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FUZZY LOGIC APPLICATIONS

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ABSTRACT

How the developing countries will be able to increase investment rates they need for sustainable improvement and continuous growth and which factors affect these investments is the most important subject in development process. The purpose of this thesis study is finding out the factors that determine private sector investments in developing countries and examining the role and importance of indeterminacy factor caused by macroeconomic and politic disablement on investments. Differently from the studies in literature, to reveal this uncertainty effect Fuzzy Logic Calculations provide several conveniences in fields of Economy, Management and Law.

Keywords: Fuzzy Logic, Application, Management

ÖZET

Gelişmekte olan ülkelerin sürdürülebilir gelişme ve sürekli büyüme için ihtiyaç duydukları yatırım oranlarını nasıl artırabilecekleri ve bu yatırımları etkileyen faktörler kalkınma sürecinde en önemli konudur. Bu tez çalışmasının amacı, gelişmekte olan ülkelerdeki özel sektör yatırımlarını belirleyen faktörleri bulmak ve makroekonomik ve politik açıdan yatırımlardaki aksaklığın neden olduğu belirsizlik faktörünün rolünü ve önemini incelemektir. Literatürdeki çalışmalardan farklı olarak, bu belirsizlik etkisini ortaya çıkarmak için bulanık mantık hesaplamaları ekonomi, yönetim ve hukuk alanlarında çeşitli kolaylıklar sağlar.

Anahtar Kelimeler: Bulanık Mantık, Uygulama, Yönetim

1. INTRODUCTION

One of the most important effects on economical development and sustainable development is real capital stock (Levine and Renelt, 1992). When the countries with high growth rate are examined, these countries have been observed to be able to sustain necessary investment rates or to be able to increase this rate (Little et.al., 1995). There have been serious studies on determining the factors effecting such important investments in terms of developing countries (Khan and Reinhard, 1990; Greene and Villanueva, 1991; Catinat et.al., 1990). But especially as in Turkey's sample not enough studies have been done on the uncertainty which is an important factor for making investment decisions in the countries under a continuous macroeconomic and politic disablement and hyperinflation. The most important reasons of this deficiency are theoretically unclear relation between uncertainty and investment demand and the difficulties about measuring uncertainty. In

Conway's study (1991) that is the only research deals the effect of uncertainty on the investments in Turkey, effects of the uncertainty on real interest rates and real exchange rates on investment decisions have been examined using annual data. By uncertainty revealing model using Vector Auto Correlation (VAC) method the negative effects of both variables on investment decisions have been revealed.

Classical probability theory methods and econometric deterministic methods fall behind of including uncertainty effect to the models and revealing this effect completely. In fact it cannot be said that the effect of uncertainty can be caught in these methods which have a deterministic approach and take the effect into two terminal points as existence or non-existence and there is no effect mentioned. And in the modelling will be done with the help of Fuzzy logic theory developed by Zadeh (1965), high level meaningful outputs have been expected by the reason of high performance Fuzzy Logic theory shows about revealing effect of uncertainty completely.

2. FUZZY LOGIC

Since people are under an uncertainty while making selections in their daily life, making decisions and predictions about future, the mostly use qualitative expressions instead of qualitative ones. Fuzzy set theory is based on the acceptances that use this thought in human brain as base. Therefore, we can say that the most suitable mathematical theory with human genius is fuzzy logic theory. Especially if it is thought that decisions in many areas of the economics are in direction of perceptions in human brain, using fuzzy set theory in economics should be expected to give important results.

2.1. Innovations and Advantages of Fuzzy Logic Theory

When Fuzzy logic theory as a theory which is used for solution of uncertainty conditions and modelling uncertainty took place in the literature first time had not been welcome due to being in contrary to classical thought that has a deterministic intelligence. But in time, it is approved as a result of successful implementations in Far East countries. The major innovations brought into science by this theory can be listed as follows (Woodall and Davis, 1994; Ross, 1995; Şen, 2001):

- ✓ In today's science world effectiveness of fuzzy logic is wished to reveal the uncertainty because of the intention that fuzzy logic should be take place in models effectively instead of escaping from uncertainty.
- ✓ In the basis of fuzzy logic there is the hypothesis that qualitative factors are more predominant than quantitative factors as in human decision making structure. Thus, fuzzy logic theory is the best fit theory to human genius.
- ✓ As in some models especially in economical areas –not formally but informally- fuzzy logic theory becomes effective for revealing qualitative acceptances (e.g. high interest rate, low rate of growth, approximately 5% growth etc.) made by model founder.
- ✓ Due to some concepts in the future model are asserted through a language, some deficiencies caused by the uncertainty inside the language reveal. Taking reading of membership functions in fuzzy logic theory in the range of [0,1] provides flexibility for this model to make up a shortage.
- ✓ There is no necessity of mathematical operations in using fuzzy logic. This accelerates to reach fruition and decreases the possibility of making a mistake.
- ✓ Not allowing human interference in the systems using fuzzy logic and being faster and cheaper are some of superiorities of fuzzy logic.
- ✓ The other advantage of using fuzzy logic is being able to catch nonlinearity of the model. Therefore, the difference between predicted parameter and actual parameter (error terms) is at its lowest ebb.

2.2. Flexibility and Disadvantages of Fuzzy Logic Theory

Contrary to these positive aspects of fuzzy logic theory some disadvantages can be observed. These advantages can be indicated as follows:

- ✓ Definition of membership functions which is the most important innovation is not clear enough. In fact membership function can be given even on the basis of previous observations.
- ✓ Otherwise, using testing method instead of experience decreases time utility provided by fuzzy logic to constitute membership functions and extra time is needed.

Fuzzy logic theory developed by Zadeh (1965) takes an important place in the literature as a result of positive side abovementioned. Especially it provided uncertainty function that has a difficulty of modelling to be included in models and to catch the effect of this function with the concept of membership functions. In the next section set theory formed with fuzzy logic theory and how the membership functions determined are approached.

3. USING FUZZY LOGIC CALCULATIONS IN ECONOMY

To create the uncertainty index to be used in the model will be established variations in consumer price index one of the effective functions for making decision (inflation rates) and nominal interests to 12 months deposits are used. Using AND/OR processes from fuzzy logic operators inflation index and interest value of the same period have been matched up.

Interest rate in an economy gives significant information about capital tendency. How the savings will be put to good use is determined by the rate of interest in the market. In fact as the interest rate is high so wish of investment with saving becomes lower (Khan and Reinhard, 1990, Grene and Villanueva, 1991, Bleaney and Greenway, 1993). Therefore, if there is a high variability in rates of interest while companies under uncertainty are taking investment decisions, they delay or give up making investment (Dixit and Pindyck, 1995).

The rate of inflation in economy is also highly effective. Most especially high variations in consumer price index affect the companies which are about to make an investment decision in risk-increasing direction (Dornbusch and Reynoso, 1989). Moreover the cost increasing effect of high inflation about floating a loan also affects investment amount detractively. It is not a wrong method using inflation as base of major source for uncertainty in economy which is used to live with high inflation during more than 30 years period.

The company that will make an investment decision pays special attention to these two factors. In economic literature, probability theory has been used in models constituted in researches to date, therefore, the explanatory power of obtained equations in the model remained quite low.

The index obtained with fuzzy logic theory will be used in the model that is under construction to use the superiority of fuzzy logic theory about revealing effects of uncertainty. Power of this balance about explaining the model is expected to become higher against the pre-existing models.

The index included in the model will be constituted using interest rate and inflation rate which are some of the effective on decisions of investment. While doing this, both interest rates and inflation rates have been split into 5 categories using the rules of fuzzy logic theory. Then using AND/OR operators of fuzzy logic, existing inflation rates and interest rates fuzzy numbers for all periods are combined to constitute a single investment willingness index. Finally this index which is exist as fuzzy number investment willingness index has been found as a real number between 0 and 1 making clarification process.

While the investment decision is being made, inflation rate in the market is quite important in terms of determining investment costs and financing. At a level of high inflation credit costs necessary for financing the investment will rise. Therefore, investment return will decrease. As a result of this

refusing or delaying investment can be discussed. Likewise, the high variation in inflation rate is also among the factors which postpone and complicate the investment decision. Thus, expected inflation value became an important variant in investment projects. In the model will be established inflation value in the future period has been accepted as equivalent to the value in the existing period.

In developing countries, the interest rate that is one of the important factors for making investment decisions is in an inverse relation with investment willingness. In fact, it has been observed that under the high interest rates investors lay off or escape from their investments by the effects of both return differentiation and economic and politic uncertainty in the country. Therefore, the company which makes an investment decision while assessing the rates of interest examines the level and variance of interest rates in previous terms and compares to present interest and reaches a decision accordingly. Hereby, current interest rates are accepted as the expected interest rate value for the upcoming period.

4. USING FUZZY CALCULATIONS IN MANAGEMENT

In Analytical Hierarchy Process (AHP) method while making pair wise comparisons decision makers have to choose relative weight of criterions and alternatives from constants in a particular scale. But they prefer making intermittent evaluation rather than a decision maker fixed asset for subjective decisions of which numerical value is not determined (Salo and Hamalainen, 1995: 475).

Most of the Fuzzy Analytical Hierarchy Process (FAHP) methods have been suggested for solution of this problem. Common point of these methods is to express the hierarchic structure for the problem using the principals of Fuzzy set theory (Zadeh, 1965). FAHP firstly suggested by Van Laarhoven and Pedrycez(1983) comparing triangular membership functions defined fuzzy rates. Buckley (1985) suggested the definition of fuzzy superiorities of comparison rates with trapezoidal membership functions. And Chang (1996) offered a new approach using magnitude analysis method for synthetic grade value of triangular fuzzy numbers and pair wise comparisons in pair wise comparison scale of FAHP (Kahraman, 2008: 54). In this section Laarhoven and Pedrycez and Buckley's methods in general principals and Chang's Order Analysis Approach is explained in detail.

4.1. Laarhoven and Pedrycez Approach

In this approach an algorithm which is a clear enlargement of AHP is suggested by Laarhoven and Pedrycez (1983). In consideration of pair wise comparisons, the components in pair wise matrix are expressed with triangular fuzzy numbers.

In enlarged version of AHP, fuzzy weights and values of fuzzy performance weights are obtained using Lootsma's logarithmic least squares method. Since calculations of this method are quite difficult and the results are not productive, it is not preferable (Kahraman, 2008: 56).

4.2. Buckley Approach

Buckley(1985) also offered a new approach to Analytical Hierarchy Process using fuzzy comparison rates. Buckley criticized Laarhoven and Pedrycez's method in two directions. One of them is that linear equation obtained from the equations collected in the method always offers only one solution. And the other one is that they are insisted on using triangular fuzzy number to find out fuzzy weights. Owing to the fact that triangular fuzzy numbers cannot always be obtained as a result of arithmetic operations on triangular fuzzy numbers, they had to apply rough methods to keep fuzzy number form. But Buckley obtained fuzzy weights using geometric average method for comparisons in which he used trapezoidal fuzzy numbers instead of triangular fuzzy numbers. This provides both continuance of fuzzy situation and obtaining a single solution from comparison matrixes (Kahraman,2008: 63).

4.3. Order Analysis Approach

Order Analysis Method which is different from other Fuzzy AHP methods was suggested by Chang (1996). Firstly it is used for triangular fuzzy numbers and pair wise comparisons. Later, synthetic rating values are calculated for criterions and alternatives using order analysis method. These

synthetic values are used to find out final significance level (Chang, 1996: 649). While this method is applied on quite a few FAHP problems, there are several versions by developing this method. The greatest advantage of this method is revealing the superiorities of decision elements clearly in significant range.

5. USING FUZZY CALCULATIONS IN LAW

Zadeh (1965) suggested the idea of fuzzy set developing fuzzy logic instead of syllogistic logic that has only two probabilities. The idea of fuzzy logic provides a natural way about accurate described source problems rather than finding random variables (Şen, 1998). Fuzzy logic theory provides systematic calculations about information verbally. Fuzzy approach makes numerical calculations using verbal tags stimulated by membership functions. Therefore, Zadeh has described values of sentences in natural or artificial languages with verbal variables (Şen, 1998). Although fuzzy logic was suggested by Zadeh in 1965, gained attention after a real control implementation performed by Mandani and Assilian in 1975 (Mandani and Assilian, 1975). Actually the main theme in fuzzy logic is allowing the global set objects belonging to various sub-sets partially rather than being belonged to a single set. Belonging to a set partially can be explained numerically with membership function that includes the values between and not excepting the numbers 0 and 1

5.1. Fuzzy Logic Inferring System

Using fuzzy set theory allows the user to include uncertain inevitable conditions in data. Fuzzy inferring is real entreating the map of a set of rule-based outputs in variable input. A general fuzzy inferring system has basically 4 components. These components are; blur, fuzzy rule base, fuzzy inference motor and clarification (Şen, 1998). Also there are input and output data. Blur turns each input data into one or more membership functions. Fuzzy rule base includes the rules that contain all possibilities of fuzzy relation between inputs and outputs. These rules are expressed in If/ in case format. Fuzzy inferring motor considers all fuzzy rules in fuzzy rule base and learning to find out the correct result from the inputs in transferred set. Basically there are two kinds of inferring operators: reduction (min) and conclusion (prod). Clarification is transformation of the fuzzy inputs that are resulted in inference motor to a number. There are great numbers of clarification methods: for example average of weights, total of weights. Fuzzy inferring systems are strong tools used for imitation of the non linear behaviours by the help of fuzzy logic and verbal fuzzy rules. Fuzzy inferring system that uses Fuzzy IF/IN CASE rules can model the humanitarian information and reasoning processes with a qualitative perspective without using fully quantitative analysis (Ho et.al, 2001). There are various methods of inferring systems: for example Mandani and Sugeno (Mandani and Assilian, 1975,-Takagi and Sugeno, 1983). Fuzzy modelling or fuzzy description was researched by Takagi, Sugeno and Kang firstly and they revealed great numbers of implementations in control, prediction and fuzzy inferring system (Sugeno and Kang, 1993).

In Sugeno fuzzy inferring systems the results of fuzzy rules can be as inputs since they produce rapid functions. In figure 1 the first organized inferring method in Sugeno style fuzzy inferring system has been shown (Jang and Sun, 1995). Mathematically if F shows continuous match-up in closed interval, in Sugeno style fuzzy inferring system non-linear matching parameter can be given as in equation 1.

$$F = \frac{\sum_{i=1}^m w_i \prod_{j=1}^n \mu_{A_j^i}(x_j)}{\sum_{i=1}^m \prod_{j=1}^n \mu_{A_j^i}(x_j)} \quad (1)$$

Here, m shows numbers of rule, n indicates data indicators and μ_A is the membership function of fuzzy set. Another significant subject that affects the performance of fuzzy inferring system is allocation of input range. In this context, there are quite a few allocation techniques: for example round wire allocation and tree shaped allocation (Jang and Sun, 1995).

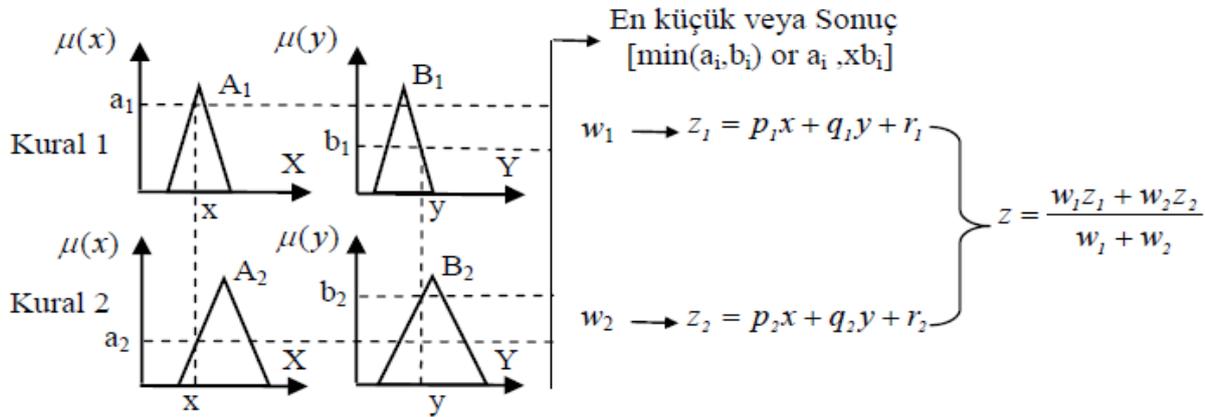


Figure1. Inferring method from Sugeno style organized with two fuzzy rules

6. CONCLUSION

Thanks to fuzzy logic effective decision and classification are used not only in engineering areas but also in social areas. Scientists no longer can make assumptions about societies with approximate values rather than squeezing and expressing the social facts in certain and clear patterns. Likewise, the language used in sociological questionnaires may give more confidential results making benefit from fuzzy logic policies and fuzzy characteristics of the language. In this concept relation of fuzzy logic with the areas of language, philosophy, religion, education and law can be said to be the important research subjects.

For example when the connection of the societies to each other is examined the remarks which will be able to make the borders more transparent can be achieved with fuzzy logic studies. In the same way, for adjudication in law fuzzy logic thought may have a determining role in the processes of straddle and stuck lawsuits. Similarly also in educational area that is the focal point of our research it helps the educational employees and students to establish a hard decision making mechanism. Academic success is known to be related with quite a few factors directly or indirectly. There have been a variety of efforts examine the academic success and in the direction of determination of cognitive- affective components that effect this success.

For academic success evaluation traditional rating systems are mostly used. Traditional rating systems are representatives of system which has been restructured using objective and subjective valuation criteria. Measurable features are usually showed by certain values. But the subjective criteria like leadership, representation and problem solving abilities are less measurable. Educational service of academic world and evaluation criteria is subjective as in the other quantitative researches. Based on the rating system, fuzzy logic is suitable (Akandere, Özyalvaç and Duman, 2010: 3).

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