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Predicting Bank Profitability in Iran by Fuzzy Inference System

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Abstract

The main purpose of this study is to develop a Fuzzy inference system to predict bank profitability in Iran and help investors in their investment decisions. For this purpose, the main effective variables on bank profitability, including facilities, deposits, manpower costs, and assets were recognized. In the next step, the data of 13 banks were collected from 2001 to 2011. The membership functions and Fuzzy rules were developed in the MATLAB software and then, Fuzzy inference system was developed. The findings revealed that the system has an appropriate performance in predicting profitability of Iranian banks and rarely makes any error in this area. The predicted profitability of many banks has increased during the study period and also the predicted profitability of private banks was more than public banks. The banks of Industry and Mine and Karafarin Bank had the least profitability and Mellat Bank had the highest. Finally, Post Bank had the most errors while Mellat Bank had the fewest errors.

***Keywords**: Fuzzy Inference System, Bank profitability, Membership Function, Linguistic labeling, Facilities*

***JEL Classification:** E59, C61, G24*

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1. Introduction

Prediction of financial variables is one of the main challenges of economic and investment studies. Several studies have been conducted in terms of prediction of share price, return on investment, etc. However, prediction of profitability is one of the most interesting issues for economists and financial researchers since correct prediction of profitability-related variables helps investors in predicting their future.

Many studies, about predicting financial variables, have used statistical analysis and regression models. However, review of the latest articles show that many researchers have employed modern problem-solving methods. Such methods are known as soft techniques that can be categorized in three groups including Soft Computing, Neural Networks, and Fuzzy Logic (Kia, 2010, p3). In addition, several studies have been done in terms of the effective factors on bank profitability and different methods of their formulation. In this case, Fuzzy Logic is an important approach that is capable of capturing vague, ambiguous or inaccurate information mainly described in natural language, and transforming it into a numerical form, thus allowing a wide range of applications in computing environments and in artificial intelligence.

The Fuzzy methods aim to consider possible combinations of input variables to achieve the most precise estimations of output variables. For this purpose, input variables of the system were collected through reviewing literature, financial statements of banks and available statistical data.

The present study aims to develop a Fuzzy inference system to bank profitability in Iran. This logic is consistent with prevailing uncertainty of the real world.

This paper is organized as follows: Section 2 reviews the main literature related to the article. Section 3 explains the research methodology of fuzzy models. Section 4 presents the empirical evaluation. Finally, Section 5 brings concluding remarks.

2. Review of Literature

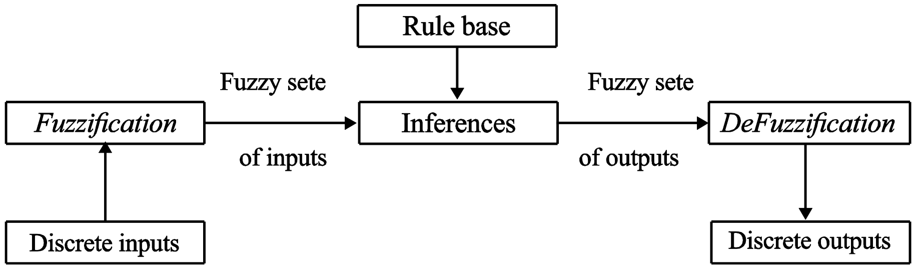
Profit and profitability are the main effective factors on economic decision making. Many studies have been done in this area. Moreover, profitability is one of the most important parameters in the financial analysis of bank performance. Indeed, profit is the fundamental factor in measuring divideneds and management effectiveness and evaluating decisions. That is why profitability is considered important by investors, managers and financial analysts. For this reason, the authors have attempted to identify the effective factors on the profitability of banks and other financial institutions. Investors prefer to deposit and invest their assets in the banks with increasing profitability.

Generally, profitability is a variable by which results of all financial and productive plans, activities, and decisions can be observed. A large part of necessary data for evaluating administrative activities of a company can be collected through profit and loss statement directly. Profit and loss statement is a summary of the results of financial operations of a company. However, administrative operations should have relationship with assets creating profit and loss. Additionally, the operations have to show perception of external individuals of administrative operations and company income. Comparison of profit and loss statements of different periods provides useful information about efficiency of management performance and financial conditions of the company. It should be noted that organizational stakeholders are concerned about profit and profitability.

Obviously, profitability is one of the main considerations in the financial analysis of all businesses. Profitability is so important that it can be said that profitability determines the success or failure of the organization. Managers of classic school considered profit and profitability as very important issues. According to Rabenz (2009), effectiveness is the degree of achievement. Profitability is one of the main parameters in achievement. Friedman (1962) refers to profitability as the oxygen for an organization (Mojtahedzade, 1998, p5).

Fuzzy set theory was first proposed by Zadeh in 1965 and was shown with reasoning using natural language in which many words have ambiguous meanings (Zadeh, 1965, p8). The proposal of Fuzzy Logic is to take a premise that varies in the degree of membership, in the range of 0 to 1, which assumes the element of the fuzzy set to be partially true or partially false. The fuzzy controllers consist of an input stage (discrete inputs tied to some sort of a numeric scale), a processing stage, and an output stage. The input stage maps the input data in such a way that is appropriate for the consecutive functions. The processing stage aims at achieving a solution for the problems and can be divided into three phases: Fuzzification, Evaluation rules, and Defuzzi fiction (Von Altrock, 2002, p37). Figure 1 depicts the phases of the processing stage.

Figure 1. Structure of a Fuzzy Logic Controller



The second phase of the processing stage is the assessment of rules. The fuzzy rules are the statements that describe the action to be performed in response to various fuzzy inputs. Finally, the third and last phase of the processing stage is the Defuzzification, although the name is not exactly the reverse process of Fuzzification. Fuzzy expert system includes:

- User interface: for communication between users and system.
- Membership function base: A mechanism that presents the membership functions of linguistic variable terms.
- Fuzzy rule base: A mechanism for storing fuzzy rules (expert knowledge)
- Fuzzy inference engine: Executable program includes fuzzy matching, fuzzy conflict resolution and fuzzy rule firing.
- Explanation mechanism: A mechanism that explains the inference process.
- Working memory: Storage to save inputs and temporary results.
- Knowledge *acquisition facility*: An effective machine learning approach to deriving rules and membership functions automatically from training instances. The way that a set of fuzzy rule is generated is illustrated in the rest of this section (Hong and Lee, 1996).

A. Rule extraction and representation of knowledge by the fuzzy "if-then" rules

Fuzzy logic formulates linguistic rules for fuzzy models so that they can be easily understood by experts, while, all mathematical details are concealed. The rules of such system are in the form of fuzzy if – then, like:
If x_1 is A_1 and x_2 is A_2…. x_m is A_m, then y is B

$x_1 \ldots x_m$, are the linguistic input variables with values of A1 to A_m and y is the linguistic output variables with value of *B.* The previous systematic approaches were not completely intelligent because the rules were obtained by the experts first and the system performed based on these rules. Therefore, the performance of such systems was depended on experts' rules. If experts modified some of the rules, the intelligent system would be removed. The main propose of this article is to perform the entire process intelligently. Therefore, we would use data to get rules and not to use predefined rules in the system. In the rule extraction phase the famous method of "Wang & Mendel" is used. It has 5 phases to get final solution (Lee and Wang, 2011):

- *Phase 1*: Divide the input and output space into fuzzy region.
- *Phase 2*: Generate fuzzy rules from given data pairs.
- *Phase 3*: Assign a degree to each rule.
- *Phase 4*: Create a combined fuzzy rule base.
- *Phase 5*: Determine a mapping based on the combined fuzzy rule base.

B. from Crisp to Fuzzy sets

Let *U* be a collection of objects of *u* which can be discrete or continuous. *U* is called the universe of discourse and *u* represents an element of *U.* A classical (crisp) subset *C* in a universe *U* can be denoted in several ways like, in the discrete case, by enumeration of its elements:

$C = \{u1, u2, \ldots, up\}$ with $i \forall i\ u \in u$

Another way to denote *C* (both in the discrete and the continuous case) is by using the characteristic function X_F: $U \rightarrow \{0, 1\}$ according to $X_F(u)=1$ if $u \in C$ and $X_F(u)=0$ if $u \notin C$. The latter type of definition can be generalized in order to define fuzzy sets. A fuzzy set *F* in a universe of discourse *U* is characterized by a membership function of u_F which takes values in the interval [0,1] namely u_F: $U \rightarrow [0,1]$.

C. Operators on fuzzy sets

Let *A* and *B* be two fuzzy sets in *U* with membership functions *A* µ and *B* µ, respectively. The fuzzy set resulting from operations of union, intersection, etc. Fuzzy sets are defined using their membership functions. Generally, several choices are possible:

- *Union*: The membership function $\mu_{A \cup B}$ of the union $A \cup B$ can be defined by:

$$\forall_u U_{A \cup B} = \max\{\mu_A(u), \mu_B(u)\}$$

or

$$\forall_u U_{A \cup B} = \mu_A(u) + \mu_B(u) - \mu_A(u)\mu_B(u)$$

- *Intersection*: The membership function $\mu_{A \cap B}$ of the union for all $A \cap B$ can be defined by:

$$\forall_u U_{A \cap B} = \min\{\mu_A(u), \mu_B(u)\}$$

or

$$\forall_u U_{A \cap B} = \mu_A(u)\mu_B(u)$$

- *Complement*: The membership function of the complementary fuzzy set A^C of *A* is usually defined by $\forall_u = \mu_{A^C} 1 - \mu_A(u)$.

The past studies are presented in this section of the article including that of: Azadeh et al. (2010) who investigated an integrated artificial fuzzy regression, neural network (ANN) and genetic algorithm (GA) for optimization of profit with uncertain inputs. Generally, truncations of α have been used to study the fuzzy regression model. In this paper, fuzzy regression is accomplished by the fuzzy neural networks and the necessary neural nets training is proposed by the fuzzy numbers which are based on genetic algorithm. The proposed neural net learning method based on GA is claimed to be a better substitute because of its higher efficiency. To show the applicability and superiority of the proposed approach an actual case study (manufacturer of aluminum radiator) is presented, applied and discussed for the improved fuzzy regression by the integrated neural network and genetic algorithm. This is the first study that integrates fuzzy regression, GA and ANN for optimization of net profit in an uncertain manufacturing environment. The results of this research indicates that a fuzzy neural network has a better result in optimization of profit with uncertain inputs.

Karami et al. (2012), developed a Hybrid model which is an adaptive Mimetic Algorithm combined with fuzzy approach that generates and optimizes a set of “if-then” rules for bankruptcy prediction for Tehran Stock Exchange (TSE) data bank, adopting 18 variables all of which are accounting ones, between 2001 and 2009. Four out of five models used in this survey have either accomplished high degree of accuracy or low level of type I error; however experimental results show that in terms of both average accuracy in prediction and occurrence of type I and II errors, fuzzy mimetic performs better than GA, MLP, C4.5 and LDA in comparison.

Shaverdi et al. (2014) study the application of fuzzy approach for financial performance evaluation of Iranian Petrochemical Sector. In this paper at the first, Iranian petrochemical industry was studied and then the required framework for a good decision making model was introduced. After that financial evaluation criteria and the main financial ratios used in this article were defined. Current ratio, quick ratio, debt ratio, long term debt, EBIT, total asset, inventory turnover ratio, total asset turnover ratio, fixed asset turnover ratio, receivable accounting turnover ratio, net profit margin, ROI, ROE, asset growth, as well as shareholder’s equity growth are among the financial criteria that were used. In the nest stage fuzzy set and fuzzy AHP is described and results of analysis indicated that Arak and Shiraz Petrochemical Companies as the lowest in ranking respectively.

Also, Ben Naceur (2013) studies profitability prediction of 10 banks in Tunisia using Fuzzy Inference System. In this paper, external factors such as gross domestic production and inflation are the main effective factors on the bank profitability. He found that Fuzzy Inference System can predict banks of Tunisia in the best manner.

Choensawat and Polsiri (2012), studied the financial institution failure prediction using adaptive Fuzzy Inference Systems. This study started with collecting financial data from 82 finance companies and 15 commercial banks operating in the period 1992-1997, before the East Asian economic crisis. Financial data on failed and non-failed firms were then examined to develop fuzzy rules based on CAMEL variables. ANFIS is applied to the area of finance for Thai firms for constructing failure prediction models. These models show that prediction accuracy is greater than 90 percent for one to five years prior to failure, indicating the robustness of models over time. In experiments, models yield more accurate forecasting than a logistic model that has been used in the area of finance for Thai firms. The purpose of this study is to present that models using ANFIS are better suited for financial data sets with high nonlinearity than a logistic model.

Chen (2014), investigates banking institution profit prediction using Fuzzy Inference Systems. They focus on selecting variables that have high predictive power to discriminate between two groups of countries. Those consider a sample of 50 emerging markets and developing countries during 1990–2010, and apply Fuzzy Inference Systems into profit prediction. Not surprisingly the results show that countries with better macroeconomic and monetary environments and healthier banking institutions are less likely to suffer systemic banking crisis.

3. Research Methodology

The theory of Fuzzy sets is the theory of acting in uncertain conditions. The theory can formulate many uncertain variables, concepts, and systems mathematically and thereby, paves the way for inference, reasoning, control, and decision-making in uncertain conditions. Obviously, a large part of our decisions and activities is in uncertain conditions and there are a few obvious situations (Kia, 2010, p.9). Fuzziness means multiplicity. In other words, fuzziness refers to the fact that there are several alternatives for each question (Azar and Faraji, 2010, p5). The process of creating a Fuzzy inference system consists of five steps. These steps are described in the following:

3.1. Fuzzification of input variables

The hierarchical construct of decision-making variables such as secondary criteria and rules should be developed in the first step of process. Also entrance of inputs and their membership degree should be determined in the first step. Indeed, hierarchical construct is developed through considering overall goal as root of decision-making tree and main criteria as subsets of the tree. For this purpose, a list of criteria is developed and the criteria are weighted. Such weights show the importance of the criteria. Sum of the weights should not be more than 1. Output of first step is a Fuzzy degree which determines degree of inputs membership in the Fuzzy set. It should be noted that the output should be a number between 0 and 1.

3.2. Applying the operators (or-and)

This step refers to scoring and prioritizing the factors and criteria of a measure and calculating the weight of each criterion through comparative methods after fuzzification of inputs. The degree of accuracy of variables is supposed in this step. If the supposed part has different parts, the fuzzy operators should be used for combining degree of accuracy of parts and creating a number as overall degree of accuracy. The number should be applied in the output function. In this regard, rational operators (or-and) should be used for explaining operators.

3.3. Inference from introduction to conclusion

In order to determine fuzzy set and membership functions of quantitative characteristics, weight of each rule should be defined. Every defined rule has a weight (between 0 and 1). These values should be applied in the value of past step. The conclusion part of determined fuzzy set is defined through membership function. The input of implication process is a number and its output is a fuzzy set. The implication process is implemented for each rule. The membership functions should be adapted through quantitative characteristics (between 0 and 1). Final score of the factor will be calculated trough multiplying the score in its weight.

3.4. Combination of results of rules

Since the decisions of fuzzy inference system are made based on the evaluation of all rules, the rules should be combined. Indeed, combination is a process in which fuzzy sets of each output are combined in a fuzzy set. In other words, fuzzy judgment matrix is calculated through multiplying fuzzy number of each criterion in weight of the criterion and sum of the criteria. Accordingly, fuzzy rank of the criteria will be calculated. Also overall score will be calculated through summing up scores of each factor weight. The combination is done only one time per each output variable. Indeed, the list of output functions creates the combination process. However, output of this step is a fuzzy set per every output variable.

3.5. Fuzzification of input variables

The input of this step is a fuzzy set and its output is a number. Indeed, fuzzy logic helps evaluation of rules, but desirable output is a number per every variable. The reason is that combinative set of fuzzy sets is a range of output values. In this regard, fuzzy value of output variable is calculated in this step and then rank of the variable will be collected. Accordingly, an advice will be calculated based on the maximum of overall score (Kia, 2010, p 12; Rashidmoy et al., 2009, p 15).

Fuzzy inference system can be used as a prediction model especially when input or output variables have higher levels of uncertainty. The reason is that the traditional models of prediction such as regression model will not be applicable in such conditions. In other words, the traditional model of prediction do not consider existing uncertainties of data.

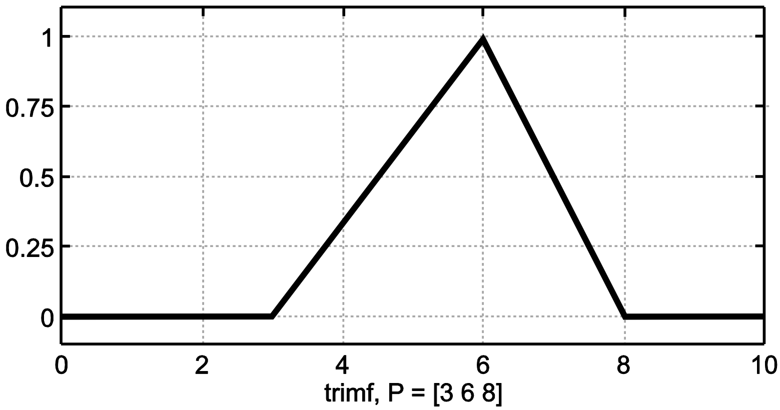
Different types of membership functions, such as triangular, trapezoidal, rectangular, gamma forms, can be used for analysis. However, triangular and trapezoidal membership functions can be used for calculating and determining data validity and quantifying uncertainty of decisions. The reason is simplicity, understandability, and computational efficiency of these methods. This is why that triangular and trapezoidal membership functions are the most applicable and important functions in the fuzzy logic.

Because of public acceptance of triangular membership function, this type of membership function is used in the present study. Indeed, this function helps us to define linguistic variables in a correct, simple, and rational method. Triangular fuzzy function is a continuous fuzzy set of “X” which depends on the parameters of “a”, “b”, and “c”. The mathematical formula and form of triangular membership function is presented in figure 2.

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

The main variables in this article are divided into two categories: The inputs, including the actual volume of total assets, actual volume of total interests, actual volume of facilities and actual price of total labor and the output, including the actual level of total profitability. These variables are analyzed in level and non-logarithmically. [1]

Fig 2. Triangular Membership Function



Souece: Authors'.

Since the present study aims to develop a fuzzy inference system, the final output will be a system based on the input variables of banks. The model aims to predict banks profitability through input variables. For this purpose, the following hypotheses were developed:

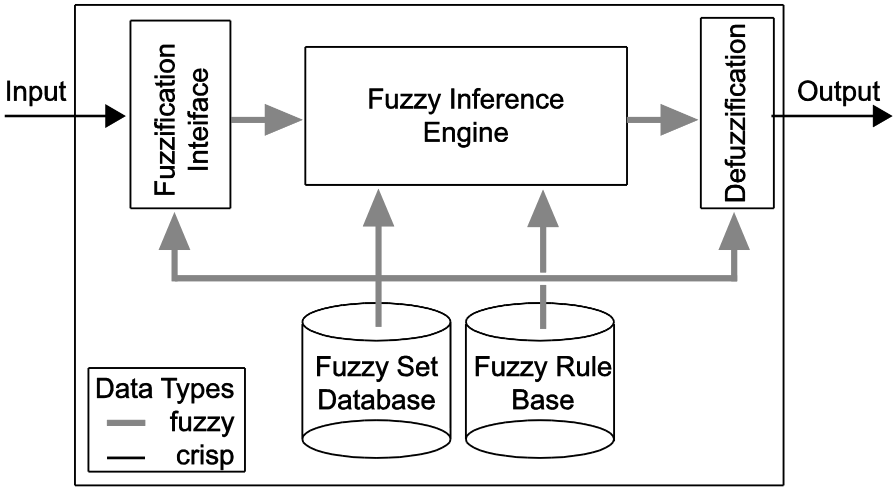
1. The developed fuzzy inference system is successful in predicting bank profitability.
2. The predicted profitability in private banks is more than public banks.

4. Data Analysis and Empirical Evaluation

Indeed, the present study aims to develop a fuzzy inference system for predicting bank profitability in a given year. In order to predict bank profitability level through input variables, including assets, deposits, facilities, labor costs, the statistical data were collected from 2001 to 2011. Deposits and facilities are weighted using Paired Comparison Analysis. The process of fuzzy inference system development is presented in figure 3.

1. Variables are realized by price index.

Fig 3. The Process of Fuzzy Inference System Development



Source: Authors' calculations.

Table 1. The Descriptive Statistics of Research Variables

	Assets	Facukutues	Deposits	Manpower costs	Profit
Number	140	140	140	136	140
Fixed value	0	0	0	4	0
Average	211983.81	258246.19	143319.94	2680.99	1630.02
Standard error	19339.448	26683.430	13522.012	320.951	191.198
Medium	149318.50	132206.00	100635.50	853.50	865.00
Standard deviation	228827.435	315722.598	159994.609	3742.901	2262.290
Variation	5.236E10	9.968E10	2.560E10	1.401E7	5117956.453
Skewness	1.793	1.891	1.932	2.328	2.459
Error standard deviation of skewness	.205	.205	.205	.208	.205

	Assets	Facukutues	Deposits	Manpower costs	Profit
Elongation	3.514	3.611	4.424	6.422	8.326
Error standard deviation of elongation	.407	.407	.407	.413	.407
Range	1181365	1543799	827857	21602	16252
Minimum	374	1	46	21	-1546
Maximum	1181739	1543800	827903	21623	14706

Source: Authors' calculations.
Note: Multiple modes exist. The smallest value is shown.

In the next step, it is necessary to test normality of the distribution of variables. This test has been done in the SPSS through Kolomogorov-Smirinof test. The results of this test have been presented in table 2. The results of Kolomogorov-Smirinof test show the normality of all variables.

Table 2. The Results of Normal Distribution Testing of Variables

Tests of Normality						
	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	**Def.**	**Sig.**	**Statistic**	**Def.**	**Sig.**
Assets	.179	136	.000	.809	136	.000
Facilities	.208	136	.000	.771	136	.000
Deposits	.186	136	.000	.796	136	.000
Manpower costs	.239	136	.000	.706	136	.000
Profit	.217	136	.000	.737	136	.000

Source: Authors' calculations.

a. Lilliefors Significance Correction.

In order to test the relationship between research variables, correlation test was used. The results of this test are presented in table 3.

Table 3. The Results of Correlation Test

Correlations						
		Assets	**Facilities**	**Deposits**	**Manpower costs**	**Profit**
Assets	**Pearson Correlation**	1	.919**	.965**	.834**	.501**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	140	140	140	136	140
Facilities	**Pearson Correlation**	.919**	1	.855**	.748**	.436**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	140	140	140	136	140
Deposits	**Pearson Correlation**	.965**	.855**	1	.870**	.544**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	140	140	140	136	140
Manpower costs	**Pearson Correlation**	.834**	.748**	.870**	1	.312**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	136	136	136	136	136
Profit	**Pearson Correlation**	.501**	.436**	.544**	.312**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	140	140	140	136	140

** Correlation is significant at 0.01 level (2-tailed).
Source: Authors' calculations.

The results of table 3 revealed that there is a significant correlation among assets, facilities, deposits, manpower costs and level of profitability.

Table 4. Determining Range of Research Variables

Variables	Very low	Low	Moderate	High	Very high
Assets	(0 22307)	(22307 90182)	(90182 202805)	(202805 405248)	(40524877 1543800)
Facilities	(0 16976)	(16976 59213)	(59213 134955)	(134955 223491)	(223491 827903)
Deposits	(0 224)	(224 495)	(495 1461)	(1461 4098)	(4098 21623)
Man power costs	(0 31417)	(31417 90890)	(90890 190336)	(190336 335151)	(335151 1181739)
Profit	(-1546 168)	(168 493)	(493 1165)	(1165 2694)	(2694 14706)

Source: Authors' calculations.

Table 5. The Parameters of Membership Function for Research Variables

Variables	Very low	Low	Moderate	High	Very high
Assets	A= 0 B= 22307 C= 44614	A= 22307 B= 90182 C=124119.5	A=90182 B= 202805 C=259116.5	A= 202805 B=405248 C= 506469.5	A=405248 B= 1543800 C=2113076
Facilities	A=0 B=16976 C=33952	A=16976 B= 59213 C= 80331.5	A= 59213 B= 134955 C=179223	A=134955 B= 223491 C= 267759	A=223491 B=827903 C=8430109
Deposits	A= 0 B= 224 C=448	A= 224 B= 495 C=630.5	A= 495 B=1461 C=1994	A= 1461 B=4098 C=5416.5	A=4098 B=21623 C=30385.5
Man power costs	A=0 B=31417 C=62834	A=31417 B=90890 C=120626.5	A=90890 B=190336 C=240059	A=190336 B=335151 C=407558.5	A=335151 B=1181739 C=1605033
Profit	A=-1546 B=168 C=336	A=168 B= 493 C=655.5	A=493 B=1165 C=1501	A=1165 B=2694 C=3458.5	A=2694 B=14706 C= 20712

Source: Authors' calculations.

Based on the results of tables 4 and 5, membership function of five linguistic groups is presented in figure 2. Based on the figure, very high has the biggest range. Indeed, dispersal of this group is the most.

Table 6. The Rules of Fuzzy Inference

Rules	Assets	Labor Cost	Deposits	Facilities	Profit	Repetition of rule
1	Moderate	Low	Moderate	Moderate	Very high	1
2	Moderate	Moderate	Moderate	Moderate	Very high	2
3	High	Low	High	High	Low	1
4	High	Low	High	High	Moderate	1
5	High	Moderate	Very high	High	Moderate	1
6	Very high	Moderate	Very high	Very high	Moderate	2
7	Very high	Moderate	Very high	Very high	Moderate	2
8	Very high	Very high	Very high	Very high	Low	3
9	Very high	Very high	Very high	Very high	Moderate	1
10	Very high	Very high	Very high	Very high	Low	3
11	Very high	Very high	Very high	Very high	Low	3
12	Low	High	Low	Low	Moderate	1
13	Low	High	Low	Low	High	1
14	Moderate	High	Low	Moderate	Very low	1
15	Moderate	High	Moderate	Moderate	Low	3
16	Moderate	High	Moderate	Moderate	Low	3
17	High	High	High	Moderate	Low	1
18	High	High	High	High	Low	1
19	High	High	High	High	Very low	1
20	High	Very high	High	High	Very low	3
21	High	Very high	High	High	Very low	3
22	High	Very high	High	High	Very low	3
23	Moderate	High	Moderate	Moderate	Moderate	1
24	Moderate	High	High	Very high	High	1
25	High	Very high	High	Very high	High	1
26	High	Very high	Very high	High	High	1
27	Very high	Very high	Very high	High	High	1

Source: Authors' calculations.

Table 7. The Results of Bank Profit Estimation for 2012

Banks	Facilities	Deposits	Labor Cost	Assets	Actual profit	Predicted profit
Melli Bank	1116892	820611	21623	1064375	8548	9240 (cen)
Sepah Bank	422347	285271	7420	368573	376	752 (cen)
Saderat Bank	726586	524339	13077	715020	6019	6458 (cen)
Tejarat Bank	735382	482061	9173	611745	8200	9210 (cen)
Mellat Bank	1543800	827903	10623	1181739	14706	14700 (lom)
Refah Bank	240878	159938	4450	179259	486	567 (lom)
Post Bank	14091	20707	829	22968	170	241 (lom)
Keshavarzi Bank	419714	219320	97	373310	231	242 (lom)
Industry and Mine Bank	149750	36783	543	190336	736	658 (cen)
Entrepreneurship Bank	47374	172343	643	77055	2795	1380 (cen)
Parsian Bank	254881	299327	1354	369509	7972	8690 (cen)
Maskan Bank	1442798	307523	4129	875063	1752	2840 (som)
Eghtesad Novin Bank	157078	191193	2002	226261	8200	8950 (cen)

Source: Authors' calculations.

The last column of the table shows the method of de-fuzzing. This method was used randomly. The results of table 8 refer to the comparison of results of tables 4 and 5 and their error.

Table 8. The Results of Comparison of Actual and Predicted Profits for 2012

Banks	Actual profit	Label of actual profit	Predicted profit	Label of predicted profit	Error
Melli Bank	8548	Very high 0.487	9240	Very high 0.545	8.09
Sepah Bank	576	Low 0.64	752	Low 0.512	30.5
Saderat Bank	6019	Very high 0.277	6458	Very high 0.313	7.29
Tejarat Bank	8200	Very high 0.458	9210	Very high 0.542	12.31
Mellat Bank	14706	Very high 0.999	14700	Very high 0.999	0
Refah Bank	486	Low 0.978	567	Moderate 0.110	16.66
Post Bank	170	Low 0.006	241	Low 0.225	41.76
Keshavarzi Bank	231	Low 0.194	242	Low 0.228	8.22
Industry and Mine Bank	736	Moderate 0.362	658	Moderate 0.246	10.59
Entrepreneurship Bank	1295	High 0.850	1380	Very high 0.141	6.56
Parsian Bank	7972	Very high 0.439	8690	Very high 0.499	9
Maskan Bank	2752	Very high 0.005	2840	Very high 0.012	3.19
Eghtesad Novin Bank	8200	Very high 0.458	8950	Very high 0.521	9.15

Source: Authors' calculations.

Table 8 shows the results of comparing actual and predicted values of bank profit for 2012. The last column shows numerical error of prediction.

In terms of linguistic labeling system, 12 items of 13 predictions were correct. The only error is about Refah Bank which is 16.66%. It can be said that the system accuracy in linguistic labeling is 92.30%. In terms of numerical prediction error, Post Bank has the most prediction error (41.76%) and Mellat

Bank has the least error (0%). Seven errors were less than 10%. The average of numerical error is 12.56% which is very desirable for a fuzzy system. In order to de-fuzzy, the methods of Centroid, Lom, and Some were used for 7 times, 4 times, and one times respectively. These methods have the least error. All in all, it can be concluded that the developed fuzzy inference system has a desirable performance in predicting bank profitability.

5. Conclusion

The results of this study show that the main effective factors on the bank profitability are facilities, deposits, labor costs, and assets. The findings revealed that there are significant relationships among facilities, deposits, labor costs, assets, and profitability.

The results of Kolomogorov-Smirinof test show the normality of all variables. Our findings show that there is significant correlation among assets, facilities, deposits, manpower costs and level of profitability.

Facilities, deposits, labor costs, and assets have been considered as input of fuzzy inference system and profitability was output of this system. The data were collected from sample banks from 2001 to 2011.

The predicted profitability of many banks has been increased during time and also predicted profitability of private banks was more than that of public banks. The bank of Industry and Mine and Karafarin Bank had the least profitability and Mellat Bank had the most profitability. Finally, Post Bank had the most error and Mellat Bank had the least error.

Based on the data, membership functions and fuzzy inference rules were developed. The findings showed that the system is successful in predicting bank profitability. The percentage of success is 92.30% and its error is 12.56%. Based on the results of this study, it can be said that the developed system is successful in predicting profitability. The results of this study showed that banks can recognize effective factors on their profitability and then utilize this system for predicting their profitability. Such a system also can be used by investors in their decision makings.

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Appendix: The Codes of Fuzzy Inference System

```
 [System]
Name='Seyyedi'
Type='mamdani'
Version=2.0
NumInputs=4
NumOutputs=1
NumRules=125
AndMethod='min'
OrMethod='probor'
ImpMethod='min'
AggMethod='sum'
DefuzzMethod='bisector'

[Input1]
Name='Tashilat'
Range=[0 1543800]
NumMFs=5
MF1='verylow':'trimf', [0 22307 44614]
MF2='Low':'trimf', [22307 90182 124119.5]
MF3='moderate':'trimf', [90182 202805 259116.5]
MF4='high':'trimf', [202805 405248 506469.5]
MF5='veryhigh':'trimf', [405248 1543800 2113076]

[Input2]
Name='Sepordeh'
Range= [0 827903]
NumMFs=5
MF1='verylow':'trimf', [-4380.42328042327 12599.5767195767 29569.5767195767]
MF2='low':'trimf', [16976 59213 80331.5]
MF3='moderate':'trimf', [59213 134955 179223]
MF4='high':'trimf', [134955 223491 267759]
MF5='veryhigh':'trimf', [223491 827903 8430109]
```

[Input3]
Name='HazinehPersonel'
Range= [0 21623]
NumMFs=5
MF1='verylow':'trimf', [0 224 448]
MF2='low':'trimf', [224 495 630.5]
MF3='moderate':'trimf', [495 1461 1994]
MF4='high':'trimf', [1461 4098 5416.5]
MF5='veryhigh':'trimf', [4098 21623 30385.5]

[Input4]
Name='Draee'
Range= [0 1181739]
NumMFs=5
MF1='verylow':'trimf', [0 31417 62834]
MF2='low':'trimf', [31417 90890 120626.5]
MF3='moderate':'trimf', [90890 190336 240059]
MF4='high':'trimf', [190336 335151 407558.5]
MF5='veryhigh':'trimf', [335151 1181739 1605033]

[Output1]
Name='Sod'
Range=[-1546 14706]
NumMFs=5
MF1='verylow':'trimf', [-1546 168 336]
MF2='low':'trimf', [168 493 655.5]
MF3='moderate':'trimf', [493 1165 1501]
MF4='high':'trimf', [1165 2694 3458.5]
MF5='veryhigh':'trimf', [2694 14706 20712]

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