

# An Analysis of the Effects of Quality Features of Bank Natural Customers in their Credit Rating, using Neural Network and Fuzzy Inference System

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## Abstract

**Background/Objectives:** Today credit risk is recognized as one of the biggest causes of bankrupting of banks and financial institutes. To control and manage this risk, designing credit rating models is an undeniable necessity. **Methods/Statistical Analysis:** Research method due to providing artificial intelligence concepts including neural network and fuzzy inference system and also due to the probability of its implementation in banking system, regarding to purpose it is developmental applicable and in terms of implementation, it is descriptive-analytic. In this research, we have introduced an overall model of credit rating and its database. **Results:** Since a high percentage of bank customers are natural persons, attention to the effective characteristics of customers in credit rating is very important. This paper has investigated the scale of the descriptive and qualitative effects (indecisive) of the customers such as commitment, faithfulness, etc. in credit rating. Although there have been proposed various methods and models based upon customers' characteristics, yet there has never been any critique and investigation regarding the scale of effects of indecisive features. The main objective of this paper is to investigate the scale of effects of qualitative effects in their credit rating and comparing their qualitative features with other quantitative features of customers using Neural Network and Fuzzy Inference System, in a way that it makes determining the measurements of customers' credits easy for the credit providers. **Conclusion/Application:** This research indicates that we cannot assess the customers only by relying on decisive, clarified indexes and their financial status, and the status of indecisive variables effectiveness (oral variables).

**Keywords:** Credit Rating, Customer Qualitative Feature JEL:C53 C40, Fuzzy Inference System, Neural Network

## 1. Introduction

The science of decision-making is permanently with human and by the emergence of organizations, firms, and specifically with the quick environmental changes it has been widely developed. Many researchers have concentrated their attempt in such field provide more appropriate and accurate patterns for improving decision making systems and provide more success for decision-makers<sup>1</sup>.

In granting facilities which is one of the major activities of banks and financial institutes for making correct decisions, the level of credit and power of reimbursement

of the main and the profit of recipient facilities shall be determined to decrease the lack of the main and profit of the provided facilities return, it means decreasing the risk of credit level. One of methods for decreasing such risk is designing the system of determining credit level for facility recipients and the canon of this system is the model of rating or credit assessment<sup>2</sup>.

By using such model, the rate or credit level of the applicant is clarified and it is decided based upon it in order to grant facilities or not. In previous studies, they relied more on statistical methods such as Logit, and probit regression models, and analytical method of audit for

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scoring and rating customers, but during recent years by developing of models based upon artificial intelligence and innovative methods, many studies have been done in usage of such methods in scoring and credit rating models. Now, intelligent systems in order to optimize and predict are highly used as advanced tools in field of different sciences. Neural network and fuzzy inference systems as intelligent systems are used in different scopes of finance including credit approval. It seems searching for practical relations have lost its significance. The thing which is important is to study the movement and the relation of a series of variables with other series of variables. In order to do this, the models of artificial intelligence are advanced beyond mind that cannot consider everything all together<sup>3</sup>.

One of effective factors on customer's credit rating is determining accurate and appropriate indexes that regarding to the previous studies it seems until now they have used decisive variables for designing models and they have not considered indecisive variables (qualitative) including ethics, behavior, beliefs, fame and etc<sup>4</sup>. The purpose of present research is to compare two categories of qualitative and quantitative variables.

## 2. Review Literature

### 2.1 Credit Risk

Credit risk refers to the probability of borrower failure or the party against bank for fulfilling its reliabilities, based upon the agreed conditions. In other words, credit risk is the probability of bank assets devaluation, specifically the provided facilities. Regarding to that the capital of banks is few in comparison with total value of their assets, even if few percentage of granted loans are irrecoverable, they banks will be faced with the danger of bankruptcy. The process of credit risk management means to identify asses, analyze and appropriate reaction against credit risk and also permanent inspection on them regarding to variable conditions of environment. In this regard, using new technologies (credit management) have been highly using, including credit risk management, credit rating, credit scoring etc. and kinds of credit assessment like 5Cs method, LAPP method, 5Ps method etc. in order to allocate credit to applicants<sup>5</sup>.

### 2.2 Accreditation

Accreditation means assessment and evaluation of reimb-

ursement power of the applicants for financial facilities credit and the probability of lack of reimbursement of the credits by them. Accreditation is an official comment that is presented by accreditation institutes about the credit of real or corporate customers of banks and financial institutes and provides the possibility of more recognition about the financial status and power of individuals in order to reimburse the received facilities and receiving more services. Rating (determining credit rate) in fact, provides necessity vision in order to recognize credit risk of customers for a firm<sup>6</sup>. The basis of accreditation is on data analysis. In the process of accreditation, customers are rated and assessed based upon different indexes and features. This rate or score in fact indicate the financial credit of the customer that bank can make decision more accurate and quicker about providing services to a customer.

The first model for determining bankruptcy of firms was multi-variant logistic regression model that is introduced by Beyeur in 1966<sup>7</sup>. After that, this model has been used for measuring the credit risk of bonds published by firms. One of the other first researches in field of measuring the credit risk of firms' bonds is the model of multi-variant giving scores by Altman in 1968 and it is famous as the model of Z score<sup>8</sup>. Z score model by Altman is a model of audit analysis by using amounts of financial ratios is trying to distinguish firms with financial distress (bankrupted) from non-financial distress firms.

Other important researches that are done in field of assessing credit risk are the studies by Almer and Brovski in 1988. Almer and Brovski in order to forecast the ability of loans' reimbursement have used multi-layered perception neural network model. Their entry variables were the same used variables in Z model by Altman. By comparison of the results of perception neural network with Z model by Altman they found out that the power of perception model forecast is more than credit scoring models<sup>9</sup>. From other researches in field of designing assessment model for credit risk we can point out Morgan studies in 1998 for designing accreditation model<sup>10</sup> and studies by Tracey in 1998 for designing the model of value in danger of risk in order to sum the density function of non-reimbursement probability<sup>11</sup>.

Nowadays, along with the studies of Basel Committee (Committee of inspection on banking laws, Bank for int'l settlements), many studies have been done by researchers and credit institutes for designing accurate model for credit risk assessment. Also many models are used by

using econometrics methods and neural networks and fuzzy inference systems for measuring credit risk in banks and credit institutes.

Despite the quantizing credit risk of banks in developed countries including USA and Europe, it is begun approximately two decades but there is no any research about the impact of features and personal characteristics of borrower and most of them have considered the decisive variables like, income amount, security, education and etc. in predicting creditworthiness or customers and they don't consider the amount of attempt and responsibility of the applicant in on time reimbursement of loan that this issue is having direct relation with cultural, ethical and spiritual characteristics.

### 2.3 Credit Scoring Models

Credit scoring models are used in two modes of qualitative and quantitative. Qualitative analysis of credit scoring depends on the capability and experience of responsible individuals for granting credit but in method of quantitative analysis prediction of non-reimbursement of the credit and the profit of credit facilities depend on the distributed function by quantitative methods. Most of quantitative patterns of credit risk are having similar conceptual framework but the differences in implementation of such models are caused the way of main parameters' conclusion from information are in access. There used extensive techniques in fields of statistics, mathematics, econometrics and operation research in banks and credit institutes about credit scoring that are divided into two overall categories, non-parametrical scoring patterns (like: mathematical planning, tree classification, closest neighbor pattern, the process of hierarchical analysis, expert systems, artificial neural networks, genetics algorithm) and parametrical scoring patterns (like: linear probability model, analytical audit model, logit model, probit model)<sup>12</sup>.

Previous researches indicate that in most of cases and conditions the best model of customer assessment is the combinational models, it means the combination of neural networks with other models. An appropriate model is a model that in addition to collecting and systematizing the comment and criterion of experts, it can analyze the data by using inference combinational model. Combination systems are able to inference and explain expert system and simultaneously they are able to learn and become consistent with the system of neu-

ral network. The results of the research indicate that such systems are having high accuracy. Using models depends on the conditions and status and kind of information and its volume<sup>13</sup>.

## 3. The Application of Artificial Intelligence Algorithms in Financial Analysis

Considering use of artificial intelligence techniques and modeling tools in field of nosiness are increasingly increasing. In recent decades the titles of neural networks, genetic algorithm and fuzzy logic are the issues drawn the attention of many academics. Such issues are known as powerful tools for resolving issues that are not solvable by traditional methods and psychologies. Artificial intelligence in addition to its usages in different fields, it's been a while it has possessed its position in accounting and financial affairs.

Researchers have used accounting, technologies and artificial intelligence techniques with success for specific purposes in reporting and financial analysis<sup>14</sup>, auditing and ensuring<sup>15-18</sup> and other fields.

### 3.1 Artificial Neural Networks and Evaluate the Validity

Artificial neural networks are of those dynamic systems transferring the knowledge or law beyond data to network structure by process on experimental data. This is the reason we call such systems intelligent, since they learn overall rules based upon calculations on numerical data or examples<sup>19</sup>. After that, by establishing a network among such neurons and applying a training algorithm to it, they train the network. In other words, neural network is used in condition that the structure of issues is not clarified and a kind of flow study or recognition of pattern shall be done. The managers of financial institutes, financial entities and professional investors are facing with many of such issues in action, in a way that they have a mass of data relating to customers' information and their banking statements that can make decision for future customers regarding to such valuable experiences and the results of their credit worthiness status. Neural network accesses to information about previous customers of the bank in addition to the result of their performance as input and in the process of its black box, learns the inter-

data rules by learning algorithms and then generalize the obtained rules to future customers and clarifies their creditworthiness status<sup>20</sup>.

### 3.1.1 Properties of Neural Networks

The features that distinguish neural networks from other branches of artificial intelligence or common evaluative methods are:

- Learning through examples: as it has already mentioned we can use the couples of input and output for teaching network.
- It ignores deficiencies: therefore we can use neural network for distorted or confusing inputs.
- They are able to diagnosis the pattern<sup>21</sup>.
- It uses parallel process, since different aspects of pattern are considered as a whole<sup>22</sup>.
- Low energy consumption of neural network: regarding two parallel process of information and maintaining learned information, it consumes little energy<sup>23</sup>.

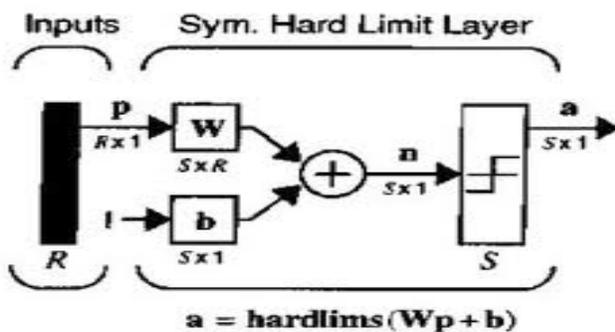


Figure 1.

### 3.2 Fuzzy Logic

Fuzzy logic is against binary logic or Aristotle-like that considers everything in two parts of black or white, yes or no, 0 or 1 and it is a logic placed between 0 and 1 and it stays away from absoluteness (only 0 or 1) and states about the belonging of a member to a series.

Fuzzy logic has been introduced in 1965 for the first time in an article with the same name by Professor Lotfi Zadeh. Fuzzy logic is a new technology that completes the general methods for designing and modeling a system that requires advanced and complicated mathematics by using amounts and lingual conditions or in other words the knowledge of expert individual and by the purpose of simplifying and becoming more applicable design. One

of the fuzzy logic features is that incomplete and non-logical inputs are reached to decisive responds by using functions like (if ... then ...). Therefore, two steps of fuzzy making shall be done in this process (the process of converting numbers and issue data to format of numbers or oral phrases in fuzz) and de-fuzzy (the process of producing an evaluable result)<sup>24</sup>.

It is one of usages of fuzzy logic in decision-making that can change indecisive inputs to absolute responds by using amounts and time conditions. In a very uncertain environment and today's changing environment, strategic decisions are having fuzzy and complicated nature. The other field of fuzzy logic use is auditing. Fuzzy logic and the theory of fuzzy series can aid in auditing in field of measuring and managing risk probability of audit and ambiguity in auditing environment. For instance, when the accountants are explaining that specific internal control is effective they put internal control in a fuzzy series. Therefore, regarding to the nature of accounting occupation it seems such potential agent is existed that one day auditing will use fuzzy theory<sup>25</sup>.

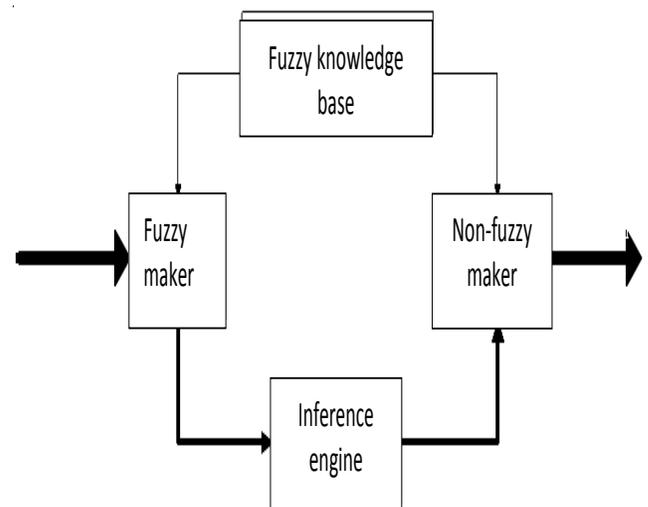


Figure 2. Model of fuzzy inference.

## 4. Research Method

The research method of this research in terms of purpose is applicable and in terms of data collection, it is descriptive-survey. In order to rate real customers' credits of Mehr Iran Qarzolhasane Bank, we have used the cases of 700 credit customer's information. Population of this research was transactional information and demography of 700 people of this bank customer that are selected com-

pletely random. This size of sample has been chosen from customers having account from year 2010.

Research method due to providing artificial intelligence concepts including neural network and fuzzy inference system and also due to the probability of its implementation in banking system, regarding to purpose it is developmental applicable and in terms of implementation, it is descriptive-analytic. In this research, by relying on concepts mentioned in theoretical literature and analyses of banking system, we have introduced an overall model of credit rating and its database.

Since, generally most of facilities granting by banks are relating to real customers, in this model also the samples were related to real customers that the indexes and rules are introduced by using the view of experts and credit models in order to assess more accurately.

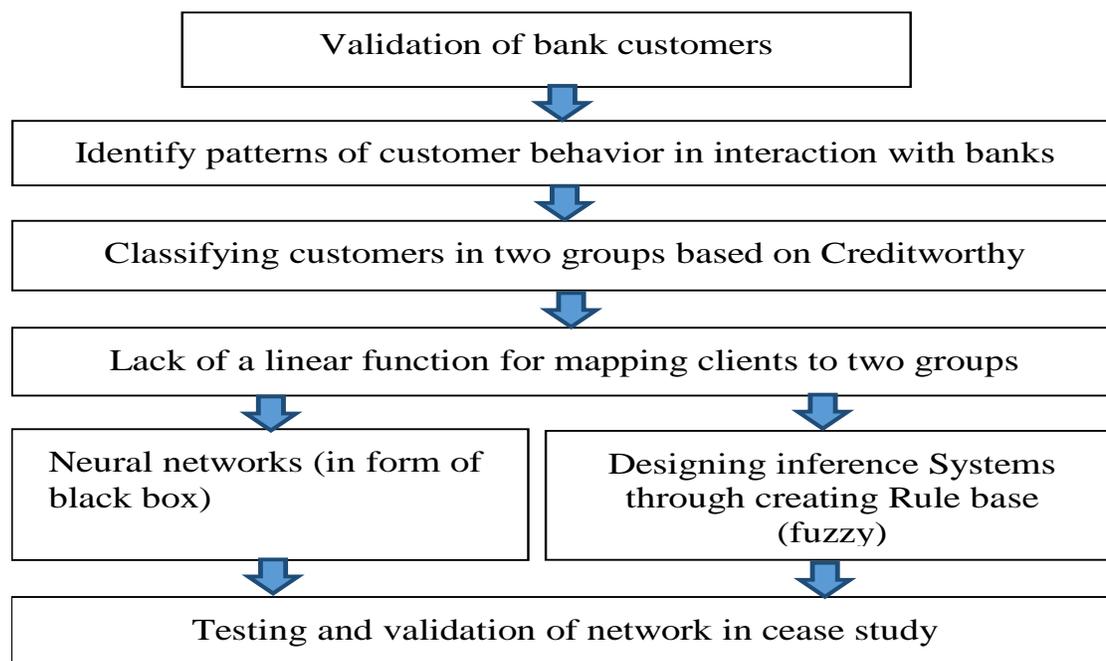
Regarding to the purpose of research that studies the amount of impact of absolute and indecisive (qualitative) indexes on credit rating, two groups of variables are considered in order to compare more promptly. First groups embraces quantitative features like income, education, security, age, credit background and occupation that it has sharp point for every customer and it is completed by a clarified score. Such groups of indexes are assessed by neural network model. Second group embraces indecisive features and in simpler talk it refers to qualitative

features they have oral descriptions like the amount of loyalty, commitment, fame that for each one of customers regarding to the significance of index includes specific range of numbers. Such group of indexes are assessed by fuzzy inference system that such model requires definition of “IF... THEN...” functions by the experts of banks and credit specialists. At the end, after implementing two models and achieving the reliability of their performance and optimization in their kinds, the features of customers are entered into two models their outputs have been compared for a test.

## 5. The Criteria used in the Customer's Credit Rating

In Iran, historically the banks are relying on the combination of their own specialists' experiences and qualitative and quantitative analysis for decision-making about paying facilities and the rate of customer credit.

Such criteria are not fixed scientific and certain rules, some of them are the result of studying, analyzing of financial statements and some of them are the comment of specialists and experiences of people involved in such field for years that of course in some researches their significance are approved that using such criteria guarantees the healthiness and sustainability of credit structure, it



**Figure 3.** Overview of problem-solving methods.

means verifying the return of facilities and their expected profits within determined time. For assuring about the completeness of considered factors and also their categorization we have used 5Cs method which is used in testing the credit level of applicant around in world.

5C includes the following components:

- Personality
- Capacity
- Capital
- Status
- Security

### 5.1 Identification of the Applicant Facility

Correct recognition of customer and understanding the actual inner of customer and not the appearance and the his financial status is one of important initial conditions to provide facilities that it is clarified by his bank visits considering his case and studying features like the type of his fame, creditworthiness, commitment, discipline in his tasks, way of interaction, behavior and his words, beliefs, education, spirituality, overall status of his family etc. for people in charge whether he is responsible enough for reimbursement regardless to other factors and factors of granting credit or despite his good financial status he is indiscipline and not reliable.

Maybe an applicant is financially capable and technically competent and has appropriate credit capacity but only he is not qualified due to that he is characteristically unreliable towards his reliabilities, therefore, the spiritual characteristic of customer is highly significant.

### 5.2 Technical Competency of an Applicant

Technical competency of an applicant means he is significantly experienced, competent, capable and he has attitude in his nominated economic activity that causes the continual and his business progress and success and maintaining his investment and its increase and lack of it causes losing his capital, competency and business capability.

### 5.3 Technical Competency of an Applicant

Accurate study of customer's financial status and his financial justifications for requesting facilities is significant. Financial status of applicant is highly significant for bank and this is important that bank knows about the applicant's financial status. Is he financially prepared

for facing with unexpected incidents or not? Or is he is requesting for facilities in accordance with his financial status or not?

When the banks are making decision about granting facilities they prefer to know how much the applicant has paid or considered for his own plan. Certainly in this regard, the more the share of customer and his advance payment is higher, banks can trust more in customer for more facilities and partnership. The more the customer is relying on banks for his own activity; the level of trust to the customer will be decreased.

### 5.4 Security

Security can be a long-term deposit, mortgage of movable and immovable assets, stocks and exchange papers or irrevocable contracts or obligatory documents and it is certain that the more they are strong, return of bank demands is easier but adequate and strong securities cannot solely be the criterion for determining and allocating credit.

However, a credit case is studied correctly and right, the probability of lack of its reimbursement will be very few and we shall not consider strong securities because the applicant will face with many difficulties.

Based upon the type of issue in this research there considered two groups of decisive and indecisive indexes for each customer. Indexes are chosen based upon 5Cs model and the comment of experts. After consultation with banking experts and banking specialists the indecisive indexes have been chosen and for scoring indexes the characteristic of questionnaire has been designed and has been filled by customers.

The scores of decisive indexes are extracted based upon credit formats within branch or database of financial system:

1. Income
2. Education
3. Securities
4. Age
5. Experience
6. Occupation

The scores of indecisive indexes questionnaires that are designed by the views of experts are extracted:

1. Capacity
2. Capital
3. Characteristic
4. Loyalty

## 5. Securities

- Determine the number of processor elements in each layer
- Number of hidden layers
- transfer function
- Learning rules

## 6. Neural Network

### 6.1 Data Preparation

- Definition and data collection
- Preliminary data processing
- Preliminary data processing
- Dividing the data into training and testing

### 6.2 Network Design

- Choose a type of model

### 6.3 Finalizing and Training Model

- Final decision model
- Model training

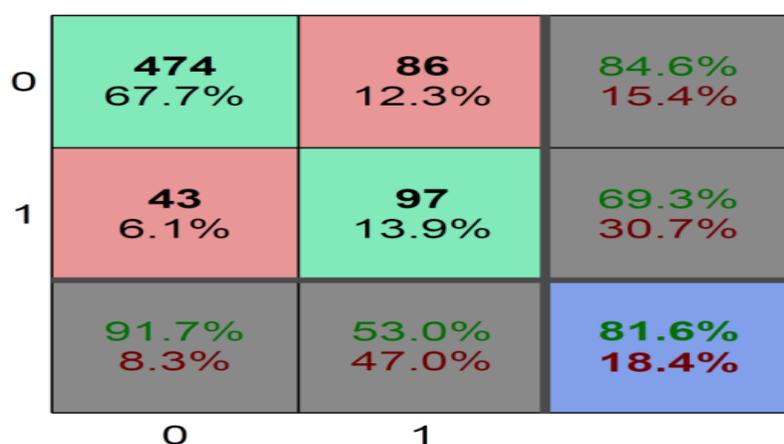
This model includes 700 examples that 517 of them are loan with low credit risks and 183 examples are high credit risks. Each period of learning for model includes 25000 repetitions that of course there is a disagreement

**Table 1.** Input variables of the neural network model

Row	Variable	Values
1	Income	Amount of income on debt
2	Education	Below high school diploma- diploma-bachelor -MA and Ph.D.
3	The amount of security	Real amount
4	Credit experience	With expertise- doesn't have experience – without experience
5	Job	Employees - employees of the institution - the seller - Other Jobs

**Table 2.** Specifications of the model

Model	Transfer function	The number of layers	The number of hidden each layer	The number of repetitions
A	Sigmoid	4	20	25000



**Figure 4.** The output of the neural network

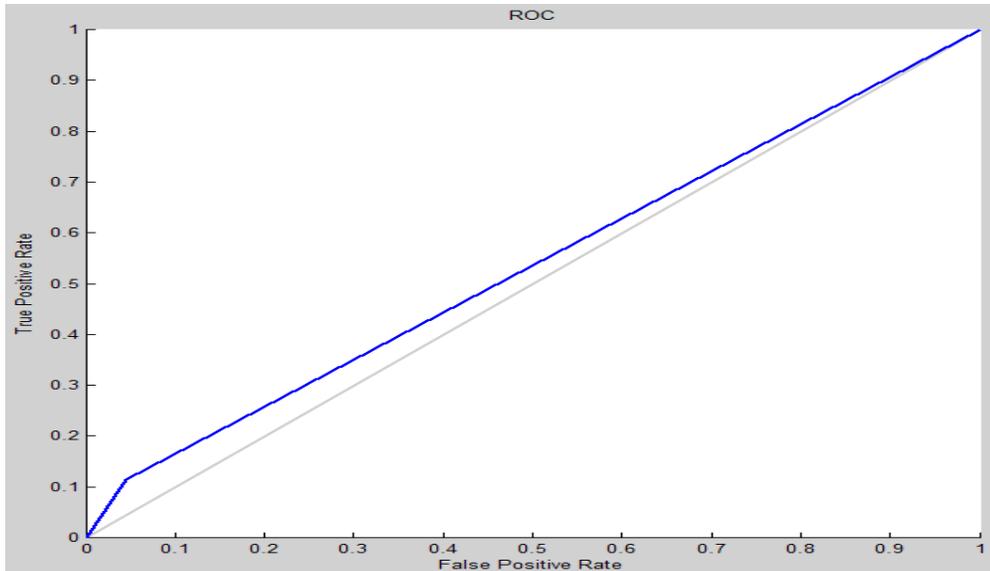


Figure 5. ROC diagram.

about the times of repetition but it is stated 25000 repeats, regarding to the theoretical principles there seem a good agreement among the views and balance among the necessary time length and model accuracy.

## 6.4 Output Neural Network Model

The results of model implementation indicate that the model can predict not creditworthy customers with accuracy of 91.7% and creditworthy customers with accuracy of 81.6%.

## 7. Fuzzy Inference System

### 7.1 Data Preparation

Input and output variables are defined as fuzzy numbers. If rules are defined using Elite opinion.

### 7.2 Designing Input Fuzzy Model

- Determine the function of membership
- Set fuzzy operator

### 7.3 Finilizing Model

- Run Model
- converting fuzzy output to non- fuzzy output
- model testing

## 7.4 Neural Fuzzy Reasoning Model Output

The results of implementing Neps model from test of 100 customers indicate that the model can predict not-creditworthy customers with accuracy of 90.2% and credit worthy customers with accuracy of 89.9%.

## 8. Analysis of Results

In this research, the features of bank customers have been divided into two groups of decisive and indecisive indexes and by using two models of multi-layered Prospetron neural network and Mamadani fuzzy inference system have assessed the credit of 700 customers of Mehr Iran Qarzolhansane Bank in MATLAB software.

Then for each one of two models we have extracted the rate of success separately that in this mode the model of fuzzy inference system has obtained better results. In next step, we have chosen some customers and both models have been implemented for test that the obtained results are indicated in table:

The comparison indicate that number of errors of neural network model and fuzzy were equal but the output error of fuzzy model (customer number 3) are less different with correct answer and the output error of neural network (customer number 4) in terms of decisiveness have more distance with correct answer.

**Table 3.** Inputs of fuzzy logic model

Row	Variable	Concept
1	Financial capability	Earning and commercial capacity
2	Personality	Ethics - Family fame - social status – faith- type of behave –discipline in work – type
3	Amount of security	The current status of the customer deposits and collateral in branch
4	Loyalty	Inventory turnover, Creditworthy , Account Balance - timely fulfillment of obligations, No Czech Returns
5	Capital	
6	Credit ( output )	Capital amount -Types of capital - the definitive document of ownership - Financial Statements

**Table 4.** Fuzzy classification

Row	Variable	Linguistic values	Fuzzy values
1	Financial capability	Low - medium - high - very high	[80,90,95]
2	Personality	Weak - medium - good	[90,110,115]
3	Amount of security	less than the loan - almost equal to the loan-Most of the loans	[110,120,130]
4	Loyalty	Low - medium - high - very high	[125,135,150]
5	Capital	Low - medium - high - very high	[80 90 100]
6	Credit ( output )	Weak - medium - good	[95 105 115]

**Table 5.** If ... Then ... Rules (Rule 48)

Row	Rule
1	If the customer security is less than the loan, and have medium financial capability ,weak personality and low loyalty and the capital will be weak , Then the group is Weak
2	If the customer security is less than the loan, and have medium financial capability ,weak personality and low loyalty and the capital will be weak , Then the group is Weak
3	If the customer security is more than the loan, and have low financial capability ,good personality and medium loyalty and the capital will be weak , Then the group is medium

4	If the customer security is more than the loan, and have low financial capability ,good personality , high loyalty and the capital will be weak, Then the group is medium
5	
6	If the customer security is more than the loan, and have low financial capability ,good personality , high loyalty and the capital will be good , Then the group is good

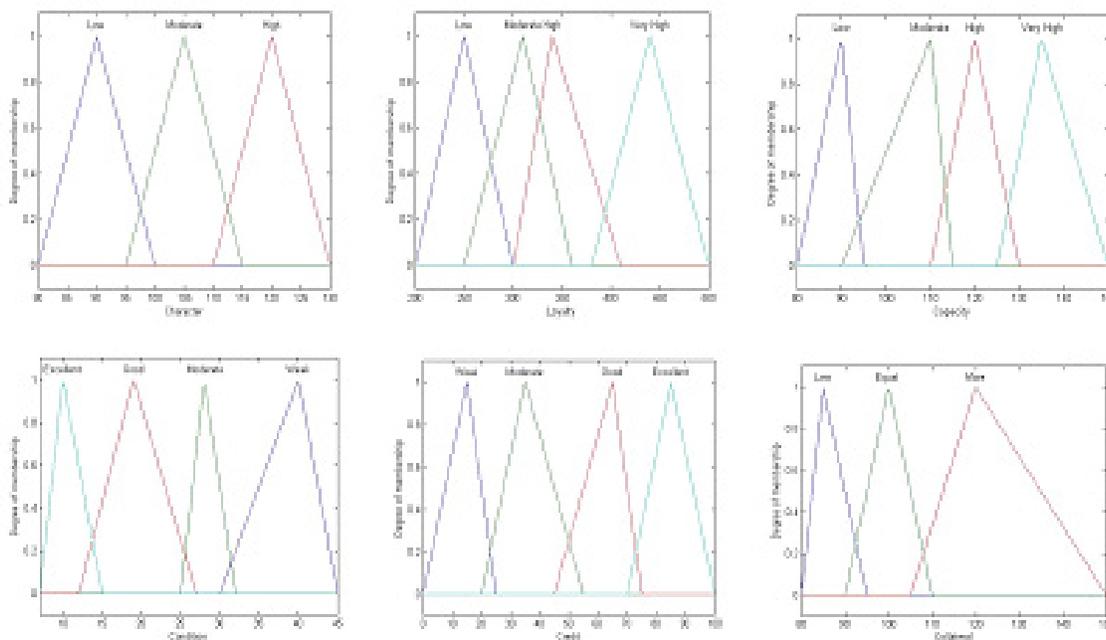
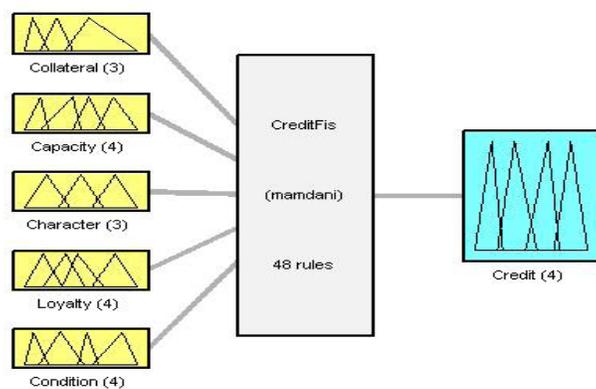


Figure 6. Input variables using membership functions in MATLAB.



System CreditFis: 5 inputs, 1 outputs, 48 rules

Figure 7. Fuzzy inference Engine.

**Table 6.** Testing Customers with deterministic and non-deterministic indexes

Credit worthy	Capital	Loyalty	Financial capacity	Security	Personality	income	Security	Exper-ience	job	Educa-tion	Client
0	Medium	High	low	More than loan	good	22	735	-1	2	2	1
0	good	Medium	High	More than loan	Medium	66	854	-1	2	2	2
0	Medium	Very High	high	Less than loan	good	31	275	-1	1	1	3
1	Weak	low	low	Equal to loan	Medium Committed	19	661	-1	1	1	4
1	Medium	Medium	Medium	Less than loan	Weak	48	137	0	1	1	5

**Table 7.** Comparison of two models

Row	Output of neural network Creditworthy	Output of fuzzy system Creditworthy	Correct output of Definitive data	Correct output of fuzzy data
1	Credit worth	Good(57.3)	Credit worth	good (65)
2	Credit worth	Supreme (83.8)	Credit worth	Supreme (85)
3	Credit worth	Good(78)	Credit worth	Supreme (85)
4	Credit worth	Medium (36.5)	Miscount	Medium (40)
5	Miscount	Weak (23.8)	Miscount	Weak (20)

## 9. Conclusion

Granting banking facilities to qualified customers is one of most important and most complicated tasks of banks. Banks by collecting financial resources from country in different ways are allocating them to their real and corporate customers. The way of allocating such resources as facilities only to qualified and competent customers can guarantees profitability and more job opportunities in country. Right allocation of financial resources in addition to provide economic and profitable results

for country, it provides the appropriate opportunity for survival of banks. Therefore, the banks before granting facilities to their customers shall consider indexes and criteria for effectiveness of their risk and their credit assessment. The results of this research indicate that we cannot assess the customers only by relying on decisive, clarified indexes and their financial status, and the status of indecisive variables effectiveness (oral variables) that are more including the behavioral features of customers, fame, loyalty to bank and etc. are indicating more than decisive indexes.

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