

Application of a Fuzzy Set and Fuzzy Logic to Economic Problems: Study Literature Review of Journal

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Keywords: Fuzzy Set, Fuzzy Logic, Economic Problems

Abstract: This article aims to describe the set of application and fuzzy logic on the economy. The problems still faced over the years is still the presence of obstacles how to create a formula approach to economic modeling. But with the development of increasingly sophisticated technology, it must be followed by the progress of the method approach refers to the development of mathematics and computer technology. Based on a review, several studies in the field of economics has been developed to address the existing problems. As one alternative approaches to modelling and in providing system solutions in the real world, especially for the complexity of the system that are not easy to approach through mathematical modelling, fuzzy logic method can be used as an alternative to solve the economic problems.

1 INTRODUCTION

The problems that occurred during this are the constraints related to the discovery of a method for the formulation and economic modelling approach. (Flood and Marion, 1998) to suggest that there are still challenges to find new methods for the formulation and estimation of economic modeling in order to obtain a high flexibility in the formulation of functional; parametric assumptions as little as possible; a good look for a data bit or a lot; as well as the possibility of computing to support large number of variables.

A long with the development of increasingly sophisticated technology, it must be followed by the progress of the method approach refers to the development of mathematics and computer technology. In the development of the past, for modeling a system used a statistical method based on the theory of probability that represent uncertainty. However, this model has not succeeded in providing an accurate prediction for a few series for the linear structure and a few other limitations (Lin et al., 2002). Therefore, around 1965, Professor LA Zadeh of the University of California at Berkeley introduced a vague set theory. Indirectly, this theory suggests that there is a theory that can be used to represent uncertainty. That is, as one alternative is fuzzy logic.

Fuzzy logic as a main component builder, softcomputing has been shown to have excellent

ability to overcome the problems of uncertainty. The set and fuzzy logic increasingly attracted many researchers to be used as an alternative to data analysis in research. Fuzzy logic implementation is already very extensive, both in the fields of education, agriculture, health, engineering, psychology, no less important social and economic field.

In economics, has had its own association which is named SIGEF (The International Association for Management and Economy Fuzzysset), which was formed on November 30 through December 2, 2006, and hold the 13th congress in Morocco (Muslim, 2007). The congress is a forum for associations of academics, professionals and practitioners in the field of economics, management, finance, and organizations to exchange ideas and experiences in research, based on fuzzy logic, ant system, neural systems, genetic algorithms, the theory of uncertainty , complexity theory and softcomputing.

2 DISCUSSION

The discussion of several journal. articles application of research results fuzzy set and fuzzy logic in the economic that has been conducted by researchers between 1987 to 2007. The results of the application of the model used and to look into further fields are described as follows.

2.1 Fuzzy Logic

Theory of probability during the period of this century, plays an important role to explain the notion of uncertainty. In 1965, Prof. Lotfi A. Zadeh of the University of California at Berkeley introduced the concept of fuzzy sets indirectly this theory states that in addition to the probability approach, the uncertainty can also be done with a different approach in this case using the concept of fuzzy set.

Fuzzy set theory is a mathematical framework used to represent uncertainty, vagueness, inaccuracy, lack information and partial truth (Studer and Masulli, 1997). Basically, vague set is an extension of classical set (crisp), the classical set A an element will have two possibilities, namely membership A member denoted by $u_A(x)$. In the classical set of two memberships are $u_A(x) = 1$ if x is a member of A and $u_A(x) = 0$ when x is not a member of A.

In contrast to the classical set of fuzzy sets treating elements in the degree of membership. For example if the price of rice Rp 5,500 relatively expensive or mediocrity? In the concept of fuzzy sets and in the real world "both statements are true" and perhaps as an answer. The figure below shows the representation of the price of rice in conventional sets and fuzzy sets.

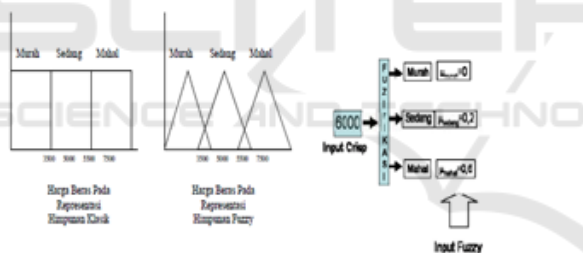


Figure 1: Representation of the Association and Fuzzyfikasi Value Crisp. Source: Adapted from Muslim (2017)

In classical logic truth values of right and wrong is only worth it in the fuzzy logic truth values are in the interval $[0,1]$ which can be determined by its membership function (Kaneko, 1996). Fuzzy logic is an appropriate way to map an input space into an output space based on the concept of fuzzy sets (Velasco, 1987). As a general overview say we have grouped the data into the data input and output data of other groups is, between the input and output are mapping process called black box, black box where it describes a process that is not known. To analyze the contents of the black box, there are several approaches that can be used such as: linear systems approach, econometrics, interpolation, expert systems, fuzzy logic, etc. However, as disclosed Lotfi Zadeh: "In almost every case, fuzzy way faster and cheaper"(Muslim, 2017).

2.2 Fuzzy Logic Applications on Economic Affairs

Use of Fuzzy Logic for Research in Economics Compared to conventional methods, for example OLS, the application of fuzzy logic approach on research in economics is still not a done deal. However, this method can be used as an alternative to modeling economic behavior. Economic modeling is a form of abstraction of economic behavior in the real world, in order to obtain a picture that is simpler and easier to understand by humans. The modeling used for "real world" is too complex to be described in detail. Although the details are not described by the model, but a good model should be able to represent anything that you want to know from the real world, and also can predict the conditions that occur in the real world. The following is some research in the field of economics that uses fuzzy logic.

(Flood and Marion, 1998) in the "Output convergence and International Trade: Time Series and Fuzzy Clustering Evidence for New Zealand and Her Trading Partners" introduces a new way to measure the convergence in the form of time series data, using the fuzzy c-means application in the clustering algorithm. Fuzzy Grouping provide a clearer picture of that difference in output will converge in groups. In the same year, Giles on "Econometric Modeling based on Pattern Recognition via the Fuzzy C-Means Clustering Encryption" using fuzzy logic in particular grouping of fuzzy c-means in economic modeling as a model of money demand with annual data 1960-1983 American trade department, models Kuznets' U-Curve "with a Gini coefficient data and US real GDP from 1947 to 1991 and the results show that the approach is better than the OLS and non-parametric models.

Accurate prediction of stock market indices is very important for certain reasons. Chief among the needs of investors is the potential to hedge against market risks, opportunities for market speculators and to make profit by trading indices. Estimating the stock market index accurately has profound and important implications for researchers and practitioners.

The most commonly used technique for predicting stock prices are the regression method and ARIMA models (Box et al., 1970). Various models and methods have been used extensively in the past. However, they failed to provide accurate prediction for several other limitations. Although there are models of ARCH / GARCH Eichengreen, (Eichengreen et al., 1995); (Bollerslev, 1986) models to overcome non-linear variance, there are still some series cannot be predicted satisfactorily. Recent

Table 1: Part 1. Selected literature on predictive economics problem mapping.

| Study | Modelling Method | Variables | Fields | Goals attained |
|---|---|---|--------------------------|---|
| Achsani, NA. 2003 | Auto Regressive Conditional Heteroskedastic (ARCH) | Y: national product at 1993 prices R: interest rate (long-term) M: Money stock. P: Consumer price index. Mr: logarithmic real balances. | Finance | If the μ coefficient increases, the interest rate elasticity decreases after the Asian crisis |
| Agenor, PR, JS Bhandari, and RP Flood. 1992 | Linear regression | Payments Crises and financial aspects | Finance | There is a relationship between payments crises and financial aspects |
| Al-Shammari, M. and Shaout, A. 1998 | Fuzzy personnel performance model | Teaching and instruction, research and scholarly, activities, service to the department, output from the fuzzy relations, merit increase, promotions, and tenure. | Organisation /managerial | The modified model offers a better evaluation performance system since it allows for dynamic changes in the strength effect of the input variables on output performance. |
| Bollerslev, T. 1986. | ARCH, Regression models | Autoregressive conditional heteroskedasticity | General economics | Empirical example relating to the uncertainty of the inflation rate is represented |
| Box, G. and Jenkins, G. 1970. | ARIMA | | Busines | |
| Buyukozkan. G., & Feyzioglu. O. 2004 | Membership function | New product development | Manajemen product | An increase in accuracy of decision-making in NPD under uncertainty |
| Chowdhry, B., Goyal, A. 2000 | Survey | Exploring the financial crisis in Asia | Finance | Represent the introduction |
| Dash, P. K., Liew, A. C., Rahman, S., & Dash, S. 1995 | Fuzzy expert system and a hybrid neural network-fuzzy expert system | Load Forecasting | General field | Represent the introduction |
| Draeseke, R & Giles, D.E. 2002 | Multiple indicators, multiple causes (MIMIC) | Tax rate and an index of the degree of regulation. | Economic | Relatively achieved |
| Eichengreen, B., AK Rose, and C. Wyplosz. 1996 | ARCH/GARCH | The causes and consequences. | Busines | Answer the problem statement |

Table 2: Part 2. Selected literature on predictive economics problem mapping.

| Study | Modelling Method | Variables | Fields | Goals attained |
|--|---|---|---------------|--|
| Engle, RF. 1982 | ARCH, Regression models | United kingdom inflation | Finance | ARCH effects is found to be significant and the estimated variances increase substantially during the chaotic seventies. |
| Flood, R. and N. Marion. 1998 | Fuzzy c-Means Clustering | Perspectives on the recent currency crisis | Finance | Represent the introduction |
| Giles, DEA. 2005 | Both bivariate and multivariate time-series | Time-series data and fuzzy clustering evidence for New Zealand and trading partners | Busines | Time-series methods are able to predict existing problems. |
| Giles, DEA and R. Draeseke. 2017 | Fuzzy c-mean Encryption, | Econometric modelling recognition via pattern | Economic | Represent the introduction |
| Kahraman, C, Tolga, E, and Ulukan, Z. 2000 | Fuzzy benefit /cost ratio analysis | Justification of manufacturing technologies | Manufacturing | The method of operating cost ratio (B/C) fuzzy logic is used to justify the making technology |
| Kaneko, Takaomi. 199 | Fuzzy Logic and Fuzzy Logic Production System (FLOPS) | Financial diagnosis | Finance | FLOPS is recommended as a function of financial diagnosis |
| Karsak, E. E., & Tolga, E. 2001. | Fuzzy Multiple Criteria Decision Making (MCDM) | Evaluating advanced manufacturing system investments. | Manufacturing | The fuzzy decision-making approach appears as a consistent and computational-efficient alternative to existing methods. |
| Lie, TT and Sharaf, AM. 1995 | Neuro-fuzzy short-term load forecasting (STLF) | Self-correcting online electric load forecasting model | Economic | Vector input affects the estimated the short-term forecast load. |
| Lin, CS et al. 2006 | Neuro-fuzzy | Currency crises | Finance | The neuro-fuzzy approach produces better predictions significantly. |
| Lin, CS; Khan, HA & Huang, CC. 2002 | Neuro-fuzzy | Stock indexes | Busines | Neuro fuzzy models predict stock indexes better than its rivals, neuro fuzzy consistent over time. |

Table 3: Part 3. Selected literature on predictive economics problem mapping.

| Study | Modelling Method | Variables | Fields | Goals attained |
|---|---|--|--------------|--|
| Munakata, Toshinori, and Jani, Yashvant. 1994 | Fuzzy system include fuzzy sets, logic, algorithms, and control | - | An overview | Fuzzy system are most suitable for uncertain or approximate reasoning, particularly systems with a algorithm model that is difficult to be controlled. |
| Muslim, Aziz. 2017 | Fuzzy logic | Fuzzy logic in economics | Economic | In almost every case, fuzzy way faster and cheaper |
| Obstfeld, M. 1994 | Linear example | Balance-of payments crisis and Devaluation | Finance | There are effects of the influence of the balance of payments crisis |
| Okada, H., Watanabe, N., Kawamura, A., and Azakawa, K. 1992 | Artificial Neural Network (ANN) | combination of fuzzy logic and ANN to describe the input | An overview | The system produces bond ratings that are very suitable for human experts, and are able to generalize better than a simple three-layer neural network. |
| Ozkan, FG and A. Sutherland. 1995 | Fuzzy system modelling, type-I, FCM | Currency crises | Finance | The predictive power of RBFSM is very encouraging. |
| Padmakumari, K. Mohandas, KP, and Thiruvengadam, S. 1999 | ANN Neuro-Fuzzy, Radial Basis Function Network (RBFN), | Land use based load forecasting | Busines | The RBFN is found to be more suitable for long-term prediction. |
| Studer, L. and Masulli, F. 1997 | Neuro-Fuzzy system (NFS) mackey Glass time series | Layer of singleton inputs, a hidden layer of Gaussian membership functions and one output unit | Organisation | The use of a Neuro-Fuzzy system for forecasting time is promising |
| Velasco, A. 1987. | Linear regression | Bank crisis and payments crisis | Finance | There is a relationship between bank crisis and payments crisis |
| Zavadskas, E. K and Turskis, Z. 2011 | Fuzzy Multiple Criteria Decision Making (MCDM) | Multiple Criteria Decision Making in Economics | Economic | MCDM is effective for supporting decisions in several conditions. |

research in neural network engineering has shown that neural networks have the properties needed for relevant applications, such as nonlinearity and fine interpolation, the ability to learn nonlinear complex mapping, and self-adaptation for different statistical distributions.

However, neural networks cannot be used to explain the causal relationship between input and output variables. This is because the black box is like the natural of most neural network algorithms. Neural networks cannot be named with the underlying knowledge. Networks must learn from the beginning, while the learning process itself does not guarantee success.

On the other hand, the expert system's fuzzy approach has been applied to the forecasting of different problem (Bolloju, 1996), (Kaneko, 1996), (Shaout and Al-Shammari, 1998), where the operator's knowledge to predict results. Although forecasting is based on Fuzzy logic, the results show that the process for constructing fuzzy-logic system is subjective and depends on the heuristic process. The choice of membership function and basic rules must be developed heuristically for each case. Rules in this way do not always produce the best predictions, and the choice of membership function still depends on trial and error. The strengths and weaknesses of Neuro-fuzzy and fuzzy logic, have combined the ability to learn from neural networks and the functions of fuzzy expert systems. Application can be found in (Dash et al., 1995), (Studer and Masulli, 1997), and (Padmakumari et al., 1999). For example the hybrid model is expected to provide understanding to humans about the meaning of 'Fuzzy' through the various advantages can be used as a concept of knowledge by studying neural networks.

Some researchers such as (Jacobs and Levy, 1989), have claimed that the stock market is not a system that can be explained by simple rules, nor is it a random system that is impossible to predict. In fact, they claim that the market is a complex system, where the behaviour of the system can be only be explained and predicted by a complex set of relationships between variables.

Recognizing the complex characteristics of the stock market to invites the researchers to further investigate whether index variations can be improved to predict nonlinear models using the neuro-fuzzy approach. (Lin et al., 2002) in the "Can the neuro-fuzzy models predict stock indexes better than its rivals?" Develop a model based on a trading system by using a neuro fuzzy model to predict stock indexes better. Thirty well-known stock indexes

were analyzed with the help of the developed model. Empirically shows the corresponding non-linear results in stock indexes using the KD technical index. Analysis of trading points and analysis of trade costs indicate endurance and opportunities for profit, it is recommended to use nonlinear neuro fuzzy systems. The analysis also shows that the recommended neuro fuzzy is consistent over time.

In 2003, (Özkan et al., 2004) in the "Currency Crises Analyzed By Type-I Fuzzy System Modelling", implementing softcomputing in the analysis of a currency crisis, with test data time series of data is the currency of Turkey. The method used is the approach of macroeconomic time series data, the Rule-based Fuzzy System Modelling (RBFSM) become the focus of research and compared to GARCH /ARMAX and ANFIS. The results show that the GARCH approach / ARMAX and ANFIS no better than predicted RBFSM.

Achsani, (2003) using a fuzzy cluster algorithm to model the demand for Indonesia with the data in 1993: 4 to 2002: 3 even though the results are not as good as the econometric model approach because it does not consider the effect of autocorrelation and seasonality of data, however, can explain in more detail the grouping of economic periods. In the same year, Achسانی, (2003) back to do research using Fuzzy-Clustering in data ASEAN + 3 as the ratio of debt / GDP, exchange rate stability, inflation rate, and the long term interest rate to determine the relative position of Indonesia in the constellation of Asian economies East.

In previous years some researchers report that their concern for the problems of economic crisis. They are concerned about the adverse consequences of the policies needed to maintain economic variables (Agenor et al., 1992; Flood and Marion, 1998; Flood and Marion, 1998). While the traditional approach emphasizes the role played by a decline in foreign reserves in triggering the collapse of the fixed exchange rate, some of the latest models suggest that the decision to abandon the parity may occur based on concerns about the evolution of the economic authorities. On the other hand, variables indicate that groups of other variables can be useful for predicting the currency crisis (Ozkan and Sutherland, 1995) and (Velasco, 1987). In addition, the latest model also suggested that the crisis can develop in the absence of fundamental changes in the real economy. This model emphasizes that the nature of the contingency of economic policy may pose some equilibria and produce that meets its own crisis (Obstfeld, 1983). Some recent research has focused on the effects of the balance of payments crisis (Eichengreen et al., 1995).

All these models recommend possible variables as the main indicators of crisis. However, some new works are opposing, for example (Chowdhry and Goyal, 2000), the results of the sample data forecasting beyond a theoretical model for the case of the Asian financial crisis is largely disappointing.

(Lin et al., 2002) in "A New Approach to Modeling Early Warning Systems for Currency Crises: can a machine-learning fuzzy expert system predict the currency crises Effectively?". Back conduct research using Neuro-Fuzzy approach to predict the crisis in Indonesia, Philifina, Thailand, and Malaysia. This model integrates the learning ability with fuzzy logic inference. The empirical it shows that the neuro-fuzzy approach produces significantly better predictions. Compared to traditional approaches such as logit techniques.

In 2007, (Muslim, 2007) in the "Implementation Algorithms and Neuro Fuzzy Fuzzy Cluster Case Studies Indonesia's exports to Japan" provide an alternative modeling especially data modeling Indonesian exports to Japan by applying algorithms and Neuro Fuzzy Fuzzy Cluster. MAPE size and Theils Inequality shows that both methods have a good performance to estimate export. When compared to conventional methods OLS-AR fuzzy method provides better results. Prediction of the input-output relationship on Fuzzy Cluster Algorithm can predict their objective structural break in 1993: Q2 and 1997: Q4 and evidenced by subjective methods chow-test. Modeling indicates that there is a conditional relationship in the model of Indonesian exports to Japan, in the context of these relationships are fuzzy low, medium, high, while in the context of time is pre Japanese Slump, after the Japanese Slump, post-crisis Indonesia.

2.3 Fuzzy Logic Applications in the Field of Business

Use information technology becomes an important part in business management in the 21st century now. Today information technology were mostly used to process data and efficient support effective communication in business management. Predictions of the future of information technology will be used as a decision-making tool automatically, have the intelligence capability to analyze and be able to do the learning to make optimal decisions. For that we need a system that is able to behave like a human being in terms of thinking and make decisions rationally. Fuzzy logic is a concept that can be used to meet the demands of the system. In the business world has made several application programs based

on fuzzy logic are: (Munakata and Jani, 1994), early application in the trading world using fuzzy approach. The system handles 65 industrial stocks in the Dow and the Nikkei 800 rule prescribed by the experts and if necessary repaired by senior business analyst. This system has been tested for 2 years and performance by using Nikkei Average showed an increase of over 20%. When tested this system recommends "sell" 18 days before the "Black Monday" in 1987. The system is operated commercially in 1988. Most financial analysts, agree to say that the "rule" for the trade was "fuzzy". Convertible Bond Rating, Nikko Securities, has been using ANN to raise the rating convertible bond since twenty seven years ago (Okada et al., 1992). This system of learning from expert instruction reaction rating, which change according to economic circumstances. The system will analyze the results, and using the results to advise. The system consists of a combination of fuzzy logic and ANN to describe the input. Ratio of the correct answer is 96%.

In (2000) (Kahraman et al., 2000) in the "Justification of manufacturing technologies using fuzzy benefit or cost ratio analysis". The application of fuzzy logic is used for the application of cash discount techniques to justify the manufacturing technologies studied many documents. The net value of the country's stock and stochastic value now are two examples of this application. This application is based on data that is outside the range. If we have the faint of data such as interest rates and cash applying the techniques of cash discounts, fuzzy set theory can be used to resolve this uncertainty. Fuzzy set theory has the ability to represent data and the vague and allows the operator to apply mathematical programming fuzzy domain. This theory is primarily concerned with measuring uncertainty in the mind and human perception. On paper, with the assumption that we have data that is not clear, the method of operating cost ratio (B/C) fuzzy logic is used to justify the making technology. After calculating the B/C ratio based on annual values, it turns out that the two manufacturing systems have different cycles.

(Draeseke and Giles, 2002) in the "A fuzzy logic approach to modeling the New Zealand underground economy". Implementing fuzzy logic to analyze the importance of the availability of data on the size of the economy "under" (EU) for macroeconomic policy. They use fuzzy set theory and fuzzy logic to draw up an annual time series for New Zealand unobserved EU during the twenty six year. Two input variables used in effective tax rate and the index of the level of regulation (REG). The result of time series UE compared to the previously built. Second, the authors use the model of "multiple

indicators, multiple cause” (MIMIC) structural. Both approaches produce each UE Photo New Zealand sensible but somewhat different during this period. The fuzzy logic approach to this problem involves several subjective considerations, but the results are quite satisfactory.

Research activities in the economic field during the last five years it has increased significantly. (Zavadskas and Turskis, 2011; Büyüközkan and Feyzioglu, 2004; Karsak and Tolga, 2001). Conducting research in the ”Multiple Criteria Decision Making (MCDM) Methods In Economics: An Overview”. Suggests that the main research field is the study of operations and sustainable development. That philosophy of decision-making in the economic field is to assess and choose the most recommended solution, apply it and to get the greatest benefits. Alternatives methods applied in problematic conditions both in the decision-making process of individuals or organizations. Several of effective decision making methods support decisions in conditions where several criteria have emerged in the last decade. The Paper’s presents methods of decision-making in the field of economics and a summary of results and important applications over the last five years. The paper considers the decision making considering the development of some of the latest methods of decision-making criteria (for the classic method is discussed in many previous publications). Researchers here using a different approach, pioneering studies and papers presented briefly.

The comparative analysis results of the reviewed article are presented in the following table:

3 CONCLUSIONS

The rapid development of technology and computers to follow the development of economic modeling representative. As one alternative approaches to modeling and in providing system solutions in the real world, especially for the complexity of the system that are not easy to approach through mathematical modeling, can be used as an alternative method of fuzzy logic to solve problems. As for some reason it is advisable to use fuzzy logic is:

- Conceptually easy to use because it is based on a simple mathematical concept.
- Their tolerance to uncertainty data;
- Program to model the system that is not linear and complex;

- Working system is based on everyday human communication.

ACKNOWLEDGEMENTS

The researchers express special thanks to Universitas Islam Riau which has facilitated this study.

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