DOKUZ EYLÜL UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

FUZZY LOGIC AND DATA MINING TECHNIQUES IN EVALUATING OF CREDIT RISKS OF COMPANIES

by

Melis BÖLGEN

October, 2010

İZMİR

FUZZY LOGIC AND DATA MINING TECHNIQUES IN EVALUATING OF CREDIT RISKS OF COMPANIES

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M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled **"FUZZY LOGIC AND DATA MINING TECHNIQUES IN EVALUATING OF CREDIT RISKS OF COMPANIES"** completed by **MELİS BÖLGEN** under supervision of Prof. Dr. **EFENDİ NASİBOĞLU** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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Prof. Dr. Efendi NASİBOĞLU

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(Jury Member)

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(Jury Member)

Prof.Dr. Mustafa SABUNCU
Director
Graduate School of Natural and Applied Sciences

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FUZZY LOGIC AND DATA MINING TECHNIQUES IN EVALUATING OF CREDIT RISKS OF COMPANIES

ABSTRACT

In this study, a method that is based on fuzy logic is proposed to determine the credit rate and to be taken assurance amount for the companies which they apply to the bank to get credit and a program is developed for that method. Totaly 109 SMEs (Small and Medium Sized Enterprises) applied for the credit to the bank which it has branch offices around Turkey and 54 of them are failed in terms of financially, have been examined.

At first stage, a model, which classifies as successes and as failed for the credit granting, has been created with supervised education. For that purpose, C&RT decision tree model of SPSS Clementine 10.1 has been used, 33 inputs and 1 output have been evaluated. 8 rules, which establish decision tree mechanism for credit granting, have been found by using C&RT algorithm. Later, fuzzification has been applied to these rules on FIS (Fuzzy Inference System) Editor of Matlab 7.0.1. Mamdani approch has been used based on FIS model, and on created model, 7 inputs and 2 outputs ("to be given credit amount to the company" and "to be taken assuarance amount from the company") have been used.

Calculated credit results of the proposed method and the results of applied bank credit policy have been compared and it is defined that credit policy of new method is reduced the loss approximately 32% of applied bank credit policy.

Keywords : Fuzzy Logic, Credit Granting, Risk Analyses, Decision Tree

ŞİRKETLERİN KREDI TALEBI DEĞERLENDİRİLMESİNDE BULANIK MANTIK YAKLAŞIMI

ÖZ

Bu çalışmada bankaya kredi talebinde bulunan şirketler için verilecek kredi miktarı ve alınacak teminat miktarının belirlenmesi için bulanık mantığa dayalı bir yöntem önerilmiştir ve bu yöntemin bilgisayar programı tasarlanmıştır. Yöntemin geliştirilmesinde Türkiye genelinde şubeleri bulunan bir bankaya kredi talebinde bulunan 54 adeti finansal açıdan mali başarısızlığa uğramış olan toplam 109 adet KOBİ (Küçük ve Orta Büyüklükteki İşletmeler) incelenmiştir.

İlk aşamada eğitmenli (supervised) sınıflandırma yapılarak kredi tahsisleri "başarılı" ve "başarısız" sınıflarına ayrıştıran model üretilmiştir. Bu amaçla SPSS Clementine 10.1 programının Karar Ağacı modeli kullanılmış, 33 adet bağımsız değişken ve bu değişkenlerin yardımı ile kredi tahsisinde karar verme mekanizmasını oluşturan kurallar tanımlanarak 8 adet kural bulunmuştur. Daha sonra ilgili kurallar bulanıklaştırılarak Matlab 7.0.1 programının FIS (Fuzzy Inference System) çıkarsama modelinde kullanılmıştır. FIS modeli olarak Mamdani metodu esas alınmış ve oluşturulan modelde, 7 adet girdi ve 2 adet çıktı (firmaya verilecek kredi miktari ve firmadan alinacak teminat miktarı) değişkeni kullanılmıştır.

Önerilen yöntemin hesapladığı kredi sonuçları ile gerçekte bankanin elde ettigi sonuçlar karşılastırılmıştır ve yöntemin önerdiği kredi uygulamasının banka uygulamasından yaklaşık olarak 25 Milyon TL daha az zarara yol açtığı belirlenmiştir.

Anahtar sözcükler : Bulanık Mantık, Kredi Tahsis, Risk Analizi, Karar Ağacı.

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CHAPTER ONE
INTRODUCTION

Banks, which have a crucial role in today's economic and commercial life, are economic foundations that work on satisfying all kinds of needs of the private and corporate bodies, the state and the enterprises which perform all kinds of operations on capital, money and loans.

Utilizing banks' resources correctly both expedites investments and contributes in speeding the economical development via increasing the investable funds.

With this special condition, banks have taken on important tasks for reaching the desired macro-economic targets determined by the economical policies put in practice in our country, both by having the possibility to create money, and by constituting the cornerstone of change mechanisms, in addition to their function of converting the country's possession into loans.

The banking sector, which is the indispensable element of a robust economic system, holds its own place in the agenda both by the services they provide, and the financial structures.

Risk factor is a very important concept that has to be taken into consideration. In the developments in banking, in the world and in Turkey, and how these developments influence the social and economic lives of people, and the policies of the states are considered, the crisis', arisen in the world in 2008, affecting the whole of the economy, and banking sector being exposed to the worst effect supports our remark. Recently, it is seen how banks which do not utilize their resources productively and which do not have capitals enough to comply the risks carried, with the fluctuations still encountered in the economy and banking sector, are easily involved in failure in crisis.

Recently, in order to prevent the banks from becoming unable to fulfill the obligations due to the risks encountered, to develop standard procedure through Basel Process, global and local regulations have been made.

These regulations, for the economic system to operate well, aim at determining the basis and procedures of the internal auditing and the risk management systems in order and having enough capital to comply the risks carried.

The correct management of risks depends on predicting the potential risk and taking the necessary measures as for today.

Many studies have been conducted on predicting the financial failure. However, from the point of view that financial data are not enough alone for failure predictions in SMEs, which are the basic foundation of our economy; systems making efficient use of qualitative variables which are thought to be influential on the results were discussed, and a new model was comprised via fuzzy logic approach and an application was conducted in this thesis study.

This study aims at taking the necessary preventive measures by presenting an alternative method in predicting the financial failure in SMEs, in which the risk measurement is more difficult compared to the large-scale corporate firms.

CHAPTER TWO
FINANCIAL TERMINOLOGY USED IN BANKING

In this section some basic financial terminology will be given.

2.1 Basel II Definition

Basel II is a regulation comprised for developing an efficient risk management, auditing and market discipline in banks, increasing the effectiveness of the capital adequacy calculations and so constituting a secure banking system; thus contributing stability.

2.2 SME Definition

When defining SME, generally various criteria such as number of employees, equity capital, machinery pool, number and power of benches used, machining capacity, and amount of area used, are taken as basis. However, mostly the number of employees and the capital are selected as a baseline (Karataş, 1991).

There are differences in the definition of SME in Turkey and in Europe; the official definitions are given in the next sections.

2.2.1 SMEs' Definition in Turkey

There is not any consistency in the definition of SME between governmental institutions and banks. However, the studies to standardize the definition in order not to give rise to confusion is continuing, and in these context new definitions for micro, small and medium sized enterprises in the official gazette dated 18/11/2005. According to these definitions;

Micro sized enterprise: Very small sized enterprises with less then ten employees annually, and with annual net sales revenue or financial balance sheet not more than one million TL,

Small sized enterprise: Enterprises with 10 to 50 employees annually, and with annual net sales revenue or financial balance sheet not more than five million TL,

Middle sized enterprise: Enterprises with 50 to 250 employees annually, and with annual net sales revenue or financial balance sheet not more than twenty five million TL.

Table 2.1 Definition of SMEs' in Turkey

SME Definition	Number of Employees	Annual Revenue or Balance Sheet Sum
Micro Sized Enterprise	Less than 10	Up to 1 million TL
Small Sized Enterprise	Between 10 and 50	Between 1 and 5 million TL
Middle Sized Enterprise	Between 50 and 250	Between 5 and 250 million TL

2.2.2 SMEs' Definition in EU

The SME is defined as and enterprise with less than 250 employees, with annual sales turnover not more than 40 million Euros or with a fixed asset not more than 27 million Euros except land and buildings, and which matches the criteria of independence (Çolakoğlu, 2002).

2.2.3 SMEs' Definition in Accordance With Basel II

Enterprises with less than 50 million Euros of annual return are considered as SMEs as part of Basel II. Depending on the SME definition "retail-corporate" distinction gain importance and SMEs with a total loan (cash + non-cash) less than 1 million Euros are defined in "retail portfolio" and with a total loan over 1 million Euros in "corporate portfolio" (Türkiye Bankalar Birliği, 2004).

Table 2.2 SME definition as part of Basel II

SME Definition	Number of Employees	Annual Return	Or	Balance Sheet
Micro Sized Enterprise	Less than 10	Up to 1 million TL		Up to 2 million Euro
Small Sized Enterprise	Less than 50	Up to 5 million TL		Up to 10 million Euros
Middle Sized Enterprise	Less than 250	Up to 250 million TL		Up to 43 million Euros

2.3 Basel II and Ratings

The Basel II process requires the use of a credit rating system in the calculations of capital adequacy of the banks (Eken, 2007). It is a system that expresses and categorizes the result obtained, depending on the previous and up-to-date qualitative and quantitative data of the loanee, as numbers, letters or a general credit grade comprising of the combination of the two, in rating the creditworthiness and predictable risks.

The rating grade obtained at the end of the evaluation of the quantitative (data obtained from the financial indicators such as balance sheet, revenues, cash-flow tables) and qualitative factors (data such as the financial history of managers or partners, intelligence, trade relations, import-export, market-share and sector information), gives the bank information on whether the loanee could fulfill the loan repayment and the liabilities to the bank regularly and in full, and on the risk carried. The result of this operation is taken as an input in determining the capital to be invested by the bank. As the rating grade of the loanee decreases, the bank will take more risks, and it will have to invest more capital as well. One of the purposes of comprising a rating system is to measure objectively the risks an enterprise carries. Therefore credit rating and comparison can be possible, and a special pricing can be made for the customer according to the risks carried and the probable amount of capital to be invested. However, the rating's being correct depends on the data being

correct and up-to-date. The banks should track their customers in the period in which the loan risk continue, and should update the rating grades of the loanees in certain periods (e.g. 3, 6, 12 months) using the up-to-date data they obtained.

2.3.1 Risk Based Pricing and Collateralization

A binding element for risk based pricing is the assurances the enterprises would give for the loans provided. The assurances mainly preferred in Turkey are presented below:

- Partner suretyship,
- Group company cross suretyship,
- Customer cheques and bills,
- Finance cheques and bills,
- Office and home mortgages,
- Pledges of commercial enterprises.

The new Basel II does not interfere with the decisions of banks to loan to SMEs but aims at that banks measure the risks logically while making the decision of loaning and have enough capital to comply the risk carried.

A controversial aspect of Basel II is that statistical process is suggested but not made obligatory in determining the weights. This approach gives the loan managers to determine the variable weights in creditworthiness measurements according to their experience and thus differences related to subjectivity to occur in application.

It is seen that in Turkish Banking system, still the classical approach depending on expert experience is used in calculating weights, and transition to statistical methods is in its early phases since an adequate and regular database have not been comprised yet. The research subject in this study, the fuzzy logic method is presented as a new vision since it reaches beyond the statistical method.

2.4 Evaluating SME Loans

The steps explained below are applied in evaluating the SME loans.

2.4.1 Evaluation Process

The evaluation process of SME loans, which shows similarities in process and workflow in the banks, comprises of the following main phases;

2.4.1.1 Loan Application and Accepting Application Documents

Loan evaluation process starts with the customers' application for loan to the branch bank. In this phase, the request of the customer and the documents related to the application is taken and subjected to a preliminary survey; in case any situation inconsistent with the laws, practices and procedures is detected, the application is rejected in this phase; or if there is any outstanding document, the customers is made to provide this document and the bank proceeds to next phase.

Various documents are collected by the banks to be used as data in the evaluation process and in the rating system.

These are the documents such as;

1. Balance Sheets and statement of profit and loss for the last 3 years, their explanatory notes, the trial balance for the last year, flow of funds statement and financial tables,
2. An intelligence report comprising of market and bank information,
3. Risk centralization reports form Office of Loan Records and Central Bank of Turkey,
4. Commercial registry gazettes of certificate of incorporation (establishment and amendments),
5. Tax Board,

6. Authorized signatures lists of partners and warranters,
7. Chamber registration certificate/certificate of activity,
8. Movable and real property information for partners, warranters and the companies,
9. Credentials of partners and warranters,
10. Provisional tax return for the last period and accrual voucher,
11. List of participants for the last general board,
12. Encouragement certificates,
13. Capacity report,
14. Quality certificates,
15. Project status report/reports for finished and continuing tasks,
16. Feasibility reports.

2.4.1.2 Intelligence

The following inquiries are conducted for the applicant enterprise, its partners and warranters, and for other group companies and it is determined whether the applicant is creditworthy:

— Inquiries of Office of Loan Records,
— Central Bank of Turkey Combined Risk Record inquiries,
— Edts (Electronic Data Transfer System) inquiries,
— Bank inquiries,
— Market inquiries,
— Bounced cheque/Protested bill inquiries,
— Verification of information and documents.

If any problems that inhibit loaning, rejection of the application is announced to the customer; in case the intelligence process is affirmative the bank proceeds to the next phase.

2.4.1.3 Financial Analysis

The documents collected from the customer and all the qualitative and quantitative data obtained as a result of the intelligence process, are carried onto the analysis systems or rating systems, if present, by trained personnel in the branches or in financial analysis departments of the head offices, and the transfer, refining and enhancement procedures are conducted; and the rating grade is obtained (With Basel II, one of the most important changes expected in banks' credit facilities is the increasing importance of rating systems. When the provisions of Basel II are taken into consideration, the banks that would use the approach based on internal rating should have a rating system that they subject their customers' creditworthiness and the riskiness level of their operations to rating. Besides, the banks that wish to make their risk management functions more effective would take note of the rating systems). In the light of all the data obtained, the evaluations are made in the branch or the head office departments, and the financial analysis report is prepared. In this phase, if any problem is detected on the data, qualitative and quantitative, and if the loan application is not rejected but accepted, the loan request is sent with the approval and opinions of the evaluating personnel, and if the loan is not approved under branch authority, it is sent to a higher authority.

2.4.1.4 Credit Granting

The loan application that passed the intelligence, financial analysis and reports phases (these authorities can be organized or combined in different ways in different banks) comes to credit granting department. Credit granting department checks whether the application is in conformity with laws, regulations and procedures, if the product is appropriate in terms of product type, extent, assurance and time, and if necessary corrects it appropriately, if it is not appropriate it rejects the application. The loan request endorsed by the credit granting department (in some banks the district offices come first in authority level, and the loan application can be completed in this level) is completed in this phase according to the authority approval levels (on a scale that the administrative board and chief executive officer

transfer their authority); if the loan approval exceed the department's authority, it is submitted to the Credit Committee for approval.

2.4.1.5 Credit Committee

The loan request, receiving the approval of credit granting department and presented to the committee, is completed, rejected or submitted to Administrative Board approval in terms of authority level by evaluating the request of members of the committee assembled under the presidency of the CEO.

2.4.1.6 Administrative Board

The loan request, taken the approval of Credit Committee, and submitted to the Administrative Board for approval can be returned to the previous phase for with approval, reject or for correction. If the loan request is deem suitable by majority or unanimity of votes, it is open for signature of the Boards and the evaluation and approval phases are completed. After the approval decision is delivered to the branch, it is delivered to the customer after conducting a risk based pricing according to the rating grade; in case of an agreement, the loan is brought into service after the assurance and other legal operations are completed according to the procedures.

2.4.2 Evaluation System

As it can be seen, the loan request, processed in different levels of authority and different phases of evaluation, passes through a long passage of approval, similar in all banks. In the banking system of our days, in which competition increases gradually, decision making periods shorten and allocating capital dependently on loan risks becomes inevitable; as decision support and risk prediction systems, various statistical models and expert systems are used such as single variable models, ratio analysis, flow of funds analysis, cash-flow analysis; and multiple regression analysis, discrimination analysis and logistics regression where the qualitative variables are used in company. The method used the number of the data, the weights

of the variables in the model the standardization and accumulation of data may vary among banks.

In the banks that carry out valuation with classical valuation methods (based on experience and non-standardized subjective factors) before the economic crisis, risk evaluation has been paid attention more especially since the mid 1990's. The rating grades, comprising of letters, numbers or combination of these two, are obtained from the score cards for small sized loans generally, the ratings are obtained from more detailed rating systems as the loan and customer volume increases.

2.4.3 Rating Concept

Rating is a categorization system that is performed in accordance with the past and present qualitative and quantitative data of enterprise, used to predict whether the enterprise would fulfill its financial liabilities in time. In order the categorization to be coherent, the results obtained from the data are transformed into coherent, de facto symbols. These symbols have universal use.

Rating, in short, is the evaluation of a specific debtor's credibility and repayment capacity (European Commission, 2005). There are two kinds of rating; external rating and internal rating.

2.4.3.1 External Rating

External rating is the rating grade which have the characteristics of an indicator, performed by the rating agencies in order to provide the relatively large-scale enterprises to take loans from capital markets. This concept will not be dealt in detail since it is not within the scope our study.

2.4.3.2 Internal Rating

Internal rating is the rating grades given to the loan applicants by the banks according to their internal evaluation criteria. Banks request from their customers, their financial tables (numbers and ratios), their official documents, and all internal and external references both qualitative and quantitative to use in rating. Since the balance sheets are not transparent, a large portion of the data is collected through personal interviews and market intelligence. The fundamental requirement for the system to operate well is the easy and standard access to the data and making this data storable and processable. Banks' using the data obtained from specific customers in advance in predicting the possibility of those customers to become non-performing, depends on past data and the possibility of standardizing the repayment characteristics of the non-performing enterprises.

The system, methods and data the banks use in internal rating may vary. There are decision support systems, of different levels of development, with regard to the prediction of financial failure, in all the banks in Turkey.

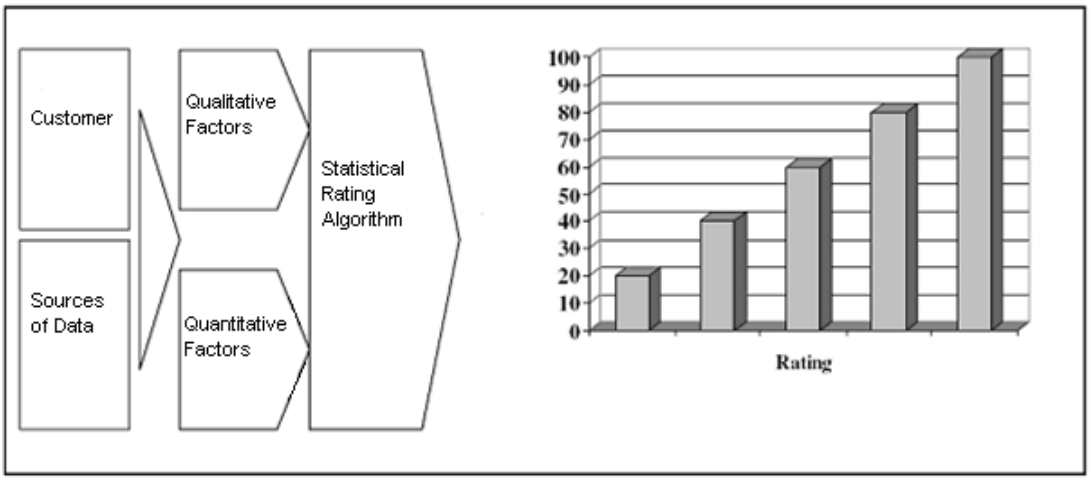

Figure 2.1 Rating system

Reference:

http://ec.europa.eu/enterprise/enterpreneurship/financing/docs/basel_2_guide.pdf,05.04.07

2.5 Predicting Financial Failure in SME's

Problems in determining financial failure in SMEs, the cost of non-performing loans in terms of banking sector and socioeconomic status, the difficulties in loan evaluating of SMEs and the necessity of search for alternative methods are discussed below.

2.5.1 Problems in Determining Financial Failure in SMEs

It is argued that, in prediction of financial failure in SMEs, non-financial data should be used in the prediction to be made since the financial data is not sufficient. The internal factors, in addition to general economic factors, are seen as the most important determiners of financial failure (Gönenli, 1985). The main reason for the requirement of using the non-financial data in predicting financial failure in SMEs, the subject of the study, is that the financial data of the enterprises are not sufficient for obtaining objective and standard results. These enterprises cannot exhibit their financial data duly, because they could not institutionalized, they do not have expert personnel on finance, they falsify the financial data in order not to pay taxes, and they show a loss deliberately.

In a survey conducted on 171 SMEs registered in Nevşehir province, the purposes of the enterprises for building up a financial statement were investigated (Ege, 2006). It is found that 92.31% of the enterprises participated in the survey prepared their financial statements for it was a legal obligation. Here one may conclude that the enterprises did not have an operative financial statement preparing system and they built up their statements for only legal and taxational reasons. Only 7.69% of the enterprises prepared financial statements for creditors. It is also worrisome that none of the enterprises used these financial statements for financial analysis and planning.

Table 2.4 Purposes of SMEs for building financial statements

	Number of Enterprises	**Percentage**
Legal obligation	24	92.31
Financial Analysis	-	-
Financial Planning	-	-
Creditors	2	7.69
Investors	-	-

2.5.2 The Cost of Non-Performing Loans In Terms of Banking Sector and Socioeconomic Status

The optimal use of the scarce resources, which is one of the main problems of economy, gains great importance in today's world where resources reduce rapidly. Economists, discussing the reasons for the global financial crisis between 1997 and 1999, arrived at a consensus that financial institutions with weakening financial structures due to partially inadequate legal regulations were the main factor in crises.

The main problems that Turkish Banking Sector confront, from its beginning to our day, especially after the reform policies put in practice after 1980, can be listed as economic instability, financial risks, high resource costs, unfair competition conditions, rapid developments in technology, the deficit in shareholder's equities, and reorganization issues (Parasız, 2000). When the foundation of the economic crises is examined, it is seen that the present resources have not been utilized duly. The main problem in banking sector, which we may think as the driving power that ensures economy to stay the course, arises from "not utilizing the present resources productively".

Banks earn money by selling the deposit money at hand. One of the main instruments the banks use in selling money is the "Loan Mechanism".

Loans take an important place in making effective use resources macro-economically by redirecting them to productivity. As for this mechanism not operate well, it causes high amounts of costs in banks and socioeconomic structure.

The first wave of bankruptcy seen in Turkish banking sector originated from the non-performing and bad debts due to the World economic crisis, in other words the non-performing loans. However, today, the share of the non-performing loans in the total amount of loans has begun to increase as the basic dynamics of the economy got out of control.

2.5.2.1 The Cost of Non-Performing Credits to Banks

A Bank, while granting a loan, should find the most suitable combination between profit and risk, and make a selection that away. If the banks make a decision on not behaving selective for the sake of selling more credits, they also accept the risk of more loans not to be repayed. Besides, conversion of resources into short-term loans in this manner will cause to take the risk of raises in the interest rates and will lead to miss the opportunities to use the money in areas more productive than loans. It is seen that missed opportunities cause less problems as compared with dead loans.

The costs of high risk and non-performing loans to the bank can be listed as below;

1. The funds reserved for the non-performing loan cannot be redirected to high-yield alternative areas.
2. Since non-performing credits need more close interest and tracking, they will cause more administrative costs.
3. Non-performing loans will prevent the managers to use their time in more productive areas.
4. The public opinion and brand name of the bank in the market will be disreputed, and this will negatively affect the growth and development of the bank.

5. Non-performing loans require a great amount of expert knowledge in legal issues, and thus cause high amounts of legal costs.
6. Low returns and limited growth, in banks with great amount of non-performing loans, affect the motivation of the employees.

2.5.2.2 Socioeconomic Cost of Non-Performing Loans

The costs of high-risk and non-performing loans to the banks may be listed as below;

— Unemployment due to bankruptcy,

— Negative effects on new investments, account owners and social wealth, in case of bankruptcy in publicly traded enterprises,

— Negative effects on resource and costs structures due to credit institutions' heading for unproductive loans,

— The negative knock-on effect on parallel sectors and subsidiary industry,

— Decrease in tax revenues of the state.

2.5.3 Difficulties in Loan Evaluating of SMEs and the Necessity of Search for Alternative Methods

The basic problems of Turkish SMEs, having many problems aside, are predicated as lack of Know-How, low technological standards, and the deficiency of financial environment (Republic of Turkey, Prime Ministry State Planning Organization, 2006).

We can summarize the problems widely seen in Turkish SMEs as below;

1- High rates of grey-economy,
2- Financial statements' not reflecting the real situation,
3- Unability to institutionalize,
4- Identification of the enterprise with the entrepreneur,
5- Technological Inadequacies,

6- Inadequacies in infrastructure, regulations and promotions,

7- Equity inadequacies,

8- Training inadequacies.

Present statistical and classical methods fall short of evaluating the SME loans. As it was expressed previously, the financial data's not being transparent is a basic factor that enlarges the grey area, which is also called the uncertainty area; other factors are the enterprises' unability to professionalise and institutionalize. Most of the SMEs do not have a finance department and a separate finance supervisor (Oktay and Güney, 2002). Also, inadequacy in training confronts us as another important issue.

Since the present methods used in banks, in addition to the costs related to the personnel and time values, works with a more classical rationale; they could not be standardize. Thus there is a need of research on new and improved decision support systems which would enable making accurate and rapid decisions since the grey areas are in majority.

A survey study was conducted on the confidence of banks on the financial statements obtained from the enterprises, in Sakarya University Department of Business Administration. The survey was applied on financial analysts and staff working in the institutional marketing positions of 49 branches in Eastern Marmara Region. 83% of the banks participated in the survey declared that they did not trust in the balance sheets and financial statements.

It is normal not to make a 100% evaluation with the financial statements in a country with high rates of grey-economy. 34.7% of the participants think that the items of the income tables are tinkered with due to high taxation in our country, and enterprises show their profits lower in order to pay lower taxes, or they show their profit higher to get higher loans; thus they express that these statements do not represent the actual data. 20.4% of the participants argue that the real business value

is not reflected in the records due to grey-economy; 18.4% of them think that the records in the financial statements are deficient and erroneous.

As it can be seen, in an environment where the financial recording system is inadequate, models, that depend on solely mathematical and statistical data, and that takes only the ratio analyses as variable, produce inaccurate or erroneous results.

CHAPTER THREE

STATISTICAL METHODS FOR CLASSIFICATION

In this section, the most widely used statistical classification methods have been explained and examples have been presented.

3.1 Linear Discriminat Analysis

Discriminant analysis is a statistical method using linear functions to distinguish groups based on the independent variables. Discriminant analysis is the appropriate statistical technique when the dependent variable is categorical and the independent variable is continuous (Hair, Anderson, Tatham and Black, 1998).

3.2 Logistic Regression

Logistic Regression is a method used to determine cause and effect relations with explanatory variables where the response variable is observed in binary, triple and multiple categories. This model, according to explanatory variables is a regression model from which the expected values of the response variable were obtained as a probability (Özdamar 2004).

Ran Braniv, Anurag Agarwal and Robert Leach are used a sample of 237 American firms filing for bankruptcy in 1978 at the study which is done in 2002. Classification and prediction accuracies are determined using a logit model.

3.3 K-Nearest Neighbours Algorithm

K-nearest neighbours algorithm (k-NN) is a method for classifying objects based on distance. In this algorithm k points that they are closest ones to data are selected and according to these points classifications are performed. According to selected k point which it is too small or too big can increase error probability.

The basic disadvantages of KNN are necessity to a priori given number of clusters and to assign equal number of elements to each class (Ulutagay, 2009).

3.4 Decision Tree

Decision tree is a widely used model based on classification. The main factor in the use of decision trees widely is the easiest method in terms of basic usage and understanding of its results. Basically there 2 steps to get results from decision trees. The first step is to set the tree. Questions, which they should parse the data most efficiently should be asked by starting from the root to get faster and reliable results on setting of decision trees. After setting of decision tree structure, second step is performed by locating the data to the suitable place on branch of the tree.

3.5 Support Vector Machines

Support vector machines (SVMs) are a set of related supervised learning methods which analyze data and recognize patterns, used for statistical classification and regression analysis proposed by Vapnik on 1992. SVM started to use widely in recent years is used for pattern recognition applications like text recognition, object recognition, voice recognition, and face recognition (Burges, 1998).

3.6 Genetic Algorithms

Genetic algorithm (GA) is an optimization technique and a search heuristic that mimics the process of natural evolution.

Basic principles were suggested by John Holland. After basic principles were proposed, so many academic researches have been issued about genetic algorithms.

Also, so many international conferences have been organised about theoretic part of genetic algorithm and its applications. There are successful applications of genetic algorithms such as function optimization, machine learning, design, cellular manufacturing, scheduling.

Genetic algorithms have some differences according to the traditional optimization methods as it does not use parameter cluster, it uses coded forms. Genetic algorithms work according to probability rules require only to objective function. They scan certain portion not the whole solution space. So, they reach to approximate solution at very shorter time by performing active search (Goldberg, 1989).

3.7 Artificial Neural Networks

An artificial neural network (ANN), usually called "neural network" (NN), is a mathematical model or computational model that is inspired by the structure and/or functional aspects of biological neural networks. It consists of an interconnected group of artificial neurons and processes information using a connectionist approach to computation. In most cases an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. The most important property is to learn from the experiments. Modern neural networks are non-linear statistical data modelling tools. They are usually used to model complex relationships between inputs and outputs or to find patterns in data.

CHAPTER FOUR

FUZZY LOGIC

In today's competitive environment, making decisions rapidly and effectively during the evaluation of loan demands is one of the most important objectives of banks. Making effective decisions at the evaluation stage of the loan demands is possible by using scientific methods that can evaluate a lot of quantitative and qualitative factors at the same time, during the decision making process of banks. (Ertuğrul & Karakaşoğlu, 2007)

System structure and dynamic properties of the system should be well known and mathematical models should be setted up to perform decision process of banks. To set up mathematic model on some systems may not be possible. Systems variables can not be known to set a mathematics model or these variables may vary over the time. In this case, whether none of the solution is proposed or performance of established mechanism can not be good enough.

In such cases, usually knowledge and experience of specialist are used. Specialist performs a control by using linguistic expression such as "few", "many", "slightly", "most", "slightly less", "a lot" etc. If these linguistic expressions transfer to the computer, it does not need an expert and it removes the control differences between the specialists. Thus, a flexible control mechanism is achieved.

The foundation of control mechanism is based on simulation of human idea and intuition to control the any system. So a human reaches to his aim taking a system from existing situation to the desired level by performing a control strategy, which it is based on his intuition and his experience.

Fuzzy logic control is based on these kinds of logical relationships. It can be said that fuzzy logic is a real world application of mathematics. Different results can come out on real world because every moment situations change (Elmas, 2003).

Fuzzy logic approach gives ability to the machines to work by processing of human personal data by using their experience and their premonition. To bring this ability, symbolic expressions are used instead of digital expressions. Transferring of these symbolic expressions to the machines is based on mathematics background.
This mathematical based are fuzzy set theory and fuzzy logic approach based on it. Base of fuzzy logic control are these kinds of linguistic expressions and logical relationships between them.

Transferring of the linguistic expressions to the computers is based on mathematics background. This mathematical background is called as fuzzy set theory and fuzzy logic approach. Fuzzy logic approach is not shown 2 level of accuracy like known classic logic {0, 1}, it express multi-level accuracy between {0, 1} (Elmas, 2003).

The concept of fuzzy logic for the first time in the United States in 1956 was announced at a conference. However, the first serious step in this regard in 1965 in an article published by Lotfi A. ZADEH fuzzy logic or fuzzy set theory under the name was put forward. Zadeh, in his study, has stated that vast majority of the human thought is fuzzy, not clear. Therefore Boolean Logic represented by 0 and 1 can not adequately express the thought process. Human logic takes into consideration the intermediate values like less open, less closed, fresh, and warm as well as the certain values like open, closed, hot, cold, 0 and 1 etc. Fuzzy logic uses multi-level processes on the contrary of classical logic used 2 levels. Furthermore, Zadeh asserted that humans on the control area are better than existing machines and make effective decisions by depending on imprecise linguistic information. As known in statistics and probability theory is worked with objective uncertainty, but people living environment is full of subjective uncertainty. Therefore to be able to understand the ability of human draw conclusions is required to work with subjective uncertainty. Because of encountered difficulties on application of classical control, fuzzy logic has developed rapidly as an alternative method and it has found wide application area on modern control area.

Fuzzy logic application area is very broad. The most important benefit is to provide easily modelling of learning events with and to allow defining mathematical expressions even to uncertain concepts. Therefore it is specifically suitable for the non-linear systems.

With fuzzy logic, modelling of linguistic uncertainty that is used on daily conversations is included and computed. People understand each others by speaking with linguistic data. The actual evaluation field of fuzzy logic is how to think to resolve in case of these kind of information exist. With fuzzy logic, it is tried modelling of any problem to be brought under control with not complex solutions as mathematical.

4.1 Fuzzy Set Theory

The history of fuzzy logic is date back to old times. The theory of Aristotle which is called "Laws of Thought" states that every proposition must either be True or False. After that Heraclitus proposed that things could be simultaneously True and not True. And it was Plato who laid the foundation for what would become fuzzy logic, indicating that there was a third region (beyond True and False) where these opposites "tumbled about." But it was Lukasiewicz who first proposed a systematic alternative to the bi-valued logic of Aristotle. In the early 1900's, Lukasiewicz described a three-valued logic, along with the corresponding mathematics. The third value he proposed can best be translated as the term "possible and he assigned it a numeric value between True and False.

In 1965 Lotfi A. Zadeh published his seminal work "Fuzzy Sets" which described the mathematics of fuzzy set theory, and by extension fuzzy logic. This theory proposed making the membership function (or the values False and True) operate over the range of real numbers [0, 1].

In classical set theory an object is an element of a set or not. It can never be a partial member. If the membership value of an object is 1, then the object is an element of a set, otherwise if the membership value of an object is 0, then the object is not an element of a set. In other words, in classical set theory, the memberships of the elements take values as {0, 1}.

Fuzzy logic imitates human behaviours and the membership values given to objects by people in ordinary language. For example, a person who put his hand into the water can never know the temperature of water exactly. Linguistic expressions such as, hot, less hot, cold, very cold are used instead.

An example to the classic set is given in Figure 4.1. If the temperature drops below 20 ° C, environment temperature is not hot. According to the theory of classical logic, a temperature of 19.5 °C implies that the environment is not hot. (Elmas, 2003).

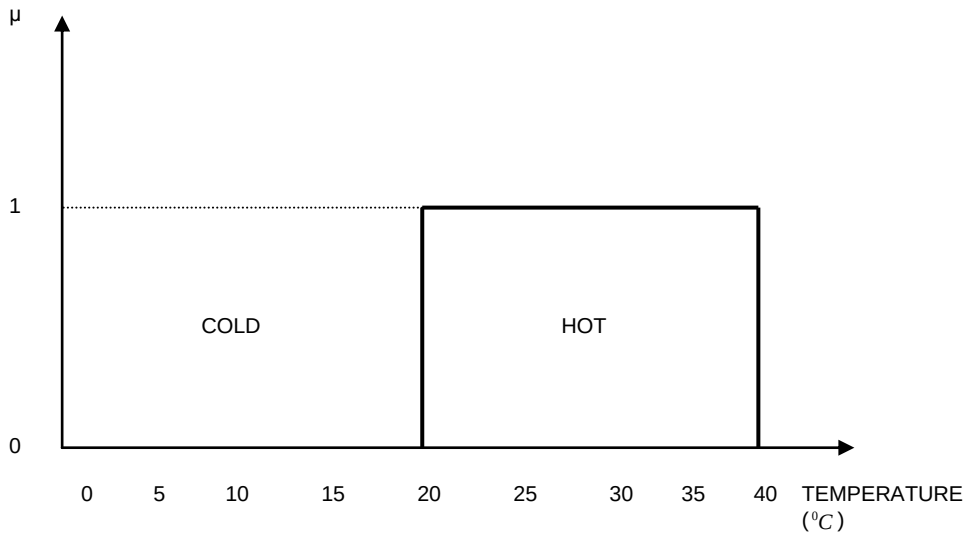

Figure 4.1 An example of temperature at classic set

4.2 Linguistic Variables

Numerical range of the data represented in the works or required for investigation can be identified by the experts whom they have knowledge about it. For example, in Ankara, the temperature variations range of -5 ° C to + 35 ° C, where it is known. This range indicates the interval where member of temperature set for Ankara can be found. So, all temperature space is identified. However, on daily conversations it is thought that this temperature space is also considered to consist of some kind of sub-intervals. For instance, 'very cold', 'cold', 'mild', 'hot', 'too hot' etc. If it is encountered with an order to decide the range of each sub-interval, maybe engineers can say that each interval does not over lap they follow each others. For example, it can be said that very cold - 5 °C to 0 °C, cold 0 °C t o +8 °C, warm + 8 °C to + 15 °C, hot + 15 °C to + 25 °C, very hot starts with +25 °C. Note that there have been estimates of the range, and each one finished and one started from a lower range (Figure 4.2).

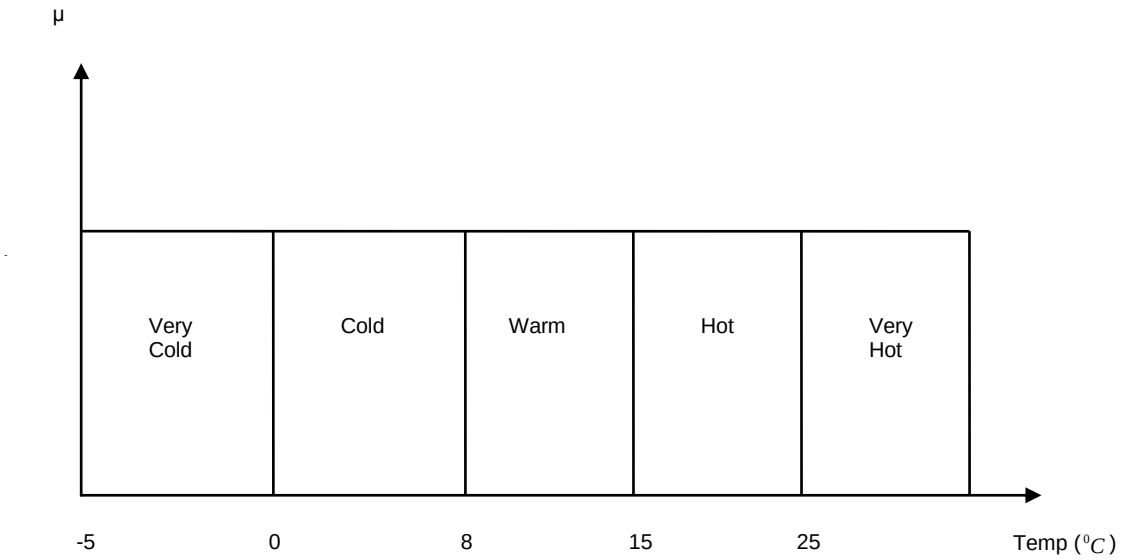

Figure 4.2 Definite assignments of temperature values.

According to Aristotelian logic in the limits of this range, strict decisions should be taken. For example, and 7.9 ° C cold, 8.1 ° C is considered as mild. An important point in this representation, the membership of each sub-interval value per degree of temperature is equal to the 1 only on that range and, it is equal to 0 in other ranges.

Therefore, any temperature sub-set membership function is a shape of rectangular as its height is equal to 1.

Fuzzy linguistic variables in the different sets may overlap and at the same temperature with different degrees may belong to different clusters. This situation has been shown in Figure 4.3.

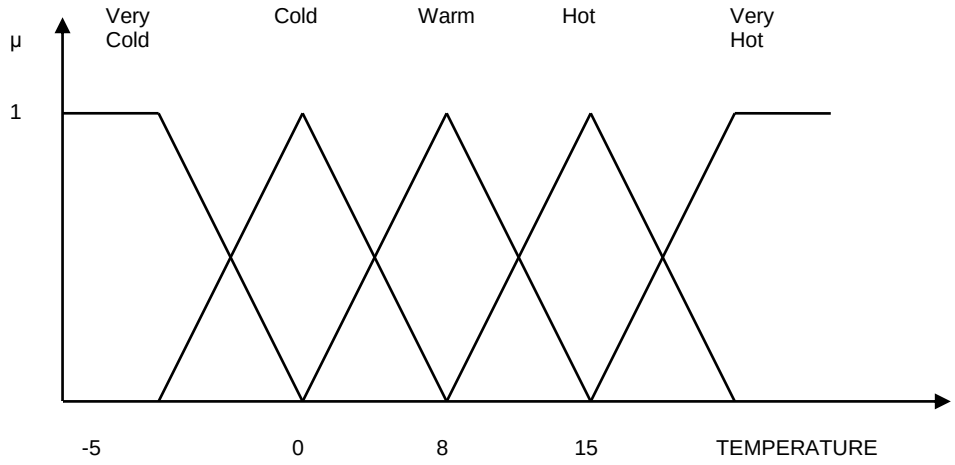

Figure 4.3 Fuzzy forms of temperature values

4.3 Membership Functions

Fuzziness in a fuzzy set is characterized by its membership functions. In order to handle the fuzzy data, it is necessary to convert the actual data into fuzzy data based on certain membership functions. It classifies the element in the set, whether it is discrete or continuous (Sivanandam, Sumathi& Deepa, 2007).

The membership functions can also be formed by graphical representations. The graphical representations may include different shapes. There are certain restrictions regarding the shapes used. Triangle, trapezoidal, and bell-shaped shapes are shown in Figure 4.4.

The rules formed to represent the fuzziness in an application are also fuzzy. The “shape” of the membership function is an important criterion that has to be considered. There are different methods to form membership functions.

The information of list of rules and membership functions of fuzzy logic approach is often obtained from experts.

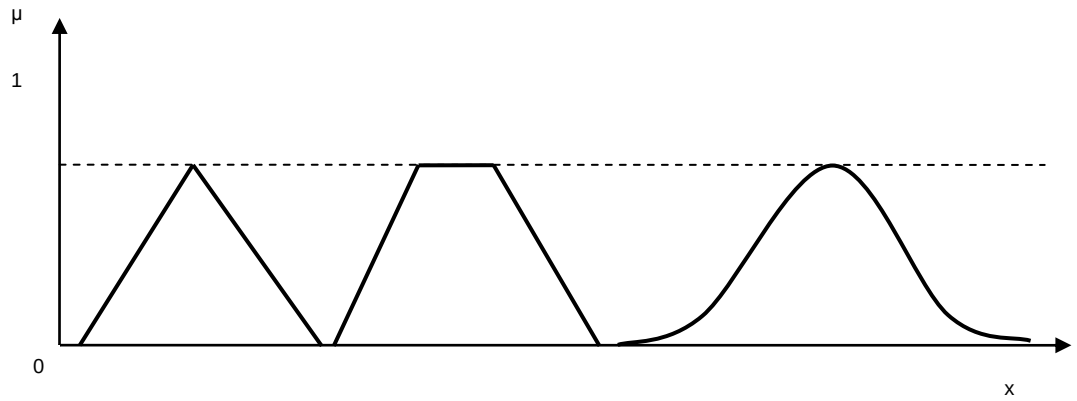

Figure 4.4 Triangle, trapezoidal, and bell-shaped shaped membership function

Membership functions are generally defined as odd numbers with 3 as, "small", "medium", "big" or with 5 tags as "small", "medium small", "medium", "medium large", "big". For example a triangle shaped membership functions defined as 5 tags has been shown in Figure 4.5.

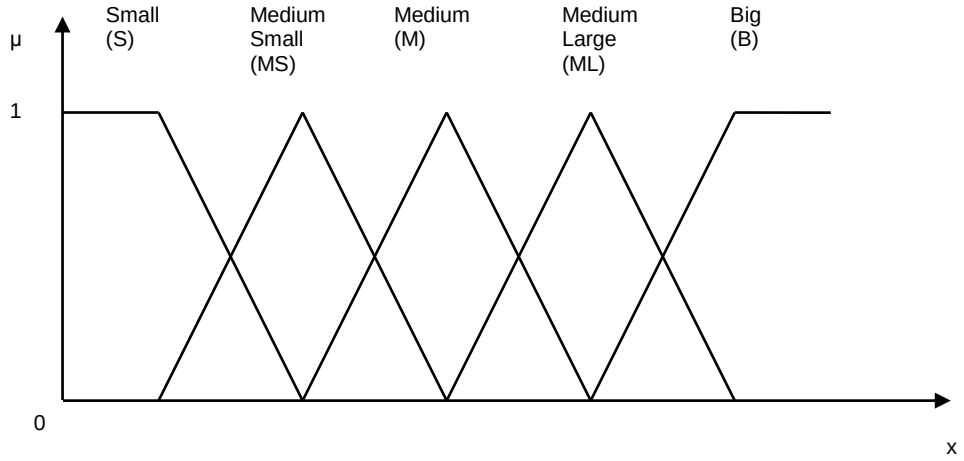

Figure 4.5 Membership function formed of 5 tags

The feature of the membership function is defined by three properties. They are core, support and boundary (Engelkıran, 2001). The membership degree can take value between 0 and 1. The elements, which have the membership function as 1, are the elements of the core (when the membership function of the set A, $\mu_A(x) = 1$).

The elements, which have the membership function between 0 and 1, are the elements of the boundary (when the membership function of the set A, $0 < \mu_A(x) < 1$). The elements, which have the membership function greater than 0 are the elements of the support (when the membership function of the set A, $\mu_A(x) > 0$). Features of membership function are given in Figure 4.6.

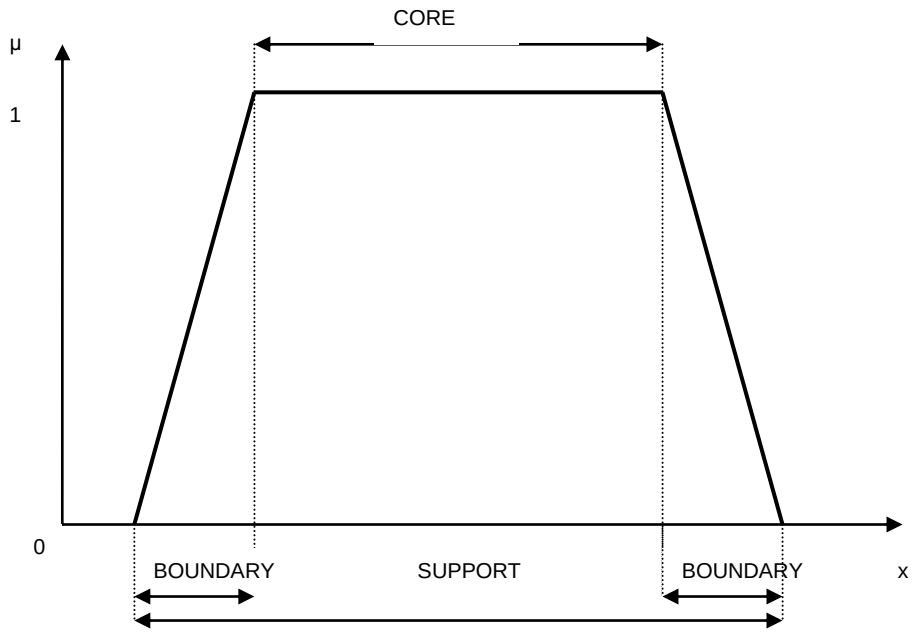

Figure 4.6 Features of membership function

Classification of fuzzy sets has been shown below.

Normal fuzzy set: If the membership function has at least one element in the universe whose value is equal to 1, then that set is called as normal fuzzy set.

Subnormal fuzzy set: If the membership function has the membership values less than 1, then that set is called as subnormal fuzzy set. Figure 4.7 shows normal and subnormal fuzzy set.

Convex fuzzy set: If the membership function has membership values those are monotonically increasing, or, monotonically decreasing, or they are monotonically increasing and decreasing with the increasing values for elements in the universe, those fuzzy set is called convex fuzzy set.

In other words, where x, y, and z are the elements of set A and $x < y < z$, if $\mu_A(y) \geq \min((\mu(x), \mu(z))$, then fuzzy set A is a convex fuzzy set (Boyacıoğlu, 2003).

Nonconvex fuzzy set: If the membership function has membership values which are not strictly monotonically increasing or monotonically decreasing or both monotonically increasing and decreasing with increasing values for elements in the universe, then this is called as nonconvex fuzzy set. In other words, where x, y, and z are the elements of set A and $x < y < z$, if $\mu_A(y) \geq \min((\mu(x), \mu(z))$, then fuzzy set A is a convex fuzzy set. (Boyacıoğlu, 2003). Figure 4.8 shows convex and nonconvex fuzzy set.

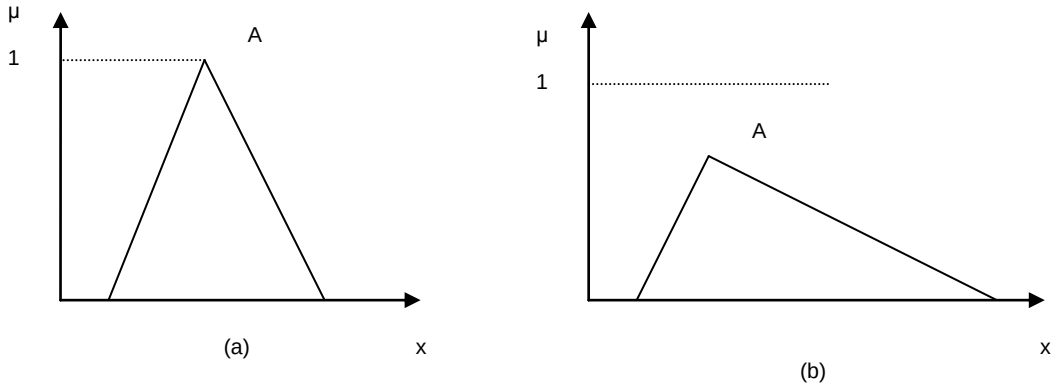

Figure 4.7 (a) Normal fuzzy set, (b) Subnormal fuzzy set

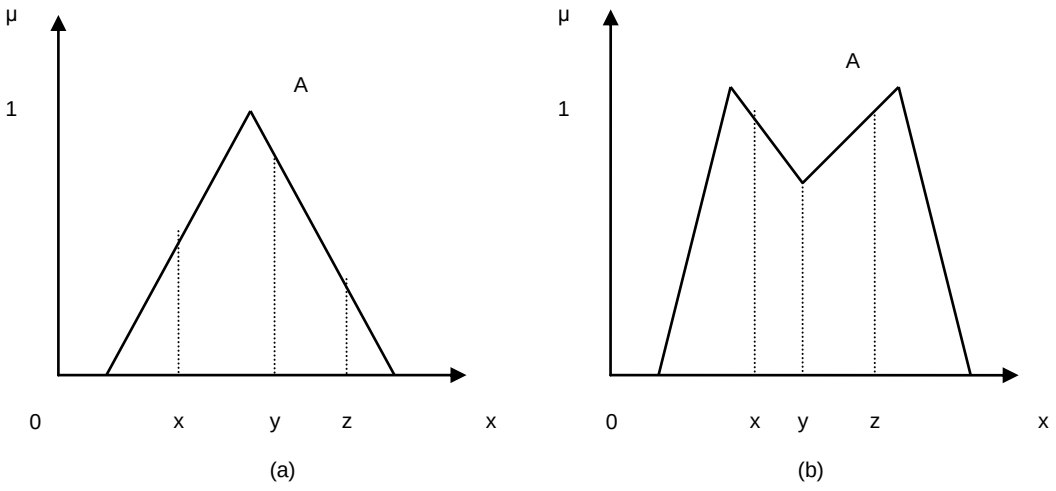

Figure 4.8 (a) Convex fuzzy set, (b) Nonconvex fuzzy set

4.4 If-Then Rules

The variables that we use in daily life are mostly expressed by the words. For example, when it is said that “today weather is very cold”,

Linguistic variable; the temperature of weather
Value; very cold

In fuzzy system words are represented with fuzzy sets in space where they defined. When it is asked to find the fuzzy model of a car's speed first it is needed to determine the space where it is defined. This range is between the maximum and the minimum speed values of a car can reach. After determining this space, the fuzzy sets that represent the linguistic variables like “very slow”, “slow”, “fast”, “very fast” are determined. It is shown in Figure 4.9.

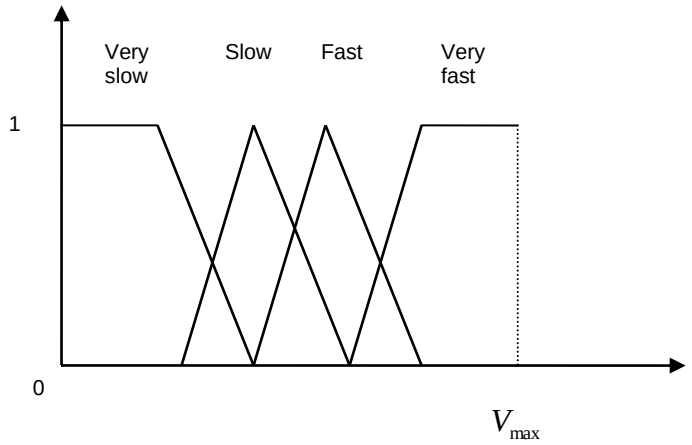

Figure 4.9 The representation of the speed of a car as a linguistic variable with fuzzy sets

Expressing human experience in terms of mathematical formula is very difficult. By using Fuzzy Logic the human experience is easily mapped in a set of IF - THEN rules.

A single fuzzy if-then rule assumes the form;

IF x is A **THEN** y is B;

where A and B are linguistic values defined by fuzzy sets on the ranges (universes of discourse) X and Y, respectively. The if-part of the rule "x is A" is called the antecedent or premise, while the then-part of the rule "y is B" is called the consequent or conclusion.

The theorem “If x is A and y is B” corresponds to the fuzzy relation in the form $A \cap B$, where A and B are two sets on the Universe X. And the function theoretic form is given as:

$$\mu_{A\cap B}(x) = \min[\mu_A(x), \mu_B(x)] \tag{4.1}$$

The theorem “If x is A or y is B” corresponds to the fuzzy relation in the form $A \cup B$. The function theoretic form is given as:

$$\mu_{A\cup B}(x) = \max[\mu_A(x), \mu_B(x)] \tag{4.2}$$

The theorem “If x is not A” is the complement of A. And the function theoretic form is given as:

$$\mu_{\bar{A}}(x) = 1 - \mu_A(x) \tag{4.3}$$

As an example the fuzzy function theoretic form of the theorem “(If x_1 is A and x_2 is not B) or if x_3 is C”

$$\max[\min[\mu_A(x_1), 1-\mu_B(x_2)], \mu_C(x_3)] \tag{4.4}$$

4.5 Fuzzy Inference System

One of the largest application area of fuzzy logic is, “Fuzzy Inference Systems” (FIS). Fuzzy inference systems are also known as fuzzy rule-based systems, fuzzy model, fuzzy expert system, and fuzzy associative memory.

Fuzzy inference system consists of a fuzzification interface, a rule base, a database, a decision-making unit, and finally a defuzzification interface. A FIS with five functional block described in Fig. 4.10. The function of each block is as follows:

- a rule base containing a number of fuzzy IF–THEN rules;
- a database which defines the membership functions of the fuzzy sets used in the fuzzy rules;
- a decision-making unit which performs the inference operations on the rules;
- a fuzzification interface which transforms the crisp inputs into degrees of match with linguistic values;
- a defuzzification interface which transforms the fuzzy results of the inference into a crisp output (Sivanandam , Sumathi & Deepa, 2007).

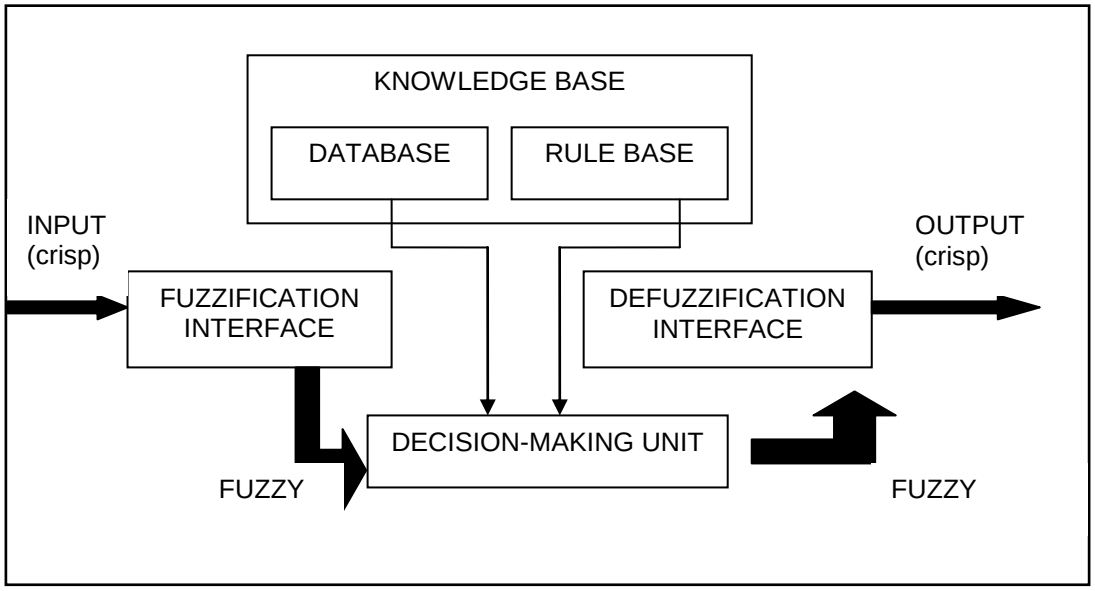

Figure 4.10 Fuzzy inference systems

The decision-making is an important part in the entire system. The FIS formulates suitable rules and based upon the rules the decision is made. This is mainly based on the concepts of the fuzzy set theory, fuzzy IF–THEN rules, and fuzzy reasoning. FIS uses “IF. . . THEN. . . ” statements, and the connectors present in the rule statement are “OR” or “AND” to make the necessary decision rules. The basic FIS can take either fuzzy inputs or crisp inputs, but the outputs it produces are almost always fuzzy sets. When the FIS is used as a controller, it is necessary to have a crisp output. Therefore in this case defuzzification method is adopted to best extract a crisp value that best represents a fuzzy set. The whole FIS is discussed in detail in the following subsections (Sivanandam, Sumathi & Deepa, 2007).

4.5.1 Fuzzy Inference Methods

There are 2 methods used most commonly in fuzzy logic. These are Mamdani and Takagi–Sugeno–Kang methods. The main difference between the two methods lies in the consequent of fuzzy rules. Mamdani fuzzy systems use fuzzy sets as rule consequent whereas Sugeno's fuzzy systems employ linear functions of input variables as rule consequent.

4.5.1.1 Mamdani Type Fuzzy Model

Mamdani's method is the most commonly used in applications, due to its simple structure of 'min-max' operations. Mamdani's method can be used is widely used in fields which require specialized knowledge and is a fuzzy logic method that can be applied to any solution of all kind of problem.

It was proposed in 1975 by Ebrahim Mamdani as an attempt to control a steam engine and boiler combination by synthesizing a set of linguistic control rules obtained from experienced human operators (Mamdani & Assilian, 1975).

Mamdani type inference, as defined it for the Fuzzy Logic Toolbox, expects the output membership functions to be fuzzy sets. Mamdani-type fuzzy model is created in the following five steps.

a) Fuzzifying inputs to resolve all fuzzy statements in the antecedent to a degree of membership between 0 and 1.

b) Determining the weights of the rules using fuzzy logic.

c) The application of AND operation or the OR operation.

d) Combining the consequences to get an output distribution

e) Defuzzifying the output distribution (this step is only if a crisp output is needed).

Advantages of the Mamdani Method as a summary

– It is intuitive.

– It has widespread acceptance.

– It is well suited to human input.

When x and y are two input variables at a two rule Mamdani FIS, it is shown how to calculate the output z with the fuzzy at functions c_i in Figure 4.11.

Rule 1: IF $x = A_1$ AND $y = B_1$ THEN, $z = C_1$

Rule 2: IF $x = A_2$ AND $y = B_2$ THEN, $z = C_2$

Mamdani fuzzy inference system using minimization and maximization methods for "AND" and "OR" operators is given in Figure 4.11.

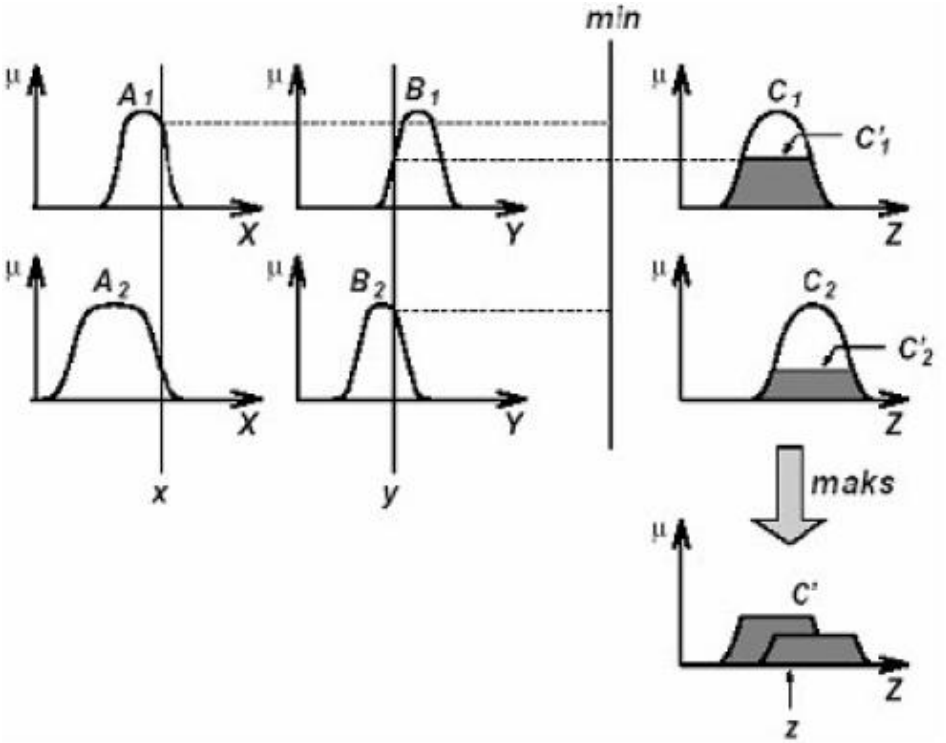

Figure 4.11 Mamdani fuzzy inference system using minimization and maximization methods for "AND" and "OR" operators (Akyılmaz, 2005).

4.5.1.2 Takagi-Sugeno Type Fuzzy Model

Sugeno fuzzy model has started to use in 1985. It is also known as Takagi–Sugeno–Kang model. It is an adaptation of Mamdani fuzzy method. It is used in the solution of problems in case the number of variables is not too much or in case these variables are not divided into too much sub-clusters.

Fuzzifying the inputs and applying the fuzzy operator are exactly the same with the Mamdani method. The main difference between the two methods is in the output membership functions. Sugeno output membership functions are either linear or constant.

When the output membership function is constant, it is called the zero-order Sugeno fuzzy model. And when the output membership functions are first-order polynomial, we have the first-order Sugeno fuzzy model.

Because it is a more compact and computationally efficient representation than a Mamdani system, the Sugeno system lends itself to the use of adaptive techniques for constructing fuzzy models.

A typical rule in a Sugeno fuzzy model has the form;

IF x = A **AND** y = B, THEN z = f(x, y) ≡ px + qy + r (c), (4.5)

where A and B are fuzzy sets at the premise parts defined for inputs x and y. P, q and r are the final output of the system. So an output value is obtained for each rule.

For a zero-order Sugeno model, the output level z is a constant (p=q =0).

Advantages of the Sugeno Method;

– It is computationally efficient.
– It works well with linear techniques (e.g., PID control).
– It works well with optimization and adaptive techniques.
– It has guaranteed continuity of the output surface.
– It is well suited to mathematical analysis.
(http://www.mathworks.com/access/helpdesk/help/toolbox/fuzzy/)

CHAPTER FIVE

APPLICATION

To evaluate loan demands of SMEs' an empirical study has been done to determine the credit level to be assigned and the collateral level to be taken for the companies.

5.1 Properties of Data Set Used In the Model

One of the three events is performed after the credit assignment. The first situation, credit is received back by the bank on its date in accordance with contract terms. The second situation is, credit terms are redefined as to be satisfactory in terms of banks and customers. And the third situation is credit in accordance with contract terms can not be received back and non-performing loan occurs.

A non-performing loan is a loan that is in default or close to being in default. Many loans become non-performing after being in default for 3 months, but this can depend on the contract terms.

According to the International Monetary Fund (IMF) a loan is nonperforming when payments of interest and principal are past due by 90 days or more, or at least 90 days of interest payments have been capitalized, refinanced or delayed by agreement, or payments are less than 90 days overdue, but there are other good reasons to doubt that payments will be made in full.

On this basis, according to the definition used in the model of failure of loan payments or principal debt not paid 90 days failed enterprises, the enterprises have made payments regularly been described as successful.

While creating the data set, recording system through a commercial bank's businesses randomly selected 54 failed businesses in terms of financially, and 53

successful businesses have been analyzed to develop of financial failure prediction system for SMEs. 2007 and 2008 year-end data into enterprise data pertaining to the period of the study examined.

Unlike other studies, because of the reasons of the unrealistic financial data, informality and the lack of professional financial management, it is also included the subjective factors (7 units), in addition to the financial factors (26 units). The relationship between the total 33 variables and the decision system were tested.

5.2 Independent Variables Used In the Model

33 independent variables used in the model, examined in two groups, as qualitative and quantitative.

5.2.1 Quantitative Variables

Working Capital (WC): Working capital is a financial metric which represents operating liquidity available to a business. It is calculated as current assets minus current liabilities. Positive working capital is required to ensure that a company is able to continue its operations and that it has sufficient funds to satisfy both maturing short-term debt and upcoming operational expenses.

$$WC = \text{Current Assets} - \text{Current Liabilities} \quad (5.1)$$

Current Ratio (CR): The current ratio is a financial ratio that measures whether or not a company has enough resources to pay its debts over the next 12 months. This ratio is an indication of a company's ability to meet short-term debt obligations; the higher the ratio, the more liquid the company is. A ratio of 2.0 or higher is a comfortable financial position for most enterprises. It compares a company’s current assets to its current liabilities. It is expressed as follows:

$$CR = \frac{\text{Current Assets}}{\text{Current Liabilities}} \tag{5.2}$$

Liquid Ratio (LR): Liquid ratio measures the ability of a company to use its near cash or quick assets to immediately extinguish or retire its current liabilities. Quick assets include those current assets that presumably can be quickly converted to cash at close to their book values. A company with a Liquid Ratio of less than 1 can not currently pay back their current liabilities. In finance, it is also called the Acid-test or quick ratio. It is expressed as follows:

$$LR = \frac{\text{Current Assets} - (Stock + \text{Other Current Assets})}{\text{Current Liabilities}} \tag{5.3}$$

Cash Ratio: Compares a company's cash and cash equivalents with its current liabilities. It is expressed as follows:

$$CashRatio = \frac{\text{Current Assets} - (Stock + \text{Other Current Assets} + \text{Accounts Receivable})}{\text{Current Liabilities}} \tag{5.4}$$

Accounts Receivable to Sales Ratio (AR/S): Shows the relationship between unpaid sales and the total sales revenue. It is considered high if it is near to 1.0, because that means a significant amount of cash is tied up with the slow paying customers. It is expressed as follows:

$$AR/S = \frac{\text{Total Accounts Receivable}}{\text{Sales Revenue}} \tag{5.5}$$

Accounts Receivable Turnover (ART): This ratio measures the number of times, on average, receivables are collected during the period. A high ratio implies either that a company operates on a cash basis or that its extension of credit and collection

of accounts receivable is efficient. A low ratio implies the company should re-assess its credit policies in order to ensure the timely collection of imparted credit that is not earning interest for the company. It is expressed as follows:

$$ART = \frac{\text{Total Net Sales}}{\text{Accounts Receivable}} \tag{5.6}$$

Accounts Receivable Collection Period (ARCP): This reveals how many days it takes to collect all accounts receivable. It is expressed as follows:

$$ARCP = \frac{365\,\text{Days}}{\text{Accounts Receivable Turnover}} \tag{5.7}$$

Inventory Turnover (IT): Inventory turnover measures how well a company coverts stock into revenues. It is expressed as follows:

$$IT = \frac{\text{Cost of Goods Sold}}{\text{Average Inventory}} \tag{5.8}$$

Inventory Turnover Period (ITP): This reveals how many days it takes the stocks to sales. It is expressed as follows:

$$ITP = \frac{\text{Inventory}}{\text{Cost of Goods Sold}} \text{x}365 \tag{5.9}$$

Current Liabilities / Shareholders' Equity Ratio: The ratio quantifies the relationship between current liabilities and shareholders' equity. A lower ratio means company is more financially stables

Debt / Equity Ratio: It indicates what proportion of equity and debt the company is using to finance its assets. A high debt/equity ratio generally means that a company has been aggressive in financing its growth with debt.

$$\text{Debt to Equity} = \frac{\text{Total Liabilities}}{\text{Shareholders' Equity}} \tag{5.10}$$

Debt / Total Assets Ratio: Indicates what proportion of the company's assets is being financed through dept. If the ratio is less than one, most of the company's assets are financed through equity. If the ratio is greater than one, most of the company's assets are financed through debt.

$$\text{Debt to Total Assets} = \frac{\text{Total Liabilities}}{\text{Total Assets}} \tag{5.11}$$

Equity Turnover (ET): Equity turnover is a measure of how well a company uses its stockholders' equity to generate revenue. The higher the ratio is, the more efficiently a company is using its capital. It is also called capital turnover. It is expressed as follows:

$$\text{ET} = \frac{\text{Net Sales}}{\text{Average Stockholders' equity.}} \tag{5.12}$$

Tangible Asset / Stockholders' Equity Ratio: This reveals how much part of stockholders' equity is used of financing tangible asset.

Ordinary Profit / Stockholders' Equity Ratio: Indicates if the stockholders' equity being used efficiently.

Ordinary Profit / Total Assets Ratio: Indicates how efficiently a company is using its' total assets.

Ordinary Profit / Net Sales Ratio: The ratio is an indicator of a company's pricing policies and its ability to control costs. A low profit margin indicates a low margin of safety

Net Profit / Stockholders' Equity Ratio: It measures a firm's efficiency at generating profits from every unit of shareholders' equity The ratio shows how well a company uses investment funds to generate earnings growth.

Net Profit / Average Total Assets Ratio: The ratio shows how profitable a company's assets are in generating revenue.

The other variables are stated below:

- Company Activity Duration
- Experience of Shareholding
- The Number of Shareholding
- Number of Banks worked
- Period income/Loss
- Net Sales

5.2.2 Qualitative Variables

- Existence of Group Companies : If Group Companies exist it was coded as 1, if there is not it was coded as 0.
- Existence of Protested Bills: If Protested Bills exist it was coded as 0, if there is not it was coded as 1 (Records within ten years are used).
- Whether the Establishment Belongs to the Company: If the Establishment Belongs to the Company it was coded as 1, if not it was coded as 0.
- Making Factoring or Not: If the Company is Making Factoring it was coded as 0, if not it was coded as 1.
- Educational Background of the Main Partner: If it is Minimum High

School it was coded as 1, if not it was coded as 0.

- Existence of Investment: If Investment exists it was coded as 0, if not it was coded as 1.
- Seasonality of Sales: If the Sales are Seasonality it was coded as 0, if not it was coded as 1.
- Existence of Foreclosure Suit Behalf of Company and/or Partners: If there exists Foreclosure Suit it was coded as 0, if not it was coded as 1.

5.3 Dependent Variable Used In the Model

Dependent variable, "Y" was coded as 0 for the failed enterprises and was coded as 1 for the successful enterprises (According to the International Monetary Fund (IMF) a loan is nonperforming when payments of interest and principal are past due by 90 days).

5.4 Investigation and Method

In this study data from 107 companies have been used. Dependent variable was coded as 0 for the failed enterprises and coded as 1 for the successful enterprises. SPSS Clementine 10.1 and Matlab 7.0.1 software programs have been used at the study. Variables in the model are presented in table below.

Table 5.1 Description of variables in the model and the units

Variable	Description of Variables	Unit
X1	Working Capital	TL
X2	Current Ratio	%
X3	Liquid Ratio	%

Table 5.1 Description of variables in the model and the units (continued)

Variable	Description of Variables	Unit
X4	Cash Ratio	%
X5	Accounts Receivable / Sales	%
X6	Accounts Receivable Turnover	Pcs
X7	Accounts Receivable Collection Period	Date
X8	Inventory Turnover	Pcs
X9	Inventory Turnover Period	Date
X10	Current Liabilities / Shareholders' Equity	%
X11	Debt / Equity	%
X12	Debt / Total Assets	%
X13	Equity Turnover	Pcs
X14	Tangible Asset / Stockholders’ Equity	%
X15	Ordinary Profit / Stockholders’ Equity	%
X16	Ordinary Profit / Total Assets	%
X17	Ordinary Profit / Net Sales	%
X18	Net Profit / Stockholders’ Equity	%
X19	Net Profit / Average Total Assets	%
X20	Company Activity Duration	Year
X21	Experience of Shareholding	Year
X22	The Number of Shareholding	Pcs
X23	Number of Banks Worked	Pcs
X24	Period Income/Loss	TL
X25	Net Sales	TL
X26	Existence of Group Companies	
X27	Existence of Protested Bills	
X28	Whether the Establishment Belongs to the Company	
X29	Making Factoring or Not	
X30	Educational Background of the Main Partner	

Table 5.1 Description of variables in the model and the units (continued)

Variable	Description of Variables	Unit
X31	Existence of Investment	
X32	Seasonality of Sales	
X33	Existence of Foreclosure Suit Behalf of Company and/or Partners	
Y	Dependent Variable	

5.5 Fuzzy Logic Application

By using certain ratios some rules were created to analyze the loan demands of the companies. For that purpose, C&RT decision tree model has been used. 107 data with 33 inputs have been evaluated by SPSS Clementine 10.1 and a model has been established. The configuration steps are given in the Table 5.2.

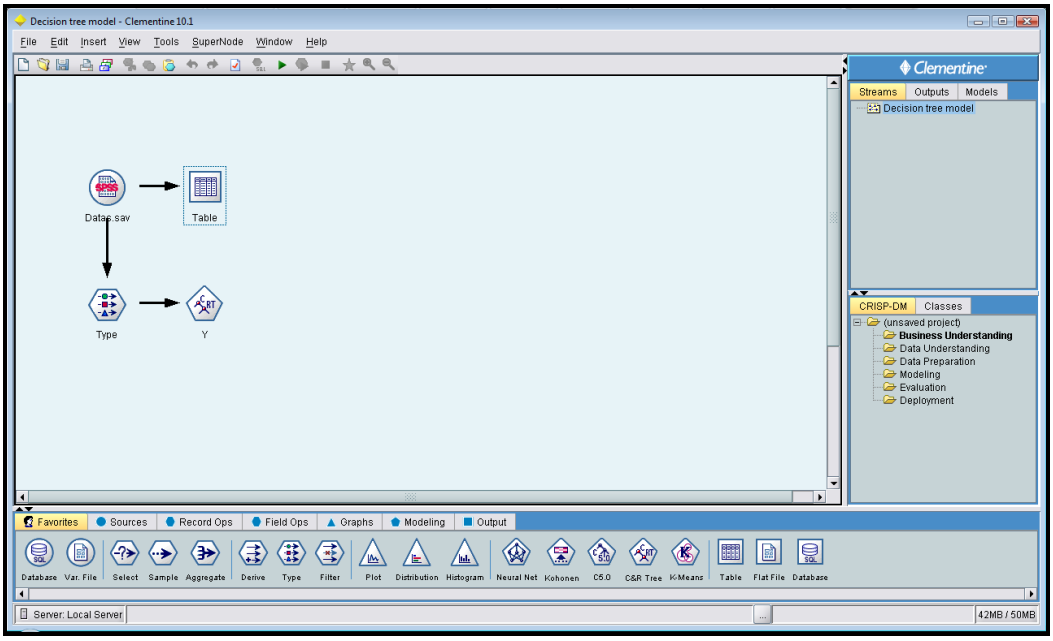

Figure 5.1 Modelling at SPSS Clementine 10.1

Totally 8 rules (4 as positive and 4 as negative) have been found by using C&RT algorithm. Related rules are given in Figures 5.2 and 5.3.

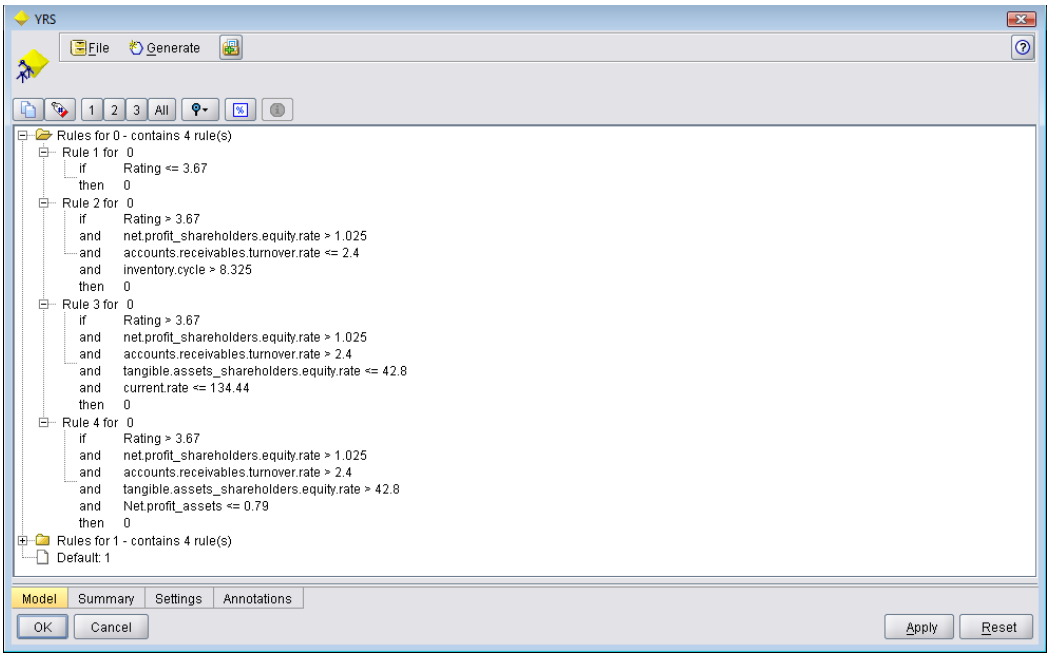

Figure 5.2 Rules for "negative" situations

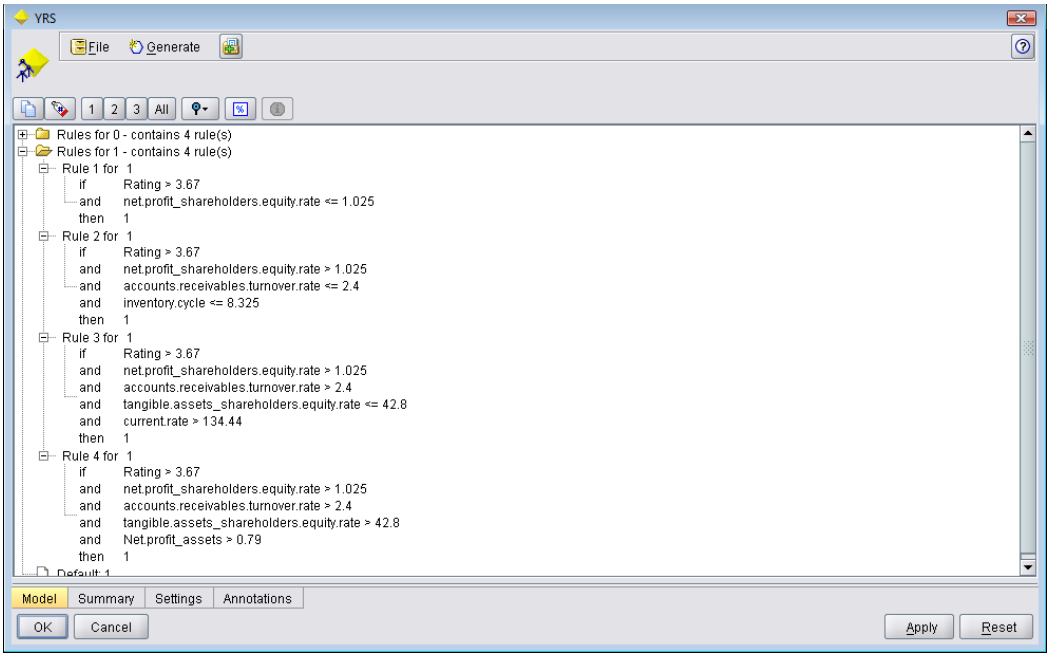

Figure 5.3 Rules for "positive" situations

When the rules are examined; 7 input variables have been found important; **rating, net profit/shareholders' equity, inventory turnover period, tangible asset / stockholders' equity, current ratio** and **net profit/average total assets.**

By using SPSS Clementine 10.1software program the percentage of correct classification at the decision tree is found 85%. (Figure 5.4) This percentage shows that, model is reliable and can be used as alternative methods in the banks.

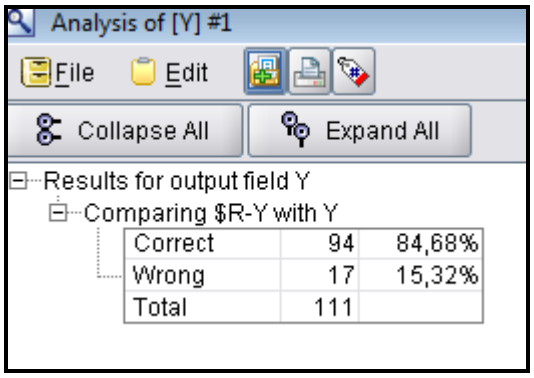

Figure 5.4 Analysis results found by SPSS Clementine 10.1

Later, fuzzification has been applied to these rules on FIS (Fuzzy Inference System) Editor of Matlab 7.0.1. Mamdani approach has been used as based on FIS model, and on created model, the significant 7 input variables and 2 output variables (for positive and negative results) have been used. Created model by using Mamdani approach is presented in Figure 5.5.

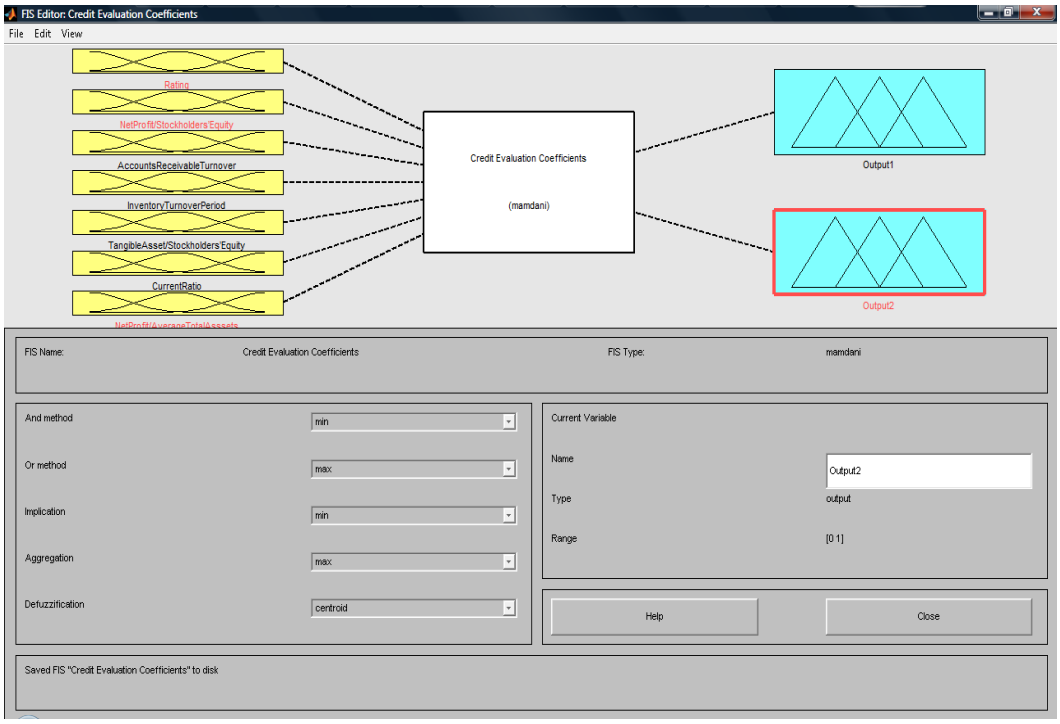

Figure 5.5 Inputs and outputs identification module of fuzzy model

The shape of membership functions are selected according to experience or it is selected by setting of related parameters after data collection. Main Built-in Membership Functions which we can use them on Matlab 7.0.1 Fuzzy Toolbox are given in Figure 5.6.

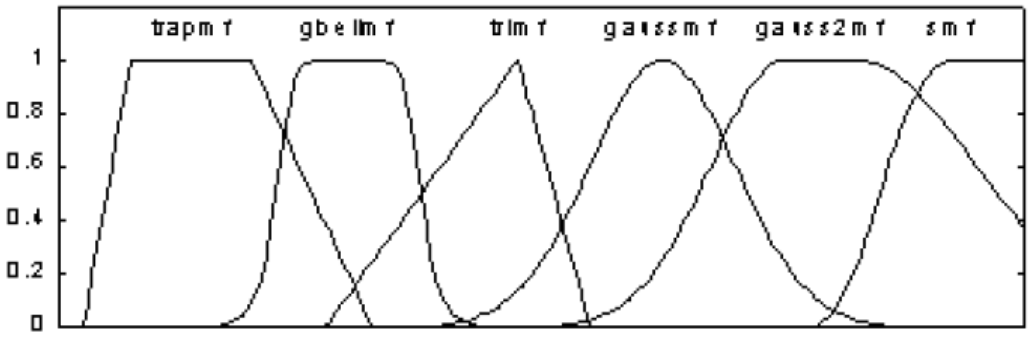

Figure 5.6 Built-in membership function at Matlab 7.0.1 Fuzzy Toolbox

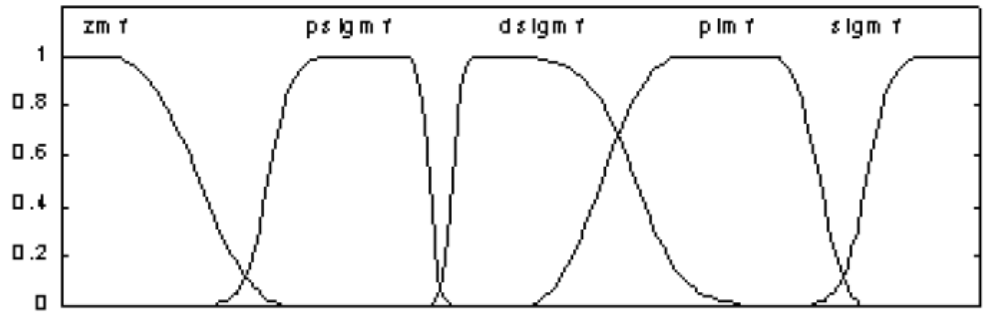

Figure 5.6 Built-in membership function at Matlab 7.0.1 Fuzzy Toolbox (continued)

In this study ***zmf*** and ***smf*** types are used to assign membership functions. The information is given below that is related with these built-in membership functions.

ZMF

Z-shaped built-in membership function

Syntax

$$y = zmf(x,[ab]) \tag{5.13}$$

Description

This spline-based function of x is so named because of its Z-shape. The parameters a and b locate the extremes of the sloped portion of the curve as given by.

$$y = \begin{cases} 1, x \le a \\ 1 - 2\left(\dfrac{x-a}{b-a}\right)^2, a \le x \le \dfrac{a+b}{2} \\ 2\left(\dfrac{b-x}{b-a}\right), \dfrac{a+b}{2} \le x \le b \\ 0, x \ge b \end{cases} \tag{5.14}$$

SMF

S-shaped built-in membership function

Syntax

$$y = smf(x,[abc]) \tag{5.15}$$

Description

This spline-based curve is a mapping on the vector x, and is named because of its S-shape. The parameters a and b locate the extremes of the sloped portion of the curve.

$$y = \begin{cases} 0, x \le a \\ 2\left(\frac{x-a}{b-a}\right)^2, a \le x \le \frac{a+b}{2} \\ 1-2\left(\frac{x-b}{b-a}\right)^2, \frac{a+b}{2} \le x \le b \\ 1, x \ge b \end{cases} \tag{5.16}$$

Independent Variable 1: Rating

The first rule found by the SPSS Clementine 10.1 is, for the stiations in case the value of rating is less or greater than 3.67. The value of the range has been given [0; 10] that includes the critical value 3.67. The parameters for all independent variables have been given as the critical value and the value of 30% deviation from the critical value. Such as, the parameters for z-shaped built-in membership function has been given 3.67 for the lower limit, and 4.771 for the upper limit. Figure 5.7 shows the values less than 3.67. In the same vein the parameters for s-shaped built-in membership function has been given 2.569 for the lower limit, and 3.67 for the upper limit. Figure 5.8 shows the values greater than 3.67. Graphs have been created for the all independent variables

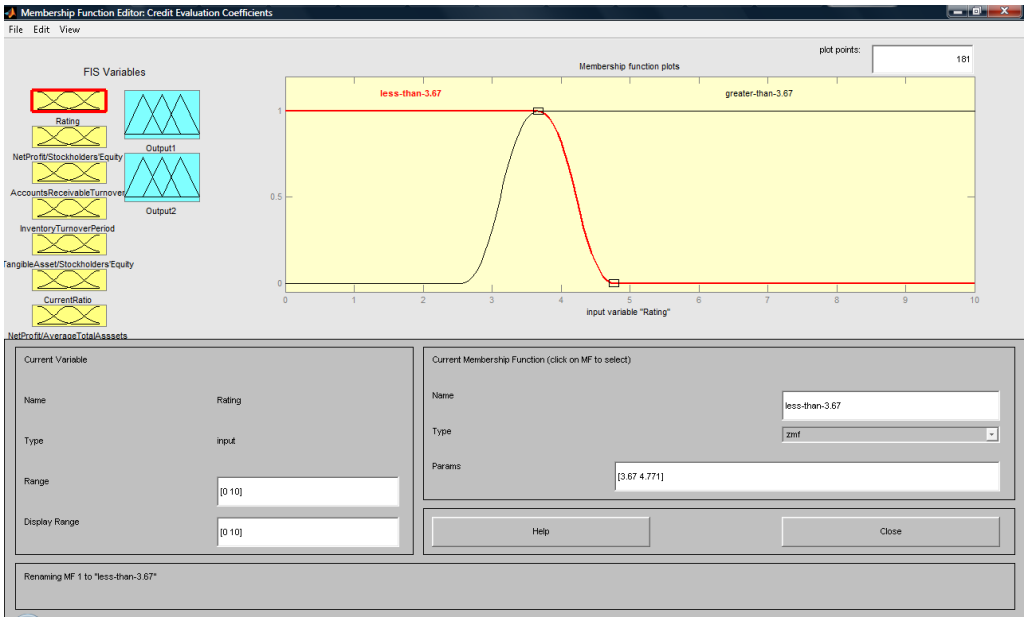

Figure 5.9 Z-shaped built-in membership function graph for variable 1 (red line).

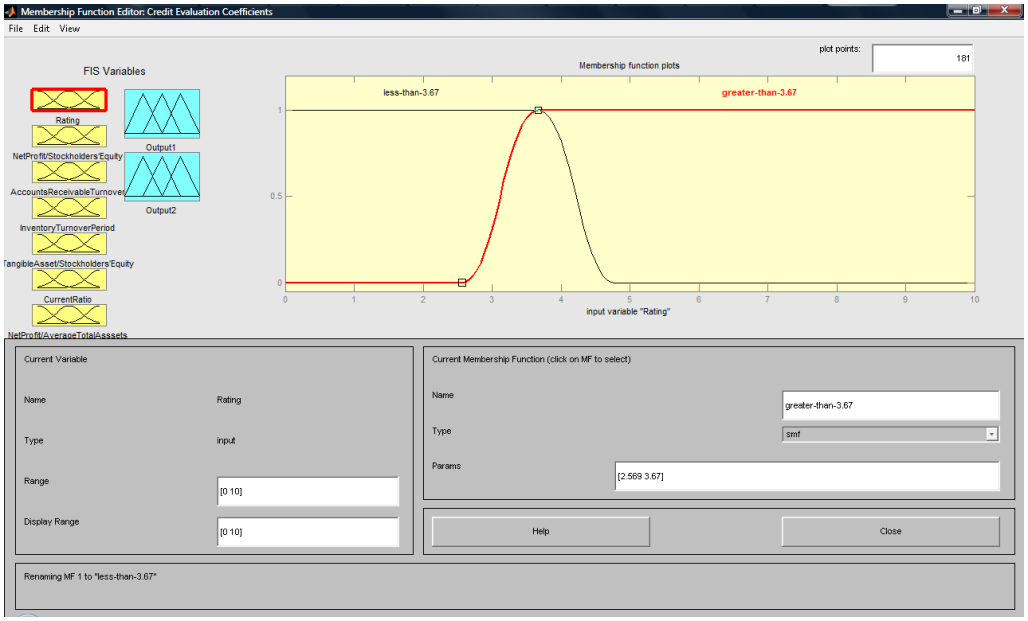

Figure 5.10 S-shaped built-in membership function graph for variable 1 (red line).

Independent Variable 2: Net Profit / Stockholders' Equity

The third rule found by the SPSS Clementine 10.1 is, for the situations in case the value of the ratio of net profit / stockholders' equity is less or greater than 1.025. The value of the range has been given [0; 2] that includes the critical value 1.025.

The parameters for all independent variables have been given as the critical value and the value of 30% deviation from the critical value. The parameters for z-shaped built-in membership function has been given 1.025 for the lower limit, and 1.333 for the upper limit. In the same vein the parameters for s-shaped built-in membership function has been given 0.7175 for the lower limit, and 1.025 for the upper limit.

Independent Variable 3: Net Profit / Stockholders' Equity

The third rule found by the SPSS Clementine 10.1 is, for the situations in case the value of accounts receivable turnover is less or greater than 2.40. The value of the range has been given [1; 4] that includes the critical value 2.40. The parameters for all independent variables have been given as the critical value and the value of 30% deviation from the critical value. The parameters for z-shaped built-in membership function has been given 2.40 for the lower limit, and 3.12 for the upper limit. In the same vein the parameters for s-shaped built-in membership function has been given 1.68 for the lower limit, and 2.40 for the upper limit.

Independent Variable 4: Inventory Turnover Period

The fourth rule found by the SPSS Clementine 10.1 is, for the situations in case the value of inventory turnover period is less or greater than 8.325. The value of the range has been given [4; 12] that includes the critical value 8.325. The parameters for all independent variables have been given as the critical value and the value of 30% deviation from the critical value. The parameters for z-shaped built-in membership function has been given 8.325 for the lower limit, and 10.82 for the upper limit. In the same vein the parameters for s-shaped built-in membership function has been given 5.827 for the lower limit, and 8.325 for the upper limit.

Independent Variable 5: Tangible Asset / Stockholders' Equity

The fifth rule found by the SPSS Clementine 10.1 is, for the situations in case the value of the ratio of tangible asset / stockholders' equity is less or greater than 42.8. The value of the range has been given [25; 60] that includes the critical value 42.8.

The parameters for all independent variables have been given as the critical value and the value of 30% deviation from the critical value. The parameters for z-shaped built-in membership function has been given 42.8 for the lower limit, and 55.64 for the upper limit. In the same vein the parameters for s-shaped built-in membership function has been given 29.96 for the lower limit, and 42.8 for the upper limit.

Independent Variable 6: Current Ratio

The sixth rule found by the SPSS Clementine 10.1 is, for the situations in case the value of current ratio is less or greater than 134.44. The value of the range has been given [80; 190] that includes the critical value 134.44. The parameters for all independent variables have been given as the critical value and the value of 30% deviation from the critical value. The parameters for z-shaped built-in membership function has been given 134.44 for the lower limit, and 174.8 for the upper limit. In the same vein the parameters for s-shaped built-in membership function has been given 94.11 for the lower limit, and 134.44 for the upper limit.

Independent Variable 7: Net Profit / Average Total Assets

The seventh rule found by the SPSS Clementine 10.1 is, for the situations in case the value of the ratio of net profit / average total assets is less or greater than 0.79. The value of the range has been given [0; 2] that includes the critical value 0.79. The parameters for all independent variables have been given as the critical value and the value of 30% deviation from the critical value. The parameters for z-shaped built-in membership function has been given 0.79 for the lower limit, and 1.027 for the upper limit. In the same vein the parameters for s-shaped built-in membership function has been given 0.553 for the lower limit, and 0.79 for the upper limit.

Together with 7. variable, the definition of independent variables, that create the rules, was completed. Definitions of the dependent variables are given below. 2 dependent variables take place in the model. The first output variable is used to define “collateral level to be taken”, and the second output variable is used to define “credit level to be assigned”.

trimf type is used to assign membership functions. The information is given below that is related with this built-in membership functions.

trimf

Triangular-shaped built-in membership function

Syntax

$$y = trimf(x, params)$$

$$y = trimf(x, [abc]) \tag{5.17}$$

Description

The triangular curve is a function of a vector, x, and depends on three scalar parameters a, b, and c, as given by

$$f(x;a,b,c) = \begin{cases} 0, x \le a \\ \dfrac{x-a}{b-a}, a \le x \le b \\ \dfrac{c-x}{c-b}, b \le x \le c \\ 0, c \le x \end{cases} \tag{5.18}$$

or, more compactly, by

$$f(x;a,b,c) = \max\left(\min\left(\frac{x-a}{b-a}, \frac{c-x}{c-b}\right), 0\right) \tag{5.19}$$

The parameters a and c locate the "feet" of the triangle and the parameter c locates the peak.

1. Dependent Variable (“negative”): Output 1

Output 1 variable is assigned for the rules which is found by SPSS Clementine 10.1 defines the negative situations. The parameters are [0 0 1]. This output will be used to define “collateral level to be taken”.

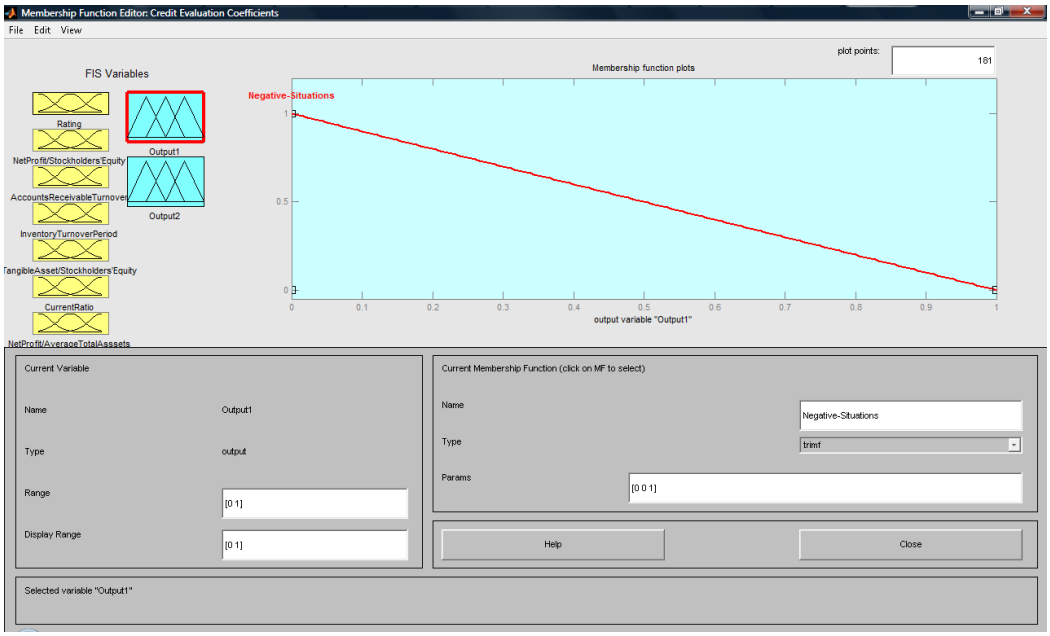

Figure 5.11 “Negative situation” membership function graph for the dependent variable (red line).

2. Dependent Variable (“positive”): Output 2

Output 2 variable is assigned for the rules which is found by SPSS Clementine 10.1 defines the positive situations. The parameters are [0 1 1]. This output will be used to define “credit level to be assigned”.

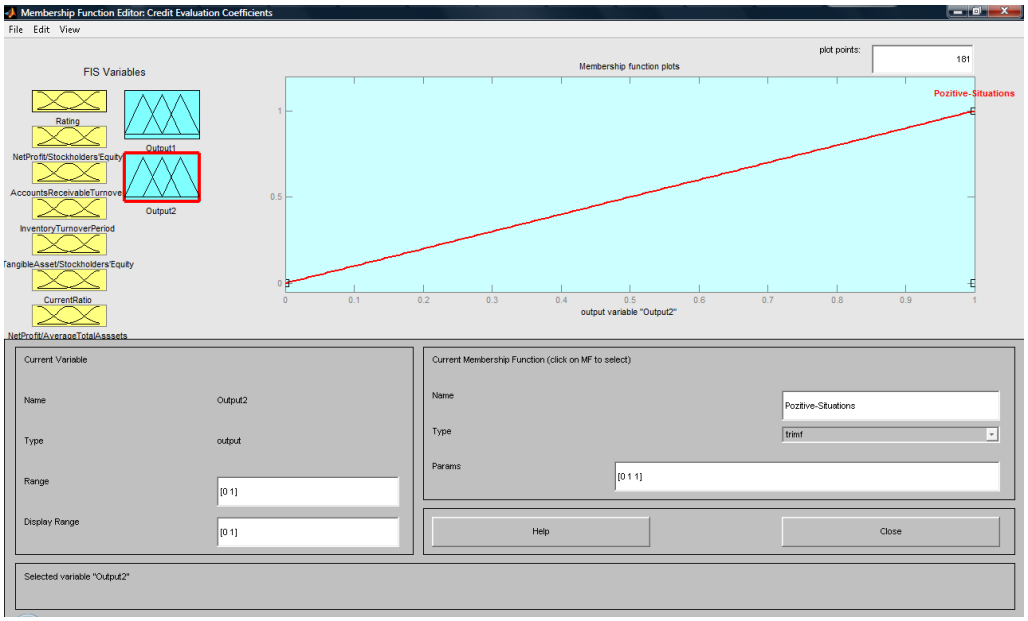

Figure 5.12 "Positive situation" membership function graph for the dependent variable (red line).

After the definitions of independent and dependent variables completed, the rules that is found by decision tree are created on Matlab 7.0.1 software program. These 8 rules are shown in Figure 5.13.

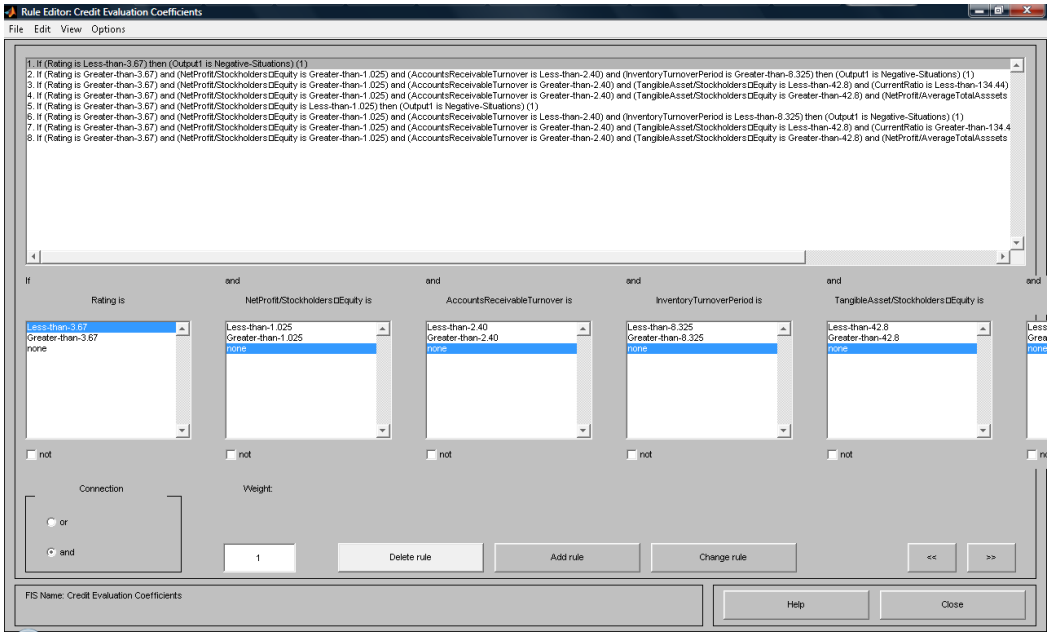

Figure 5.13 Rule Editor Module

As the first four rules are found for the failed enterprises, dependent variable for the first four rules is “Output 1”. While “Output 1” variable is selected as “negative”, variable selection is not done for “Output 2”, “none” was put in place. The other four rules are found for the successful enterprises. So, the situation is exactly the opposite way. Dependent variable for the rules 5, 6, 7, and 8, is “Output 2”. While “Output 2” variable is selected as “positive”, the variable “Output 1” is selected as “none”.

With the rules organized in this way, the multiplication of the “Output 1” variable by the loan demand of company will show the collateral level to be taken. In the same way as the multiplication of the “Output 2” variable by the loan demand of company will show the credit level to be assigned.

Data entries of the companies are made at the “**Rules**” tab.

By putting in place 109 data are at the “**Rules**” page, “**Output 1**” and “**Output 2**” are observed. As an example for a given data, entering values of the 7 significant independent variables are shown below.

Rating: 5.80, Net Profit / Stockholders’ Equity: 3.29, Accounts Receivable Turnover: 0.77, Inventory Turnover Period: 63.45, Tangible Asset / Stockholders’ Equity: 6.32, Current Ratio: 110.10, Net Profit / Average Total Assets: 1.99.

Table 5.2 Input Values of the Example Company

Criteria	Inputs
Rating	5.80
Net Profit / Stockholders’ Equity	3.29
Accounts Receivable Turnover	0.77
Inventory Turnover Period	63.45
Tangible Asset / Stockholders’ Equity	6.32
Current Ratio	110.10
Net Profit / Average Total Assets	1.99

As shown in Figure 5.14, the independent variables are entered to find the output variables. “Output 1” is found as 0.33, “Output 2” is found as 0.5. Related ratios indicate the collateral level to be taken and the credit level to be assigned. The first dependent variable, which is used to find the collateral level, is 0.33. It means that, the result of the multiplication of the loan demand amount of the company by 0.33 will be the collateral level to be taken. The second dependent variable, which is used to find the credit level, is 0.50. It means that, the result of the multiplication of the loan demand amount of the company by 0.50 will be the credit level to be assigned. Accordingly, for 750.000 TL loan demand of company, 375.000 TL credit can be assigned in return for taking 247.500 TL collateral.

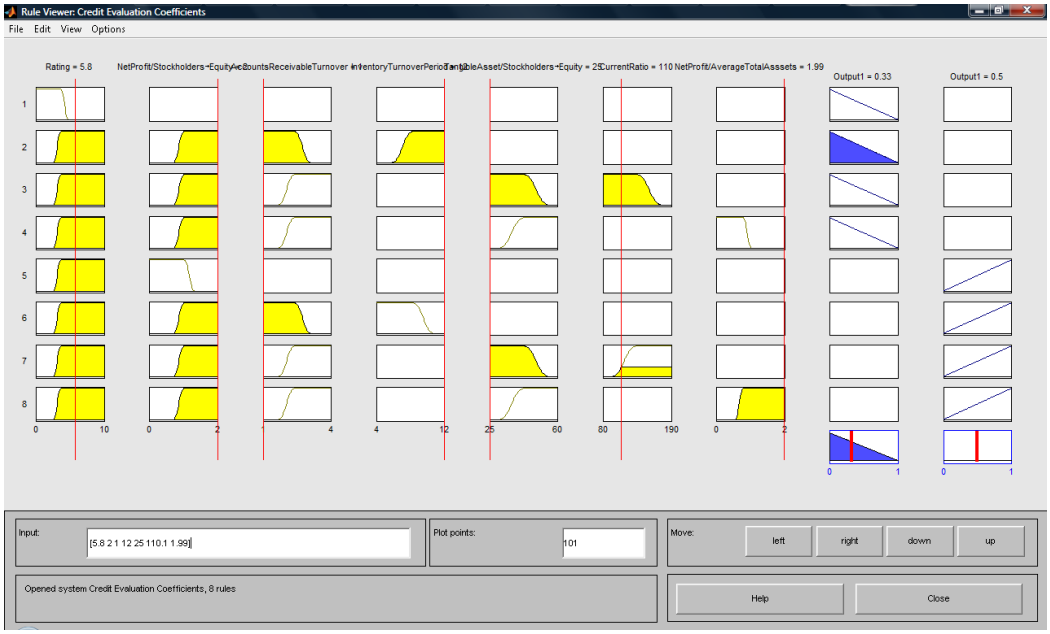

Figure 5.14 rule viewer module

The related variables of the 109 data are put in place one by one and dependent variables for each data are recorded. These results are multiplied by the loan demand amount of the companies. Found results, which are credit level to be assigned to the company and reciprocally collateral level to be taken from the company, are compared with the classical logic. The results are presented in Table 5.3.

Table 5.3 Comparative results of fuzzy logic and real bank operations

				RESULTS OF FUZZY LOGIC		REAL BANKING OPERATIONS	
	LOAN DEMAND (TL)	**Output 2**	**Output1**	**Recommended Collateral Amount (TL)**	**Recommended Credit Assignment Amount (TL)**	**Credit Assignment Amount (TL)**	**Collateral Amount (TL)**
1	750.000	0.33	0.5	247.500	375.000	750.000	734.257
2	1.500.000	0.33	0.5	495.000	750.000	1.500.000	0
3	0	0.33	0.5	0	0	0	0
4	570.000	0.33	0.54	188.100	309.510	0	0
5	750.000	0.33	0.5	247.500	375.000	750.000	0
6	1.000.000	0.33	0.55	330.000	548.000	1.000.000	0
7	4.000.000	0.33	0.5	1.320.000	2.000.000	2.097.800	0
8	800.000	0.33	0.5	264.000	400.000	800.000	0
9	1.250.000	0.33	0.5	412.500	625.000	1.250.000	0
10	14.500.000	0.33	0.5	4.785.000	7.250.000	14.500.000	9.436.994
11	1.250.000	0.33	0.56	412.500	705.000	1.250.000	374.917
12	750.000	0.38	0.67	283.500	502.500	750.000	0
13	300.000	0.33	0.67	99.000	200.400	300.000	260.000
14	300.000	0.33	0.5	99.000	150.000	300.000	0
15	25.800	0.33	0.67	8.514	17.286	25.800	250.000
16	250.000	0.33	0.64	82.500	160.500	250.000	60.000
17	1.000.000	0.33	0.6	330.000	602.000	1.000.000	225.000
18	150.000	0.33	0.5	49.500	75.000	150.000	0
19	300.000	0.33	0.5	99.000	150.000	300.000	0
20	400.000	0.33	0.5	132.000	200.000	400.000	0
21	200.000	0.33	0.5	66.000	100.000	200.000	0
22	126.000	0.5	0.67	63.000	84.420	126.000	0
23	1.000.000	0.33	0.67	330.000	670.000	1.000.000	0
24	150.000	0.33	0.5	49.500	75.000	150.000	0
25	1.500.000	0.33	0.51	495.000	757.500	1.500.000	0
26	249.800	0.33	0.59	82.434	148.131	0	0
27	350.000	0.5	0.67	175.000	234.500	350.000	104.000
28	1.600.000	0.33	0.67	528.000	1.070.400	0	0
29	1.500.000	0.33	0.53	495.000	795.000	1.500.000	600.000
30	1.500.000	0.33	0.67	495.000	1.005.000	0	0
31	50.000	0.33	0.54	16.500	27.050	50.000	0
32	3.000.000	0.33	0.67	990.000	2.010.000	3.000.000	0
33	3.500.000	0.33	0.5	1.155.000	1.750.000	3.500.000	0

Table 5.3 Comparative results of fuzzy logic and real bank operations (continued)

				RESULTS OF FUZZY LOGIC		REAL BANKING OPERATIONS	
	LOAN DEMAND (TL)	Output 2	Output1	Recommended Collateral Amount (TL)	Recommended Credit Assignment Amount (TL)	Credit Assignment Amount (TL)	Collateral Amount (TL)
34	1.000.000	0.4	0.67	400.000	670.000	1.000.000	173.000
35	1.000.000	0.5	0.67	500.000	670.000	534.200	183.004
36	400.000	0.33	0.5	132.000	200.000	400.000	460.000
37	950.000	0.44	0.67	420.850	636.500	950.000	200.000
38	400.000	0.33	0.5	132.000	200.000	400.000	0
39	1.250.000	0.33	0.66	412.500	825.000	1.250.000	0
40	2.000.000	0.33	0.5	660.000	1.000.000	1.000.000	0
41	300.000	0.33	0.5	99.000	150.000	300.000	0
42	400.000	0.33	0.57	132.000	229.600	400.000	0
43	750.000	0.33	0.58	247.500	433.500	750.000	0
44	1.000.000	0.33	0.64	330.000	640.000	1.000.000	0
45	415.000	0.33	0.5	136.950	207.500	415.000	375.000
46	500.000	0.33	0.63	165.000	317.000	350.000	0
47	1.500.000	0.33	0.67	495.000	1.005.000	1.500.000	525.800
48	2.050.000	0.33	0.63	676.500	1.281.250	1.516.800	0
49	750.000	0.33	0.5	247.500	375.000	750.000	0
50	450.000	0.33	0.5	148.500	225.000	450.000	273.000
51	0	0.33	0.64	0	0	0	0
52	2.000.000	0.33	0.65	660.000	1.308.000	0	0
53	1.500.000	0.33	0.62	495.000	933.000	1.500.000	0
54	1.550.000	0.5	0.67	775.000	1.038.500	1.572.800	1.170.000
55	4.000.000	0.5	0.67	2.000.000	2.680.000	2.000.000	285.563
56	7.000.000	0.38	0.67	2.667.000	4.690.000	7.000.000	0
57	1.500.000	0.5	0.67	750.000	1.005.000	1.500.000	0
58	3.000.000	0.33	0.62	990.000	1.869.000	3.000.000	550.580
59	750.000	0.5	0.67	375.000	502.500	750.000	624.335
60	2.000.000	0.42	0.67	846.000	1.340.000	0	0
61	475.000	0.33	0.5	156.750	237.500	400.000	329.600
62	1.000.000	0.45	0.67	446.000	670.000	1.000.000	0
63	8.000.000	0.5	0.67	4.000.000	5.360.000	5.000.000	289.375
64	1.500.000	0.5	0.67	750.000	1.005.000	1.250.000	0
65	250.000	0.49	0.67	123.000	167.500	150.000	0
66	900.000	0.34	0.67	308.700	603.000	900.000	751.387
67	590.000	0.33	0.67	195.290	395.300	0	0
68	1.500.000	0.33	0.67	495.000	1.005.000	0	0
69	0	0.33	0.67	0	0	0	0

Table 5.3 Comparative results of fuzzy logic and real bank operations (continued)

				RESULTS OF FUZZY LOGIC		REAL BANKING OPERATIONS	
	LOAN DEMAND (TL)	**Output 2**	**Output1**	**Recommended Collateral Amount (TL)**	**Recommended Credit Assignment Amount (TL)**	**Credit Assignment Amount (TL)**	**Collateral Amount (TL)**
70	3.000.000	0.5	0.67	1.500.000	2.010.000	1.500.000	0
71	250.000	0.39	0.67	96.500	167.500	250.000	105.000
72	750.000	0.35	0.67	263.250	502.500	0	0
73	500.000	0.5	0.67	250.000	335.000	500.000	441.290
74	2.000.000	0.33	0.5	660.000	1.000.000	2.000.000	0
75	2.500.000	0.42	0.67	1.055.000	1.675.000	2.500.000	2.869.810
76	750.000	0.5	0.67	375.000	502.500	0	0
77	800.000	0.5	0.67	400.000	536.000	800.000	0
78	2.500.000	0.33	0.5	825.000	1.250.000	0	0
79	1.200.000	0.5	0.67	600.000	804.000	1.200.000	617.488
80	1.500.000	0.35	0.67	522.000	1.005.000	1.000.000	0
81	3.000.000	0.5	0.67	1.500.000	2.010.000	2.000.000	0
82	400.000	0.49	0.67	195.200	268.000	400.000	0
83	750.000	0.33	0.5	247.500	375.000	400.000	0
84	500.000	0.5	0.67	250.000	335.000	350.000	210.000
85	1.500.000	0.33	0.5	495.000	750.000	1.500.000	0
86	1.500.000	0.5	0.67	750.000	1.005.000	1.500.000	0
87	400.000	0.5	0.67	200.000	268.000	300.000	0
88	500.000	0.33	0.5	165.000	250.000	400.000	662.031
89	500.000	0.39	0.67	194.500	335.000	500.000	106.500
90	500.000	0.5	0.67	247.500	335.000	250.000	310.551
91	1.000.000	0.5	0.67	500.000	670.000	1.000.000	0
92	0	0.5	0.67	0	0	0	0
93	1.000.000	0.38	0.67	380.000	670.000	0	0
94	4.000.000	0.5	0.67	2.000.000	2.680.000	4.000.000	2.170.000
95	2.000.000	0.5	0.67	1.000.000	1.340.000	1.500.000	632.510
96	3.000.000	0.5	0.67	1.500.000	2.010.000	3.000.000	0
97	250.000	0.34	0.67	85.000	167.500	250.000	185.235
98	400.000	0.33	0.67	132.000	268.000	400.000	182.500
99	2.000.000	0.44	0.67	874.000	1.340.000	2.000.000	2.190.535
100	200.000	0.33	0.5	66.000	100.000	200.000	0
101	500.000	0.33	0.67	165.000	335.000	500.000	0
102	3.000.000	0.5	0.67	1.485.000	2.010.000	3.000.000	0
103	750.000	0.33	0.65	247.500	484.500	750.000	734.257
104	500.000	0.5	0.67	250.000	335.000	500.000	0
105	750.000	0.48	0.67	363.000	502.500	750.000	0

Table 5.3 Comparative results of fuzzy logic and real bank operations (continued)

				RESULTS OF FUZZY LOGIC		REAL BANKING OPERATIONS	
	LOAN DEMAND (TL)	**Output 2**	**Output 1**	**Recommended Collateral Amount (TL)**	**Recommended Credit Assignment Amount (TL)**	**Credit Assignment Amount (TL)**	**Collateral Amount (TL)**
106	850.000	0.33	0.67	280.500	569.500	850.000	700.350
107	1.350.000	0.37	0.67	503.550	904.500	1.250.000	160.000
108	1.000.000	0.5	0.67	495.000	670.000	1.000.000	1.020.430
109	600.000	0.33	0.5	198.000	300.000	245.600	525.000

Orange rows shows the information related to bankrupted companies and the green rows shows the information related to successful companies.

In Table 5.3 it is defined as;

Recommended Collateral Amount = Loan Demand x Output 1

Recommended Credit Assignment Amount = Loan Demand x Output 2

The columns “Collateral Amount” and “Credit Assignment Amount” state the real results of bank according to their evaluation.

Credit Assignment Rate (CAR): It is the ratio of assigned credit to the loan demand.

$$\text{CAR} = \frac{\text{Credit Assignment}}{\text{Loan Demand}} x100\% \tag{5.20}$$

Performance: It is the ratio of repayment of assigned credit to the company.

$$\text{Performance} = \frac{\text{Returned Amount}}{\text{Credit Assignment}} x100\% \tag{5.21}$$

Results are shown separately by considering of bankrupted and successful companies in below.

Credit Assignment Rate of the Bankrupted Companies:

Traditional Bank Approach: 54 pcs companies have been applied for 64.7 Million TL loan demand. 54.7 Million TL Credit has been assigned by Bank. With Traditional Bank Approach, Credit Assignment Rate is;

$$CAR = \frac{54.7}{64.7} x100\%$$

$$CAR = 84\%$$

Fuzzy logic Approach: 54 pcs companies have been applied for 64.7 Million TL loan demand. 22 Million TL has been predicted to assign with developed program. With Fuzzy Logic Approach, Credit Assignment Rate is;

$$CAR = \frac{22}{64.7} x100\%$$

$$CAR = 34\%$$

Performance of the Bankrupted Companies

Traditional Bank Approach: 54 pcs companies have been applied for 64.7 Million TL loan demand. 54.7 Million TL Credit has been assigned by bank and 15.4 Million TL has been taken back. With Traditional Bank Approach, Performance is;

$$\text{Performance} = \frac{15.4}{54.7} x100\%$$

$$\text{Performance} = 28\%$$

Fuzzy Logic Approach: 54 pcs companies have been applied for 64.7 Million TL loan demand to the bank. 36.4 Million TL has been predicted to assign to the company with developed program, 22 Million TL has been predicted for assurance.

For this case with Fuzzy Logic Approach, Performance is;

$$\text{Performance} = \frac{22}{36.4} x100\%$$

$$\text{Performance} = 60\%$$

Credit Assignment Rate of Successful Companies:

Traditional Bank Approach: 55 pcs company have been applied for 80.9 Million TL loan demand to the bank. 61.4 Million TL credit has been assigned by bank. For this case Credit Assignment Rate of Traditional Bank Approach;

$$CAR = \frac{61.4}{80.9} x100\%$$

$$CAR = 76\%$$

Fuzzy Logic Approach: 55 pcs company have been applied for 80.9 Million TL loan demand to the bank. 52.6 Million TL credit has been predicted to assign by developed program. For this case Credit Assignment Rate of Fuzzy Logic Approach;

$$CAR = \frac{52.6}{80.9} x100\%$$

$$CAR = 65\%$$

Performance of Successful Companies:

Because there is no problem on repayments of credits for both approach performances are %100.

Obtained results have been shown separately below in Table 5.4 and Table 5.5

Table 5.4 Real Bank Results

	Bankrupted Companies	**Successful Companies**
Credit Assignment Rate	84%	76%
Performance	28%	100%

Table 5.5 Proposed Fuzzy Logic Approach.

	Bankrupted Companies	**Successful Companies**
Credit Assignment Rate	34%	65%
Performance	60%	100%

While 76% of loan demands are assigned to the successful companies with traditional bank approach, 65% is assigned with fuzzy logic approach. Despite the fact that 11% differences are seen on fuzzy logic approach, this difference is not 11% according to bank profit. It is as far as rate of interest over the 11% differences (Nasibov & Bölgen, 2010).

While, 84% of the loan demands is provided loan by the bank for the bankrupted companies, 34% is provided loan by the fuzzy logic approach. By fuzzy logic method, credit assignment ratio gives 60% a better result for predicting bankruptcy of the company compared to conventional banking approach. By the conventional banking approach the success rate is 28% for the bankrupted companies, as this proportion has increased to 60% by the fuzzy logic approach.

This situation shows that, the program, developed with fuzzy logic approach, will reduce the potential losses of the bank from 84% to 34% according to the conventional banking approach. And at the same time the success rate will increase from 28% to 60%.

The comparative results based on real amount of TL between fuzzy logic approach and conventional banking approach has given in Table 5.6.

Table 5.6 Comparison of results

		Fuzzy Logic Approach		Conventional Banking Approach	
	TOTAL LOAN DEMANDS (TL)	**Recommended Collateral Amount (TL)**	**Recommended Credit Assignment (TL)**	**Collateral Amount (TL)**	**Credit Assignment (TL)**
Bankrupted Companies	**64.736.600**	**22.090.848**	**36.467.047**	**15.404.972**	**54.788.400**
Successful Companies	**80.915.000**	**35.418.740**	**52.604.800**	**16.654.327**	**61.495.600**

As it is shown at above table, while, 61.495.600 TL credit has been assigned by bank to the companies that have regular payments, 52.604.800 TL credit has been predicted to assign by the developed program.

The bank has provided a 54.788.400 TL loan to the bankrupted companies in return for taking collateral. It means that, when assume that 15.404.972 TL is convert into cash by bank but 39.383.428 TL can not be received back. When considered the results found by the fuzzy logic approach, The bank will provided 36.467.047 TL loan to the bankrupted companies in return for taking collateral. Assuming to convert 22.090.848 TL into cash, 14.376.199 TL can not be received back. The related results are shown in Table 5.7.

Table 5.7 Comparison of the Non-Performing Loan

Fuzzy Logic Approach	**Conventional Banking Approach**
Non-Performing Loan	Non-Performing Loan
14.367.199 TL	**39.383.428 TL**

As a result, the continuity of a credit mechanism requires the transfer of liquidity undoubtedly. It means that credit institution must have cash that, the credit granting process could continue. Any given credit contains risk. The credit risks are varying according to the carried risk premium of the loanee. The cost of credit is determined by the level of risk premiums. At this point, credit institutions have to assign capital as margin of safety though the carried risk premiums. But as the allocation capital increase, the provided potential equity capital profitability of the credit institution will decrease.

CHAPTER SIX
CONCLUSION

Utilizing the resources for the right customer with the most appropriate term and interest rate is one of the most important problems of the banks. Determining the right customer depends on constituting decision support systems aimed at making the right decision in rating the creditworthiness. Banks perform intense studies on this issue, especially in improving their internal rating systems.

However, today's decision support systems that depend on mostly statistical methods, cannot be adequately revealing for SMEs, that do not have professional finance management, whose financial data do not reflect the actual situation, where the enterprise and the owner become identical; thus subjective factors are used intensively, and decisions are made in highly employed departments, in environments involving non-standard, high-cost, and long decision periods, each different in different banks.

Even the evaluation of the data in the balance sheets and financial statements may cause different results for different enterprises by different experts. Besides, the expert evaluating the enterprise should analyse certain information such as views, opinions and intelligence about that enterprise. This situation causes the classical analysis techniques to fall behind.

Evaluation of loan requests has an important place in terms of the economic system as well as the banks. The mistakes the banks make in their loan decisions cause resource profusion in the economy, and also create negative influence on economic stability. The 60% difference between the method practiced by the bank and the method we suggested here in terms of performance evaluations is an obvious example for this situation.

Granted loans' becoming non-performing ones and banks entering into bankruptcy process are adverse events for the financial system.

In this study, application based on fuzzy logic are conducted as an alternative to the decision support systems used in the banks, and the results obtained are compared to the results of classical logic used in the banks. The fuzzy logic method, which was determined as the most appropriate method at the end of the comparison, is also suggested as the alternative decision support system. The ultimate purpose of the study is suggesting as an alternative a cheap, fast, coherent decision system that imitates human intelligence, instead of expensive complex models that no one other than the experts understands, and which needs long data input and interpretation.

Banks should play safe about the amount of risk they can undertake during granting loans. The possibility for loans to become non-performing increases while working with high risks, the situation of missing many important opportunities in the market arises while working with lower risks. At this point, one should take into consideration that the cost of missing an opportunity in the market will be lower than a non-performing loan.

Avoiding these risks is important for the commercial customers to maintain their financial stability, and to minimize the default risks of the loans granted to these enterprises. In this context, the enterprises which do not have competent personnel or which have a tendency of avoiding the costs of these kinds operation should be counseled by the banks.

The increase seen in the amount of non-performing loans does not only damage the banking sector, but also affects the economy of the country negatively. Banks' resorting in collecting the debts in the shortest time possible from the loan customers, and backing off granting new loans to these customers in order to restore their financial structures, lead to an economic recession or deepen it, in countries where banking has a major importance in the financial system.

The classical analysis techniques should be supported by several new techniques. The analysis technique with a fuzzy logic approach, suggested in this study, will be advantageous in this respect, by applying on not only numerical values but also on certain linguistic expressions.

The fuzzy logic approach to credit rating of enterprises, developed in this study, is an approach that is applicable in the special conditions of our country. Also it is a dynamic method for it analyse different evaluations of experts in terms of different conditions of the periods. It provides an alternative decision support system to the decision makers for the banks to see their risk more clearly.

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