in business and finance [2], [3], [21], [22] or [27]. This research helps to identify current imbalances in the market based on similarity to past known events. The fuzzy model then processes several input variables to calculate recommendations for investors. Instead of promoting short term speculation this research aims to provide a decision making support model that helps to identify long-term critical imbalances and helps the investor to find possibilities for making long-term profits with low risk.

2   Methods

The proposed model is based on fuzzy logic and fuzzy sets. A fuzzy set A is defined as (U, μ_A), where U is the relevant universal set and μ_A: U $\rightarrow \langle 0,1 \rangle$ is a membership function, which assigns each elements from U to fuzzy set A. The membership of the element $x \in$ U of a fuzzy set A is indicated $\mu_A(x)$. We call F(U) the set of all fuzzy set. Then the "classical" set A is the fuzzy set where: μ_A: U $\rightarrow \{0, 1\}$. Thus $x \in$ A $\Leftrightarrow \mu_A(x) = 0$ and $x \notin$ A $\Leftrightarrow \mu_A(x) = 1$. Let U$_i$, i = 1, 2, ..., n, be universals. Then the fuzzy relation R on U = U1$\times$U2 $\times...\times$ Un is a fuzzy set R on the universal U.

The creation of the model was preceded by a thorough statistical analysis of the historical data. It was necessary to identify ideal moments in the past when the investor could buy or sell stocks to generate profit – these moments are often characterized as maximum or minimum values of the Dow Jones index. To increase the reliability of the designed model it was necessary to use not only the data from the long-term time series of the Dow Jones index but also variables that are not directly related to the index itself. Therefore it was necessary to find more variables that have a relationship with the Dow Jones index and describe the situation in the financial market. After the maximum and minimum values were found it was necessary to collect information about all the variables that are used in the model. The fuzzy model uses five input variables: Dow Jones industrial index, past trend of this index, EUR/USD currency pair, oil price and VIX index. Due to the constraints of this paper the input variables are not discussed in greater detail.

The fuzzy model requires a set of rules that capture the important relationships between the input variables [30]. These relationships have to be researched from the past data. A key step in this research even before the work on the fuzzy model began was to find extreme imbalances of the Dow Jones index in the past two decades. To

find these imbalances it was necessary to analyze carefully the historical time series [14], [19] and [29]. The long-term time series was analyzed differently several times in order to find key moments in the past that were opportunities for the investors [18]. A very simple and reliable method to find these past moments is to compare the historical prices with the long term averages. When the historical price is very high in a certain time period and above both calculated long-term averages then this moment in time is a good opportunity for the investor to sell. When the price is the lowest in a certain time period and well below both long-term averages it is an ideal opportunity to buy. These two rules were used to determine the moments in time that were used in the model. When these dates were found the values for all the input variables were calculated. After all the values of the input variables had been determined the work on the fuzzy model started.
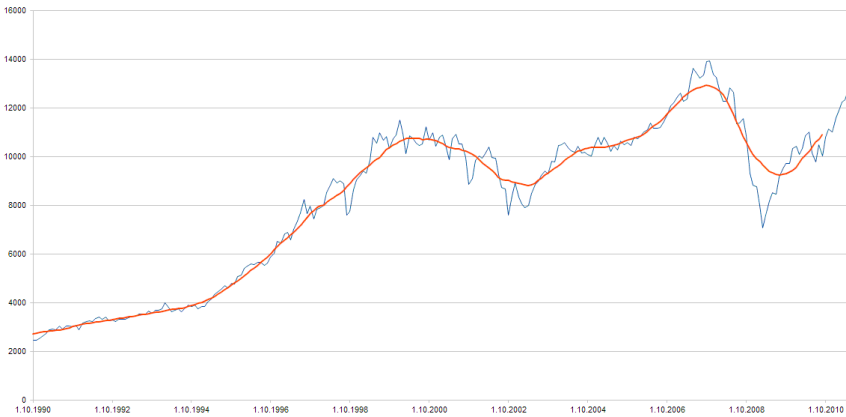

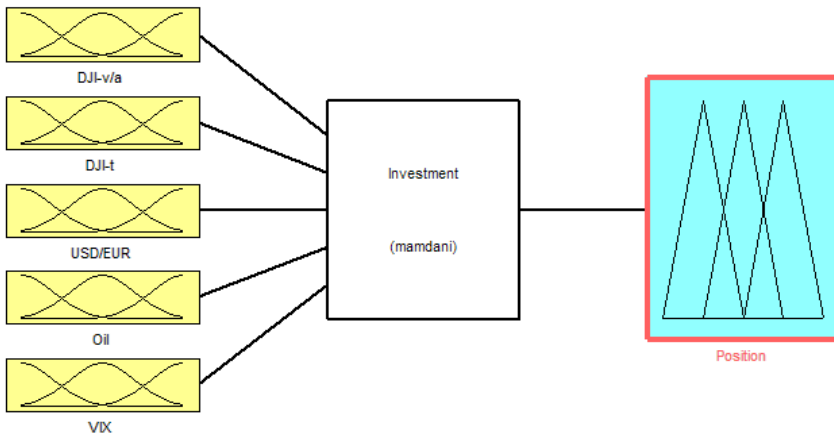**Fig. 1** Long-term statistical analysis of the Dow Jones index

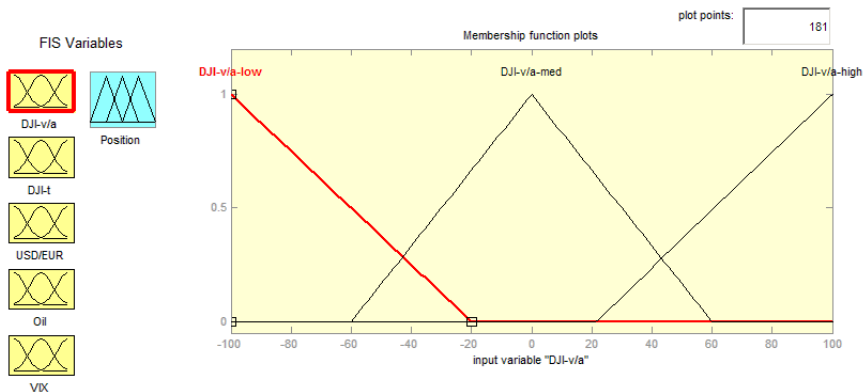
Fig. 2 FIS editor – input and output variables

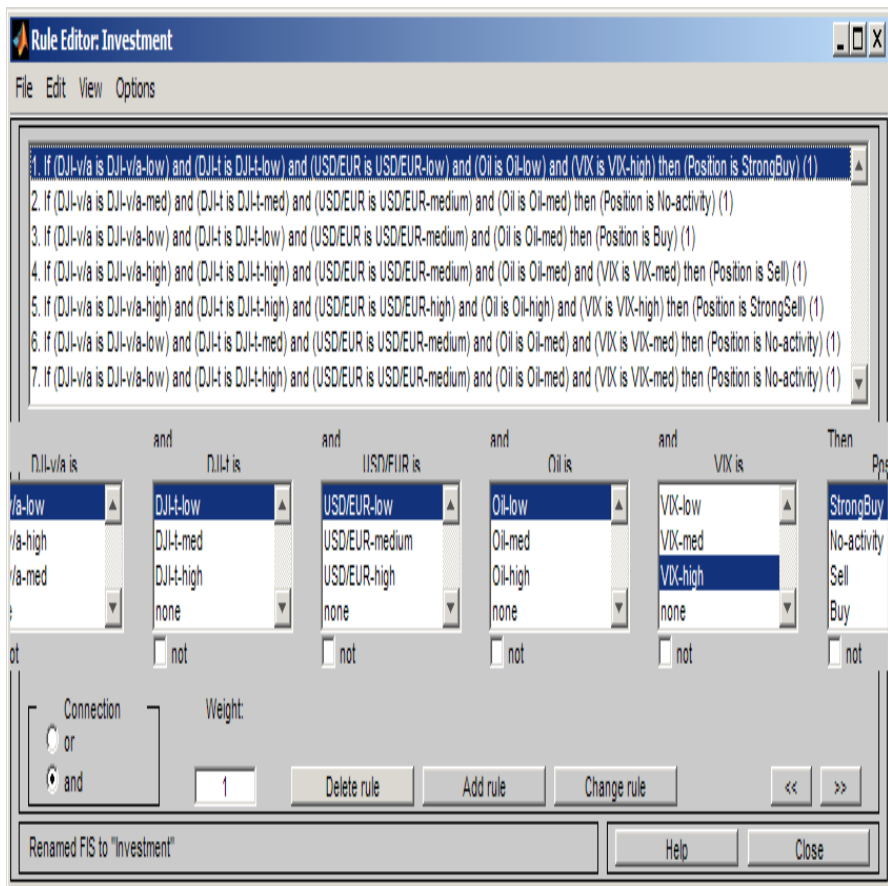**Fig. 3** Membership function editor

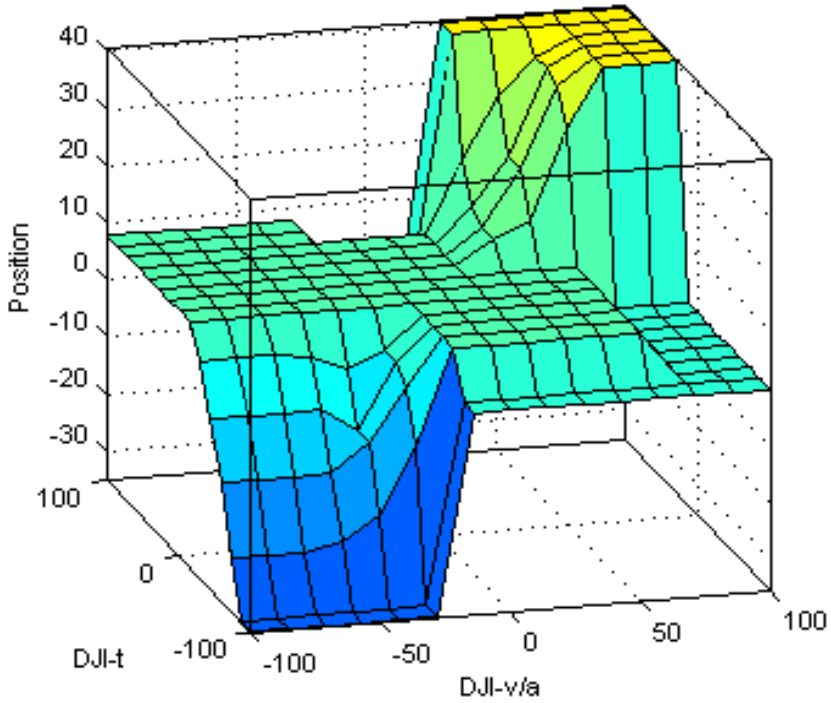**Fig. 4** Rules of the rule editor

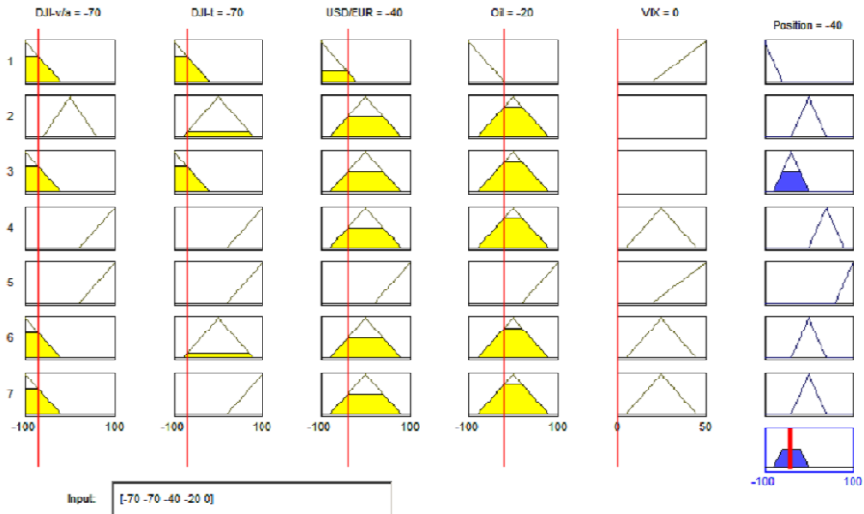**Fig. 5** Visualization of dependence Position = f(DJI-t, DJI-v/a)

Fig. 6 Rule viewer and calculated output variable

The fuzzy model is implemented in the Fuzzy logic toolbox in MATLAB. First the input variables are defined. The model then calculates the value from these input variables based on the defined rules and returns an output variable called Position. This variable is the recommendation for the investor. In order to keep the model as simple as possible only three attributes were used for each variable (low, medium and high and a small number of rules were defined. These rules record the basic relationships that have been determined from the analysis of the past data and from the values of input variables in the key past situations. Before the work on this research the authors were looking for an algorithm or method that could be used by investors who are not skilled enough to use complicated financial software. That led the authors to this research with a simple model with a few input variables. After the rules have been defined the surface viewer can be used to visualize the dependency between input variables and the output variable. Further information about modeling in MATLAB can be found in [28].

3   Results

This chapter contains a simple table showing the input values for the five input variables for the selected key situations determined from the long-term Dow Jones index time series. The fuzzy model calculated the output value in each case from the input variables based on the simple set of rules. When the model outputs a value it can then be clearly translated to recommendations for the investor. Even without the fuzzy model very interesting and useful information can be learned from the values of the input variables. There are some relatively strong dependencies and relationships between the input variables. It would of course be possible to add more input variables and make the model more sophisticated but the objective of this research was to keep the set of input variables and the model itself as simple as possible.

Table 1 Input variables and calculated recommendations

Date	DJI	DJI-v/a	DJI-t	USD/EUR	Oil	VIX	Calculated value	Recommendation
30.8.1998	7640	-10	-40	-40	-30	45	-87,3	strong buy
1.1.2000	11722	90	90	50	50	25	40	strong sell
11.2.2002	9739,81	-70	-70	-40	-20	22	-40	strong buy
1.7.2007	13800	95	90	50	90	30	84	strong sell
9.3.2009	6625,74	-90	-70	-50	-100	80	-84	strong buy
1.5.2011	12600	80	80	80	-30	18	40	strong sell

4   Discussion

This chapter discusses the results obtained from the fuzzy model. It can be seen that the input variables have very different values for all the key moments in the

past. These selected imbalances of the market were chosen to demonstrate the model. The financial market is dynamic and a very complex system so there is no simple way to predict the future development [1], [5] and [20]. The objective of the model is not to predict the future development but merely to identify opportunities and calculate recommendations from the input variables. Because this model focuses on the extreme imbalances of the market it can identify them safely. When the calculated recommendations are combined with other information and investing skills of the individual investor this decision support model is very valuable. This model promotes long-term investing strategy with low risk. That is a major difference when compared to most other methods that promote short-term speculation with high risk [15] or [17].

The designed model is intended as a decision making support for long-term investment. The financial market is a complex, dynamic and chaotic environment. A large number of factors influence the developments in the financial market each day. The reliability of the model would decrease significantly if it were used for short-term investing. Another limitation is that the model is designed for investing in large mutual funds that are highly correlated with the Dow Jones index. The model is designed to be as simple as possible and easy to use. The objective of this research is to develop an easy to use model that has a few simple input variables and yet is able to provide reliable recommendations to the investor. The research has shown that at some point the model becomes too complex and the reliability of the model decreases [31]. This research shows that it is possible to reliably detect the long-term major imbalances of the financial markets which can then be used by investors to generate profits while maintaining low risk.

5 Conclusions

Investment decision making support based on the fuzzy model can prove to be very useful for investors who are looking for a path to manage risk when dealing with their long-term investment portfolio. The proposed model uses several input variables to evaluate the current situation in the market and calculate recommendations for the investor. The objective of this research is of course to limit risk and safely identify opportunities. This research does not promote risky short-term speculations. The designed model has been tested extensively on the historical data and it has proved to provide correct investment recommendations with high statistical probability. This research will be continued in the near future.

References

1. Abel, H.: Digital Day Trading, Dearborn, USA, 269p. (1999) ISBN 0-7931-3113-8
2. Aliev, A., Aliev, R.: Soft Computing and Its Applications, 444 p. World Scientific Pub. Ltd., UK (2002) ISBN 981-02-4700-1

3. Altrock, C.: Fuzzy Logic & Neurofuzzy – Applications in Business & Finance, 375 p. Prentice Hall, USA (1996) ISBN 0-13-591512-0

4. Armstrong, S.J.: Principles of Forecasting, 849s p. Kluwer Academic Publishers, USA (2001) ISBN 0-7923-7930-6

5. Baird, B., Burney, C.: Electronic Day Trading to Win, 220 p. John Wiley & Sons Inc., USA (1999) ISBN 0-471-35072-9

6. Bernice, C.: The Edge of Chaos - Financial Booms, Bubbles, Crashes and Chaos, 379 p. John Wiley & Sons Ltd., UK (1997) ISBN 0-471-96907-9

7. Dostál, P., Sojka, Z.: Financial Risk Management. In: Zlín 2005, Skripta, 60 p. (2005) ISBN 80-7318-343-9

8. DostÁL, P.: Prediction of Competitive Environment in Business. In: 28th International Symposium on Forecasting, Nice, France, p. 171, 6p., ISSN 1997-4116, ISSN 1997-4124

9. DostÁL, P., Rais, K.: Stock Market Decision Machine. In: 29th International Symposium on Forecasting, Hong-Kong, China, p. 171, 5 p. (2009) ISSN 1997-4116

10. Dostál, P., Budík, J.: System for Intelligent Investment Portfolio Making. In: 30th International Symposium on Forecasting, San Diego, USA, 6 p. (2010) ISSN 1997-4116

11. Dostál, P.: Advanced Decision Making in Business and Public Services, 168 p. CERM, Brno (2011) ISBN 978-80-7204-747-5

12. Dostál, P., Brož, Z.: Fuzzy Logic Investment Support on the Financial Market. In: 31th International Symposium on Forecasting, Praha, CZ, 6 p. (2011) ISSN 1997-4116

13. Ehlers, F.J.: Cybernetic Analysis for Stock and Futures, 256 p. John Wiley & Sons Inc, USA (2004) ISBN 0-471-46307-8

14. Franses, P.H.: Time Series Models for Business and Economic Forecasting, Cambridge, 213 p. University Press, UK (2001) ISBN 0-521-58641-0

15. Frost, A.J., Pretcher, R.: Elliott Wave Principle, 245 p. New Classic Library, USA (2000) ISBN 0-932750-43-5

16. Gleick, J.: Chaos, 330 p. Ando Publishing (1996) ISBN 80-86047-04-0

17. Gozzhelf, P.: Techno Fundamental Trading, 267 p. Probus Publishing Company, USA (1995) ISBN 1-55738-541-6

18. Hand, D., Mannila, H.: Principles of Data Mining, 546 p. The MIT Press, USA (2001) ISBN 0-262-08290-X

19. Herbst, F.: Analyzing and Forecasting Futures Prices, 238 p. John Wiley & Sons Inc., USA (1992) ISBN 0-471-53312-2

20. Howard, A.: Digital Day Trading, Dearborn, USA, 269 p. (1999) ISBN 0-7931-3113-8

21. Chen, S., Wang, P., Wen, T.: Computational Intelligence in Economic and Finance. Springer (2004) ISBN 978-3-540-72820-7

22. Chen, S., Wang, P., Wen, T.: Computational Intelligence in Economic and Finance, vol. II. Springer (2007) ISBN 978-3-540-72820-7

23. Klir, G.J., Yuan, B.: Fuzzy Sets and Fuzzy Logic, Theory and Applications, 279 p. Prentice Hall, New Jersy (1995) ISBN 0-13-101171-5

24. Peters, E.E.: Fractal Market Analysis – Applying Chaos Theory to Investment & Economic, 315 p. John Wiley & Sons Inc, USA (1994) ISBN 0-471-58524-6

25. Peters, E.E.: Chaos and Order in the Capital Markets: A New View of Cycles, Prices, Wiley Finance Edition, USA, 274 p. (1996) ISBN 0-471-13838-6

26. Trippi, R.R.: Chaos & Nonlinear Dynamic in the Financial Markets, 505p. Irwin Professional Publishing, USA (1995) ISBN 1-55738-857-1

27. Ribeiro, R., Yager, R.: Soft Computing in Financial Engineering, 590 p. A Springer Verlag Company (1999) ISBN 3-7908-1173-4
28. THE MATHWORKS. MATLAB – User's Guide, The MathWorks, Inc. (2010)
29. Weigend, A.: Time Series Prediction: Forecasting the Future and Understanding the Past, 643 p. Addison-Wesley, Massachusetts (1993) ISBN 0-201-62602-0
30. Williams, L.V.: Information Efficiency in Financial and Betting Markets, 353 p. Cambridge University Press (2005) ISBN 0–521-81603-3
31. Wisniewski, M.: Quantitative Methods for Decision Makers, 4th edn., 592 p. Pearson Education Limited, England (2006) ISBN 0 27368 789 1