Indian Journal of Science and Technology, Vol 9(28), DOI: 10.17485/ijst/2016/v9i28/98395, July 2016
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Fuzzy Rule based Expert System for Evaluating Defaulter Risk in Banking Sector

Amandeep Kaur, Vishu Madaan, Prateek Agrawal*, Ranjit Kaur and Sanjay Kumar Singh

School of Computer Science Engineering, Lovely Professional University, Phagwara - 144411, Punjab, India;
grewala91@gmail.com, vishumadaan123@gmail.com, prateek061186@gmail.com,
reetbansal09@gmail.com, sanjayksingh.012@gmail.com

Abstract

Background/Objectives: Banking sector faced many problems like credit assessment, credit worthiness, and credit risk etc. Many techniques are used to solve these problems in artificial intelligence. But these problems are not fully resolved in previous years. **Methods/Statistical Analysis**: One of the most important problems is credit risk as customer defaulter risk. Recent studies have not discussed about defaulter or non-defaulter customer. This research work has discussed about customer's defaulter risk as well as credit risk. **Findings:** A fuzzy expert system has been designed which can categorized customer as defaulter and non- defaulter. The defaulter risk is calculated by considering factors as CS (CIBIL Score), LVR (Loan to Value Ratio), AAL (Already Availed Loan), IRF (Income Ratio Factor). Data of customers are collected from Indian Overseas Bank (IOB) branches. Different defuzzification methods are used to verify the result of customers. It also verified by the expert in banking domain. Further it is also tested on the data of other branches of banks. **Application/ Improvements:** The system can be helpful for the bank employees in decision making process. In addition to this the system can be used for training new employee for loan approval tasks.

Keywords: Banking Sector, Credit Risk, Defaulter, Fuzzy Expert System, Intelligent System

1. Introduction

Bank is a commercial institution. It accepts money from public for the purpose of lending and investment. It provides various services like lending loans, public money deposit, credit and debit card, electronic fund transfer like fix deposit, NEFT (National Electronic Fund Transfer), RTGS (Real Time Growth Settlement), Demand Draft (DD), loans, lockers and many more. In day to day transactions banks play a very important role. Banking system is the mechanism of stock exchanging in world[1].

Lending loan to anyone could be a risky activity for the banks. Therefore there should be an appropriate method through which the risk of lending loan to any individual can be evaluated. In credit assessment of customers number of factor are considered like sex, age, education, marital status, career, no return check, deposit account, deposit period (month), average salary[2].

The main reasons of defaulters are:

- Vulnerability in credit-risk assessment by the bank and they have accepted the loan application[3]. These problems faced by the decision maker are due to the fact that a large number of parameters should be considered with different weight for different cases.
- Don't have enough knowledge about each and every aspect that affects the credit decision.
- The main reason of financial failure is the lack of experts in banking domain[4].

To overcome these problems various expert systems are now available in world which can help in taking a decision about credit assessments.

This research work includes those factors which could help in evaluating defaulter risk of the customer taking loans from the banks. These factors are CS (CIBIL Score),

*Author for correspondence

LVR (Loan to Value Ratio), IRF (Income Ratio Factors), AAL (Already Availed Loan) are shown in Table 1.

2. Research Methodology

Fuzzy expert system is an expert system that uses a grouping of fuzzy membership function and rules instead of Boolean logic. Fuzzy expert system is also called knowledge based or rule based system[5]. In this proposed system fuzzy logic toolbox of MATLAB has been used to implement the system[6].

The first step to start with development of fuzzy expert system is to convert real values into fuzzy values after which the membership function are selected, rule base is created, and inference system is generated[7]. Last step of the development is to convert fuzzy values to real or crisp values. The general process of developing fuzzy expert system is shown in Figure 1[8]. It describes the various stages in detail and also shows how the steps are followed to build a fuzzy expert system.

2.1 Data Collection and Factors Identification

This step includes the collection of data of customers from various branches of the Indian Overseas Bank which could help to evaluate the defaulter risk of a customer. Table 2 shows the acquired data which includes the values for various factors such as Loan to Value Ratio (LVR), Annual Income, EMI, CIBIL Score (CS) and Already Availed Loan (AAL). These factors act as the input to the fuzzy expert system and output will be defaulter risk. The ranges for membership functions for these input variables

Table 1. Main Factor that affects credit decision

FACTORS	What It Is?
CV(CIBIL Score)	It represents the score before granting any loan.
IRF(Income Ratio Factor)	It includes annual income, EMI, AAL of customers. It helps to describes customers able to repay the amount what they want from banks.
LVR(Loan To Value Ratio)	It represents the amount which is decided after ready to accept loan application.
AAL(Already Availed Loan)	It represents the amount of availed loan.

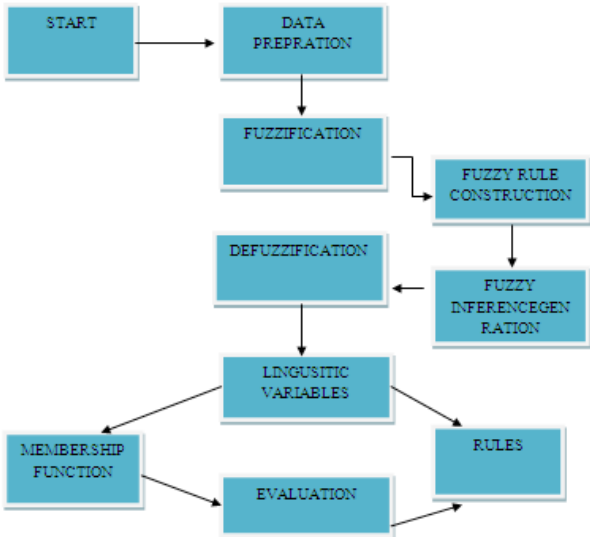

Figure 1. Process of developing fuzzy expert system.

Table 2. Collected data of an IOB branch's customer

LVR(%)	ANNUAL INCOME	EMI	CS	AAL
48	820300	6525	760	Nill
73	470000	16069	706	Nill
26	578000	10777	740	Nill
78	522000	21596	753	Nill
74	1214387	17670	not avail	Nill
57	260000	6540	737	Nill
80	219710	6888	Nill	Nill
50	290000	6888	Nill	Nill
60	130000	5342	Nill	Nill
80	100000	4150	739	Nill
77	591000	10900	675	1100000
80	1098000	20031	697	400000

are also decided by taking into consideration the collected data of the customers.

The meaning of all the main factors such as CV (CIBIL Score), LVR (Loan to Value Ratio) and AAL (Already Availed Loan) and IRF (Income Risk Factor) are described as follows:

- **CS (CIBIL Score):** CIBIL Score of the customer is calculated before accepting any loan application. Its range is from 300 to 900. It includes various factors like customer personal information, identity proof, AAL (Already Availed Loan), and credit history. If a customer have no credit record availed then the value of CS is -1.

- **IRF (Income Ratio Factor)**: It includes annual income, EMI, AAL of the customers. It helps to describe whether the customers are able to repay the amount they want to borrow from the banks. The banking norm says that if a person is having 50% of the income which can covers all the EMIs, then they can take the loan from banks. This is explained through the following equation Equation (1).

$$EMI < \frac{annual\ income}{2} - AAL \quad (1)$$

The Income Ratio factor can then be calculated through the following equation Equation (2).

$$INCOME\ RISK\ FACTOR = \frac{EMI}{\left(\frac{annual\ income}{2} - AAL\right)} * 100 \quad (2)$$

- **LVR (Loan to Value Ratio):** It represents the amounts that are received by customer from banks after accepting any loan application. LVR can be calculated as shown in Equation (3).

$$LVR = \frac{Mortgage\ amount}{Appraised\ value\ of\ property} \quad (3)$$

- **AAL (Already Availed Loan):** AAL (Already Availed Loan) represents the amount of availed loan. It shows availed loan history in CIBIL score. In other words, it shows remaining total amount of all loans.

Table 3 shows the computed values of Income Risk Factor (IRF) factor taking into consideration the Already Availed Loan, EMI and Annual Income of the customer as explained in Equation (2).

Table 3. Computed values of IRF based on other factors

LVR (%)	ANNUAL INCOME	EMI	CS	AAL	AAL(%)	IRF
77	591000	10900	675	1100000	75	3.689
80	1098000	20031	697	400000	82	3.649
80	360000	17800	812	325000	66	9.8925
60	700000	10673	701	750000	87	2.965
74	619000	12274	731	808000	78	3.966
85	513000	6270	793	600000	55	2.444
78	302000	7646	794	303800	45	5.065
55	336000	10290	763	203000	40	6.096
85	102000	1385	773	62866	20	2.716

2.2 Fuzzification

Fuzzification is the technique of transforming crisp values into fuzzy values[9]. Each input variable have 3 triangular membership functions as well as 3 triangular membership functions for output variable. The membership functions of input variables and output variables are in Table 4.

The overlapping regions created by membership functions represents the fuzziness in the input variables as well as in the output variables[10]. Figure 2 shows the membership functions and their overlapping for LVR (Loan to Value Ratio) factor.

2.3 Fuzzy Rule Construction

After fuzzification next step is construction of rules. Rules help in taking decision according to different input values. The rules for evaluating defaulter risk are in IF-THEN format as shown below.

Table 4. Fuzzy linguistic variables and their fuzzy elements

Linguistic Variables Values		LOW	MEDIUM	HIGH
INPUTS	CS	0-300	300-700	600-900
	IRF	-10-0	-3-6	3-10
	LVR	45-65	60-80	73-90
	AAL	0-40	30-70	60-100
OUTPUT	D_RISK	1-4.5	3.5-7.5	6.5-10

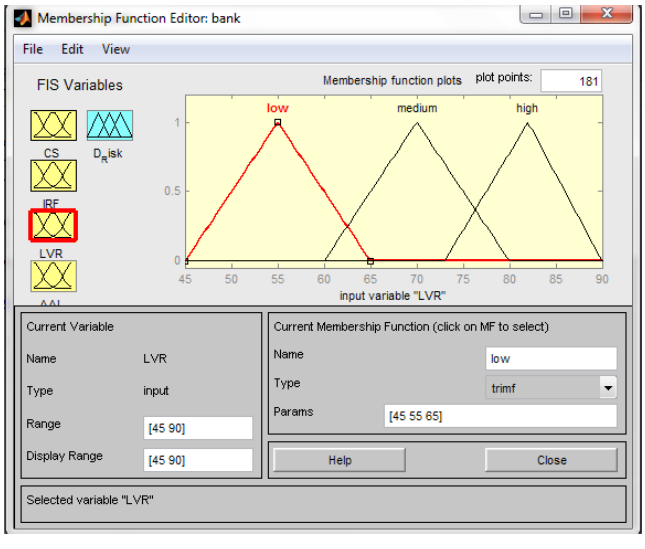

Figure 2. Membership functions of LVR (Loan to Value Ratio).

IF (condition1 AND condition2) THEN (action)

The input is described by IF part and the THEN described output of the system. The proposed system has 84 rules which are constructed with the guidance of IOB bank's expert. Some IF-THEN rules of the system are shown below:

- IF (CS is low) AND (IRF is low) AND (LVR is low) AND (AAL is low) THEN (D_Risk is medium).
- IF (CS is low) AND (IRF is low) AND (LVR is low) AND (AAL is medium) THEN (D_Risk is high).

2.4 Fuzzy Inference Process

The proposed system uses Mamdani Fuzzy Inference System to develop the system. The Mamdani Inference System for the proposed system is shown in Figure 3 which deal with 4 inputs variable CIBIL Score (CS), LVR (Loan to Value Ratio), IRF (Income Risk Factor), AAL (Already Availed Loan) and 1 output named as D_risk (Defaulter Risk). It shows selected input CIBIL score and its other related detail about CIBIL score. The 84 fuzzy rules for evaluating the defaulter risk are shown in Figure 4. The surface view of fuzzy rules having two input variables CS and IRF and one output variable D_Risk is shown in Figure 5.

2.5. Defuzzification

The proposed system is defuzzified to check the correctness of results. The proposed system is defuzzified using centroid defuzzification technique. In this proposed system different input values are taken and its corresponding outputs are recorded using all the built in defuzzification methods of MATLAB such ascentroid, bisector, LOM, SOM and MOM[11]. After obtaining the output values using different defuzzification techniques, these output values are given rank[13]. These ranks are compared to check the accuracy of the system[12]. The Table 5 shows defuzzified values and their corresponding ranks.

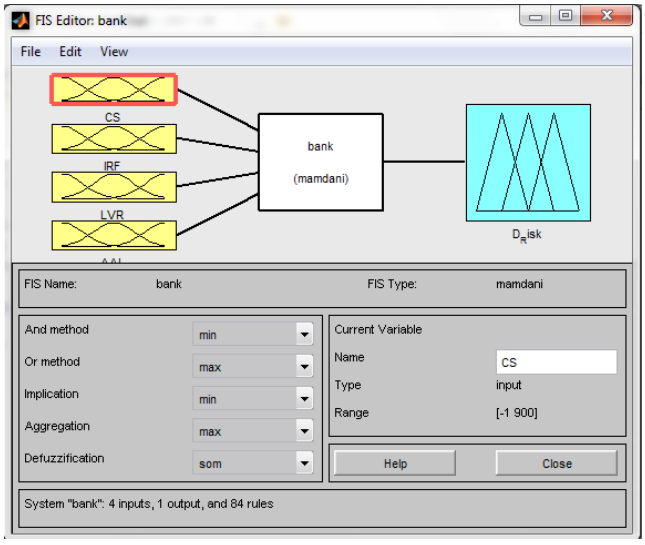

Figure 3. Mamdani inference system.

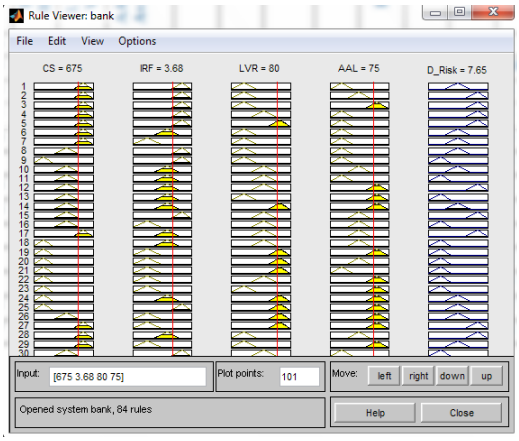

Figure 4. Fuzzy rules and inference process.

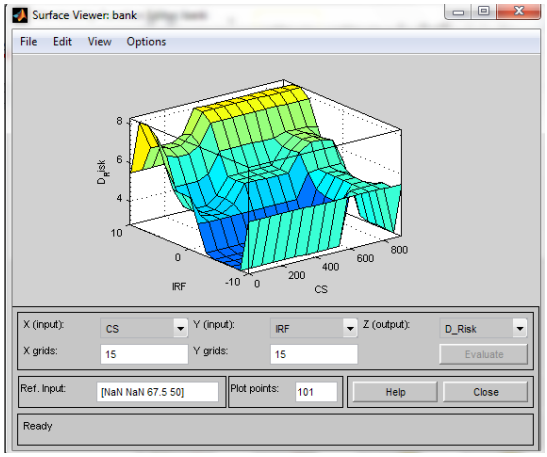

Figure 5. Surface viewer of the rules.

3. User Interface

A graphical user interface is a form of interface between user and computer system[14]. The users interact with GUI through icons, symbols, images. A non-professional person can easily use the graphical user interface.

Table 5. Defuzzified values and their ranks

Inputs				Defuzzification and ranking									
CS(CIBIL Score)	IRF(Income Ratio Factor)	LVR(Loan to Value Ratio)	AAL(Already Availed Loan)	LOM	Ranks	MOM	Ranks	BISECTOR	Ranks	CENTROIDE	Ranks	SOM	Ranks
706	5.59	85	62	9.01	**10**	8.38	**8**	8.29	**8**	8.32	**9**	7.75	**9**
650	5	65	35	6.1	**6**	6.58	**6**	8.38	**9**	9.19	**10**	7.57	**7**
550	2	70	50	5.5	**5**	5.5	**5**	5.5	**4**	5.5	**4**	5.5	**6**
700	4.5	72	55	9.37	**11**	6.83	**7**	6.76	**6**	6.79	**6**	4.33	**5**
300	-1	75	65	6.67	**7**	5.5	**5**	5.59	**5**	5.59	**5**	4.33	**5**
-1	-2	80	75	3.88	**4**	2.84	**1**	3.61	**3**	4.77	**3**	1.81	**1**
300	-3	78	65	3.61	**3**	2.89	**2**	2.8	**1**	2.81	**1**	2.17	**2**
200	-4	84	80	3.34	**2**	2.93	**3**	2.8	**1**	2.83	**2**	2.53	**3**
-1	7	56	0	3.07	**1**	2.98	**4**	2.89	**2**	2.83	**2**	2.89	**4**
-1	2	70	0	5.5	**5**	2.98	**4**	2.89	**2**	2.83	**2**	5.5	**6**
-1	6	84	0	8.43	**8**	8.83	**10**	8.38	**9**	8.32	**9**	8.02	**10**
675	3.68	80	75	9.1	**9**	8.38	**8**	8.02	**7**	7.65	**7**	7.66	**8**
697	3.64	80	82	9.1	**9**	8.43	**9**	8.29	**8**	8.21	**8**	7.75	**9**

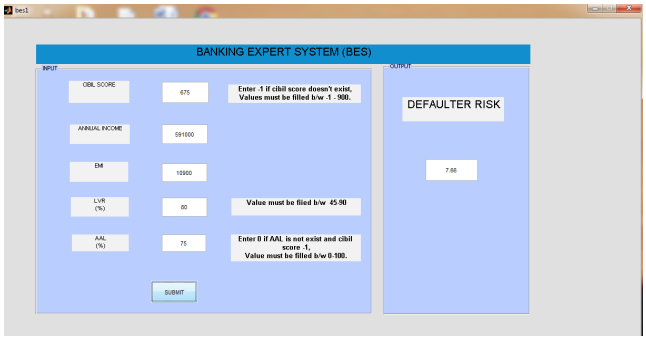

Figure 6. Graphical User Interface (GUI).

A user interface has been developed for the proposed expert system shown in Figure 6. It shows 5 inputs as CIBIL score (CS), annual income, EMI, Already Availed Loan (AAL) and LVR. The user needs to fill all these input values. The inputvalues of annual income and EMI are used to find out the IRF (Income Risk Factor). These input factors are passed to the Fuzzy Inference System (FIS) which calculates the defaulter risks based on the rules. The computed value of defaulter risk is then shown on the user interface.

Table 6. Comparison of the outputs given by the expert system and domain expert

CUSTOMER NAME	INPUT FACTORS				OUTPUT BY BANK'S EXPERT	OUTPUT BY BANKING EXPERT SYSTEM (BES)	RESULT
	CS	IRF	LVR	AAL			
C1	**675**	**3.68**	**77**	**75**	**High**	**7.39**	**True**
C2	**697**	**3.64**	**80**	**82**	**High**	**7.75**	**True**
C3	**776**	**-2**	**77**	**0**	**High**	**7.39**	**True**
C4	**729**	**3.86**	**53**	**47**	**High**	**2.08**	**False**
C5	**-1**	**7**	**55**	**0**	**Low**	**2.8**	**True**
C6	**793**	**2.44**	**85**	**55**	**High**	**7.75**	**True**
C7	**812**	**9.89**	**80**	**66**	**High**	**6.58**	**True**
C8	**773**	**2.71**	**85**	**20**	**High**	**7.75**	**True**

4. Testing of the System

Data of the customers has been collected from Indian Overseas Bank (IOB) branches for testing purpose.

These real data values helped in checking accuracy of the proposed system. These acquired values for all the input factors are given to the developed expert system and the computed defaluter risks are recorded. Defaulter risk for same set of values are also determined by consulting the domain expert. Both the result obtained from the the developed system and the domain expert are compared for validation of the systemas shown in Table 6.

5. Discussion and Conclusion

The proposed rule based fuzzy expert system is developed to classify customers into defaulter and non-defaulter groups. This system not only checks whether the person would be defaulter or not but it also calculates the risk of assigning loan to a person. This research work includes the factors such as EMI, CS, LVR, AAL, IRF and Annual Income which was not considered in previous studies. A user interface is also developed for the user so that it could be easy for the user who doesn't have any knowledge of Expert Systems to use the system. The proposed system can help the bank employees in decision making process. Also the system can be used for training new employee for loan approval tasks.

This research work can further be extended by considering more factors for evaluating the defaulter risk. Also this system could be developed using Neuro-Fuzzy technique.

6. Acknowledgements

The authors want to acknowledge the expert Mr. Dhrampal Acharya who works as credit officer at IOB branch, Ludhiana, Punjab, India for his support during the development and testing of the Expert System.

7. References

1. Celtek C, Vipul K, Gupta G. A fuzzy expert system for small business loan. J Int Inf Manag. 2001; 10(1):17–30.
2. Bazmara A, Donighi SS. Classification of Bank Customers for Granting Banking Facility Using Fuzzy Expert System Based on Rules Extracted from the Banking Data. J Basic Appl Sci Res. 2013; 3(12):379–84.
3. Paradi JC, Zhu H. A survey on bank branch efficiency and performance research with data envelopment analysis. Omega. 2013; 41(1):61–79.
4. Kaur EN, Navleen E, Rekhi S, Nayyar A. Review of expert systems based on fuzzy logic. Int J Adv Res Comput Commun Eng. 2013; 2(3):1334–9.
5. Bazmara A, Donighi SS. Bank customer credit scoring by using fuzzy expert system. Int J Intell Syst Appl. 2014; 6(11):29–35.
6. Pourdarab S, Nadali A, Nosratabadi HE. A hybrid method for credit risk assessment of bank customers. Int J Trade, Econ Financ. 2011; 2(2):125–30.
7. Mahmoud M, Algadi N, Ali A. Expert system for banking credit decision. Computer International Conference on Science and Information Technology (ICSIT'15); 2015. p. 813–9.
8. Pourdarab S, Nosratabadi HE, Nadali A. Determining the blend knowledge management strategy by a fuzzy expert system. IJIMT. 2012; 3(5):507–11.
9. Naaz S, Alam A, Biswas R. Effect of different defuzzification methods in a fuzzy based load balancing application. IJCSI. 2011; 8(5):261–7.
10. Nosratabadi HE, Nadali A. Credit assessment of bank customers by a fuzzy expert system based on rules extracted from association rules. International Journal of Machine Learning and Computing. 2011; 2(1):261–5.
11. Itoo RA, Selvarasu A. Case study of consumer credit scoring: A proposal. Int J Recent Sci Res. 2015; 6(4):3627–41.
12. Vishu, Agrawal Prateek, Singh Sanjay K, Jain Leena. Fuzzy rule based expert system to automate university examination grading. International Conference on Computing Sciences. ICCS; 2013. p. 285–305.
13. Prateek A, Madan V, Kumar V. Fuzzy rule-based medical expert system to identify the disorders of eyes , ENT and liver. International Journal of Advanced Intelligence Paradigm. 2015; 7(3/4):352–67.
14. Garibaldi JM. Fuzzy expert systems. Res Gr Sch Comput Sci IT; 1991. p. 1–27.