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# CREDIT RISK EVALUATION USING KNOWLEDGE MINING

**SREEKANTHA D.K.[1]* AND KULKARNI R.V.[2]**
[1]PG Department of Computer Science, Basaveshwar Science College, Bagalkot- 587101, Karnataka, India.
[2]Department of Statistics and QT, SIBER, Kolhapur- 416004, MS, India.
*Corresponding Author: Email- sreekantha.desai@gmail.com

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**Abstract-** The Micro, Small and Medium scale Enterprises (MSME) segment is one of the fastest growing industrial segment all over the world. The researchers estimate that about 60% of the MSME credit is provided by commercial banks alone. Over the past decade, the credit risk evaluation of MSME by banks and financial institutions has been an active area of research under the joint pressure of regulators and shareholders. The mathematical models of risk evaluation are at the core of modern credit risk management systems. This paper focuses on the design of expert system model for credit risk evaluation by mining the knowledge bank of Credit Rating Experts. This expert system is named as Credit Risk Evaluation Expert System (CREES). This Expert System performance resembles human expert credit risk executives thought process in decision making. CREES uses soft computing technique called Evolutionary Neuro Fuzzy logic. Authors have designed a Credit Rating Framework (CRF) comprising a large number of risk parameters parameters such as financial, business, industry and management lines. Authors have tested CREES on the selected sample data. The results obtained from CREES are compared with manual decisions to evaluate its accuracy. CREES needs to be tested using international standard German and Australian credit data sets.

**Keywords-** MSME, CreditRisk, FuzzyJess, CreditRatingFramework, ExpertSystem, NeuroFuzzyLogic

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## Introduction

The Micro, Small and Medium scale Enterprises (MSME) segment constitutes over 90% of total enterprises in most of the economies of the world. MSME client needs financial assistance to run their business operations and approach banks for credit. At present a team of credit rating executives in banks and financial institutions are assessing the credit worthiness of the MSME client manually. Each bank adopts a separate credit rating procedure and disclosure requirements for sanctioning loans.

MSME clients find themselves spending a significant amount of time and effort while approaching the various banks for credit. A MSME client always has more private information about the risk in his proposal, so that when a client comes with a loan request, the banks have no way to judge its risk extent from the facts in the loan documents. This is the direct reason leading to credit risk for the banks and becomes the crux of the problem for the banks. An incorrect credit decision endangers bank's financial capability ending up in steep decline in the margin of profits. The goal of credit risk management is to maximize a bank's risk-adjusted rate of return by maintaining credit risk exposure within acceptable limits.

The effective management of credit risk is a critical component of risk management and essential to the long term success of any bank or lending organization.

### Outlook of Industry

MSME Manufacturing sector accounts for 30-50% of GDP and drives the economies of Asian countries such as Thailand, Indonesia, Malaysia, Singapore, Hong Kong, Taiwan, Philippines, Korea and China. China's manufacturing segment contributes to 50% of GDP, but India is lagging behind china by 25% share of GDP. The present conditions in India do not promote manufacturing.

MSME segment has been the second largest employer after agriculture in all Asian countries. MSME segment makes up over 80-90% of all enterprises, provide over 60% of the private sector jobs, generate over 30-40% of total employment, contributes about 50% of sales or value added and share about 30% of direct total exports. Availability of timely and adequate credit is the lifeline for MSME segment. The quick results of 4$^{th}$ all India census of MSME (2006-07) reveals that the sickness in MSME has increased from 13.98% in 2001-02 to 14.47% in 2006-07, one of the reasons for sickness is the shortage of working capital.

The main reasons for the financial constraints faced by MSME are quite generic and high on the list is the perception that MSME are historically a high risk group lacking in financial discipline and unable to provide trustworthy financial track records. The President of Federation of Indian Export Organizations (FIEO) A Sakthivel pointed out that Interest rates in India are much above the international benchmark.

**Present Status of Credit Risk Management**

The manual credit risk evaluation systems are quite expensive and very difficult to maintain. It involves a high cost for keeping the qualified, experienced and trained credit rating executives for this purpose. Research has shown that human brain is capable of evaluating only a small number of factors at a time, but the credit risk analyst is expected to analyze many types of parameters to arrive at a proper decision with in a shortest possible time.

**Survey of Credit Risk Literature**

The author's present work comprises an exhaustive survey of relevant literature of about 250 most relevant articles on credit risk evaluation from leading international journals with good impact factor such as IEEE Transactions on Credit Risk, Machine intelligence, Business Research journals and proceedings of various symposiums. Some selected recent articles from the survey are discussed by way of illustration.

Paul F Smith [1] Credit risk evaluation initially started with a relatively simple statistical method for measuring risk on individual accounts. This simple statistical model can also be used for measuring, controlling portfolio quality and for estimating loss rates.

Rekha Jain [2] MARBLE- (Managing and Recommending Business Loan Evaluations) is a loan evaluating expert system (Shaw and Gentry, 1988). MARBLE combines financial projections with qualitative data. The loan granting decision is a combination of factors related to an analysis of the firm's historical, financial and qualitative information about its product market, industry characteristics and overall performance of the management.

A.G. Williamson [3] Simulated genetic process is used to automate the configuration and training of a back propagation trained multilayer perceptron network for credit application vetting. The network was trained on past loan data and used to classify the suitability of issuing credit on new loan applications.

Kasper Rozsbach [4] A Tobit model with sample selection and variable censoring thresholds has been constructed for estimation. This model was useful to predict the expected survival time on loan on any kind of applicant.

Sushmita Mitra [5] has conducted exhaustive survey of neuro fuzzy rule generation algorithms. This neuro fuzzy approach, symbiotically combines the merits of connectionist, fuzzy approaches and constitutes a key component of soft computing at this stage. Authors have applied a unified soft computing framework and included rule extraction, rule refinement in a broader perspective of rule generation. Authors study found application in medical diagnosis.

Markus Kern/Bernd Rudolph [6] has conducted a study on comparison of various credit risk models especially with regard to their applicability on typical middle market loan portfolios in Germany. The difference in the result on a certain loan portfolio is mainly due to different approaches in approximating default correlations. Rodrigo Canales and Ramana Nanda from Harvard business school have studied the relationship between the organizational structure of banks and the terms of lending to small businesses. They found that banks are more likely to restrict credit and charge higher interests rates when they have market power, more so to smaller firms that has fewer outside options for external finance.

D.K. Sreekantha and R.V. Kulkarni [7] have published the article Industrial Loan Processing Using Neuro Fuzzy Logic. They have designed a credit rating framework for manufacturing sector of SSI (Small Scale Industries) by organizing the five risk areas such as Technical Feasibility, Management Commitment, Commercial Variability, Financial Analysis and Economic Analysis. Authors have used fuzzy logic to capture the domain expert knowledge and assigned the standard weights to each of these risk parameters. The client's score is evaluated against these standard scores. This client score is used in determining the client risk rating, which ranges from AAA-Highest Safety to D-Default. Authors have described the process of computing the credit worthiness with a typical client example.

Shaomei Yang and Junyan Zhao [8] have studied commercial banks credit risk based on CAMEL rating system and identified five areas of risk such as Capital adequacy, Asset quality, Management ability, Earnings and Liquidity. The initials of five words form the term CAMEL. CAMEL rating system is used for the assessment of commercial banks credit rating system.

R.C. Chakraborty [9] authored Hybrid Systems Integration of Neural network, Fuzzy logic and Genetic algorithm discussed the characteristics of hybrid systems employing fuzzy logic, neural networks and genetic algorithms. Hybridization of technologies can have pitfalls and therefore needs to be done with care. Authors suggested that if one technology only solves the problem, hybrid technology ought to be used if it provides better solution. There are two types of hybrid systems one is sequential hybrid system and auxiliary hybrid system.

Shorouq Fathi Eletter, Saad Ghaleb Yaseen and Ghaleb Awad Elrefae [10] have proposed a model that identifies artificial neural network as an enabling tool for evaluating credit applications to support loan decisions in the Jordanian commercial banks. A multilayer feed-forward neural network with back propagation learning algorithm was used to build up the proposed model. Their study covers different representative cases of loan applications based on the guidelines of different banks in Jordan, to validate the neural network model. The results indicate that artificial neural networks are a successful technology that can be used in loan application evaluation in the Jordanian commercial banks.

Amir E. Khandani, Adlar J. Kim and Andrew W. Lo [11] have applied machine-learning techniques in their paper Consumer Credit Risk Models via Machine-Learning Algorithms. Authors have constructed non linear, non parametric forecasting models of consumer credit risk by combining sample customer transactions from credit bureau data from January 2005 to April 2009 from major commercial banks. They are able to construct out-of-sample forecasts that significantly improve the classification rates of credit-card -holder delinquencies and defaults, with linear regression $R^2$'s of forecasted/realized delinquencies of 85%. Authors have developed a machine-learning model for consumer credit default and delinquency that is surprisingly accurate in forecasting credit default events 3 to12 months in advance.

Adel Lahsasna, Raja Noor Ainon and Teh Ying Wah [12] have discussed Credit Scoring Models using Soft Computing Methods Neural networks, Genetic algorithms and Support vector machines. Authors claim that their methods are most accurate methods as compared to other methods. The classification accuracy is the key determinant of success in financial lending industry. Author's study has shown the benefits of using hybrid methods to overcome some limitations of single methods by using fuzzy system, artificial methods like neural networks, genetic algorithms. Hybridization of fuzzy logic, neural networks and genetic algorithms has led to creation of a perspective scientific trend known as soft computing. Neural networks mimic the ability to adapt to circumstances and learn from past experiences. Fuzzy logic addresses the imprecision or vagueness in input and output. Genetic algorithms are inspired by biological evolution, can systemize random search and reach to optimum characteristics.

D.K. Sreekantha and Kulkarni [13] in their paper have discussed the expert system design model for credit risk evaluation. They have used Expert System Builder tool to demonstrate the workability of their expert system design. They have also authored an article A Survey of Credit Risk Assessment Techniques [14].

### The Problem Description- Credit Risk Evaluation

Authors aim at designing an expert system solution that resembles that credit rating executive's thought process in credit risk evaluation. This paper discusses a hybrid soft computing technique called evolutionary neuro fuzzy logic for implementing an expert system. The system is called Credit Risk Evaluation Expert System (CREES) developed in Fuzzy Jess Platform.

MSME segment has been classified in to three major sectors like Manufacturing, Trading and Service. The risk parameters and risk assessment procedure for each of the sectors are different.

### Credit Rating Framework

Authors have designed a Credit Rating Framework (CRF) by mining the knowledgebase of credit rating experts and documentation, procedures and guidelines from controlling authorities. The CRF incorporates and organizes the hundreds of credit risk decision parameters in various hierarchical levels. Each decision parameter is assigned with a weighed score based its significance in credit risk decision making context. The risk parameters for each sector are different, so a separate CRF needs has been designed for each sector. The CRF structure and contents varies based on the size of the business like Micro, Small and Medium scale. The major decision parameters in manufacturing sector of small scale industry and their relative weights are shown in [Fig-1]. The Technical Feasibility parameter of Manufacturing sector takes 40% of total weightage and remaining three constitutes to 60%.

The credit risk parameters of trading sector for small scale industry are shown in [Fig-2]. The finance risk is assigned highest 40% weightage, Business Risk is 33% and Management risk is assigned remaining 27%.

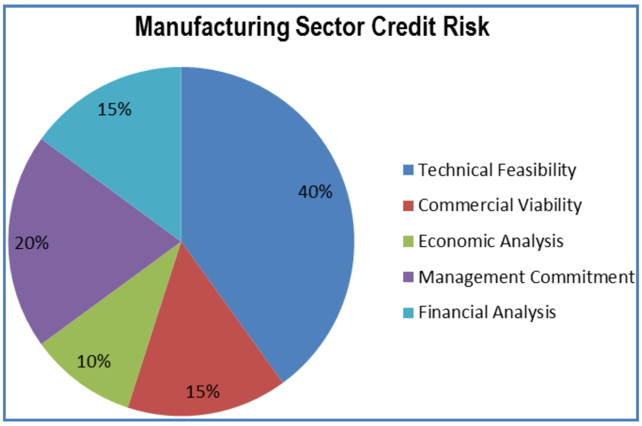


**Fig. 1-** Manufacturing Sector Credit Risk Parameters

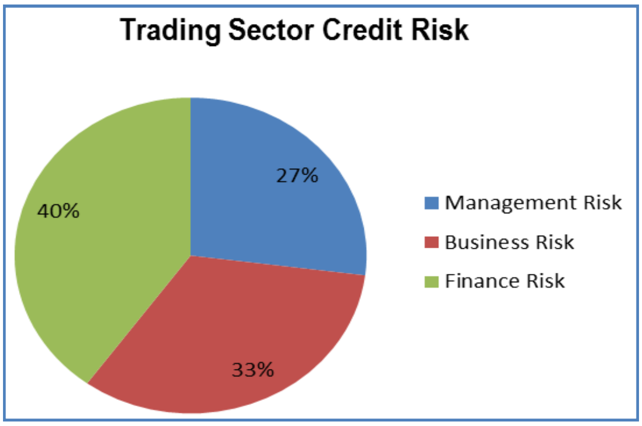


**Fig. 2-** Trading Sector Credit Risk Parameters

The risk parameters for service sector are very much service specific. The healthcare industry risk parameters are different from hotel industry, Training and Consultancy services. Authors are worked on healthcare and Hotel services and designed credit rating frameworks for credit risk assessment.

### Proposed CREES Model

The expert systems represent an opportunity to assist users lacking expertise in a specific area to carry out complex tasks, promote efficient governance and enable sustainable decision-making in developing regions

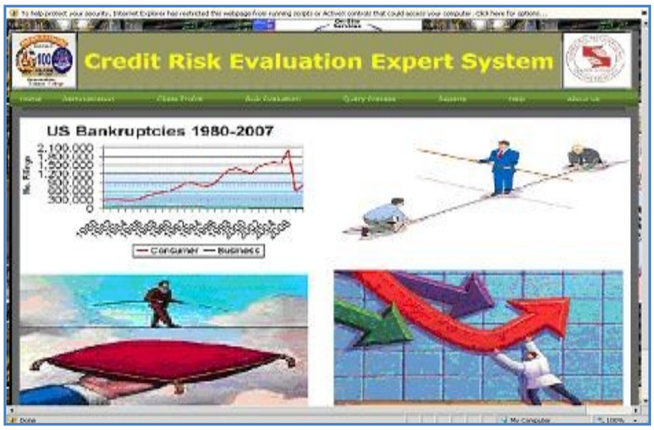


**Fig. 3-** The desktop of CRESS system

The CREES expert system has been developed and implemented using dream viewer, eclipse and fuzzy jess tools. [Fig-3] shows the desktop of CREES.

CREES provides the data entry screens to enter the data from client's credit loan application forms and supporting documents. [Fig-4] shows sample data entry screens for risk parameter loan purpose assessment.


**Fig. 4-** Data entry screen for loan purpose parameter

[Fig-5] show the sample data entry screens for risk parameter cash flow assessment of the client


**Fig. 5-** Data entry for cash flow assessment

CREES menu based system designed be used to enter the client's data for any size and any sector client.

**Proposed Expert System Architecture**

CREES Expert system architecture model is shown in [Fig-6]. The system is implemented using Fuzzy Jess (Java Expert System Tool). The Expert system prototype consists of four major components such as Language interface, Knowledgebases, Inference machine and Explanation facility.

**User Interface**: It is used for designing, creating, updating and using expert systems. The overall purpose of the user interface is to make the development and use of an expert system easier for users and decision makers.

**Current Client Database:** It stores the facts/data collected from various sources about the clients currently doing business with the bank.

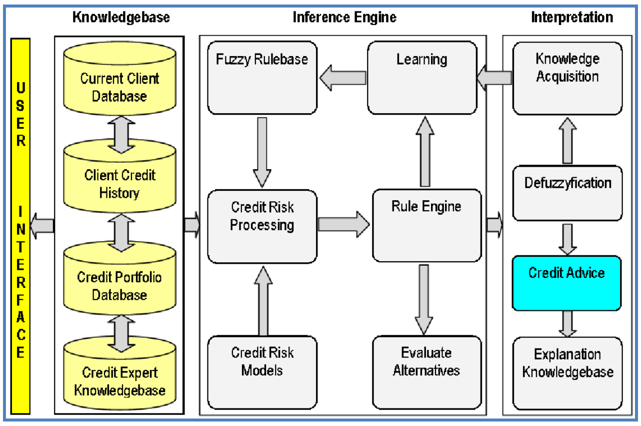


**Fig. 6-** CREES architecture model

**Client Credit History Database:** It stores all the credit history/ Account behavior of the clients and their credit performance for extending the credit facility.

**Credit Experts Knowledgebase:** It accumulates the knowledge of a team of human credit rating experts and stores all relevant information, data, rules, cases and relationships to be used by the expert system.

**Credit Portfolio Knowledgebase:** The various types of risks, which banks face in the credit domain, do not necessarily reside in a single transaction; rather, it is in the portfolio. It is odd that even today most credit risk analysis is based on a transaction rather than portfolio. It stores the all the information about the various portfolios of business. This will help in taking credit decision of the client business portfolio.

**Inference Engine:** This unit seeks information and relationships from the knowledgebase and provide answers, predictions, suggestions the way a human expert would thinks and decide. The inference engine must find the right facts, interpretations, rules and assemble them correctly.

**Knowledge Acquisition Facility:** The overall purpose of the knowledge acquisition facility is to provide a convenient and efficient means for capturing and storing all components of the knowledgebase.

**Credit Processing Block:** It evaluates the credit worthiness of the client using credit rating framework. The computation of credit risk uses the client credit history accumulated from previous experiences and relevant client references.

**Credit Rating Models Knowledgebase:** It is the warehouse of credit rating models applicable to various MSME clients.

**Fuzzy Inference Engine:** It evaluates the client's numerical data in terms of fuzzy linguistic variables and grades the client as Best, Good Average and Poor.

**Credit Advising Block:** This block interprets the credit rating ranging from AAA, AA to D in to Highest Safety, Significant Safety and High Risk to Default.

**Learning Block:** It records the new facts, relationships and trends needed for future evaluation and also updates the knowledgebases.

### Rulebase Design

A separate fuzzy rulebase has been developed for every major risk such as management risk, business risk and finance risk in the credit rating framework to facilitate change of rules easily. [Table-1] shows some sample rules randomly selected from a set of 300 rules developed for manufacturing sector.

*Table 1- Samples Rules for Manufacturing Sector*

| Management Sector Assessment Rulebase | | |
|---|---|---|
| Rule No | IF Antecedent | Then Consequent |
| 4 | Technical Feasibility is OK *AND*<br>Management Commitment is Excellent *AND*<br>Commercial Viability is Excellent *AND*<br>Financial Analysis is Excellent *AND*<br>Economic Analysis is Excellent | Technical Feasibility is *Good* |
| 37 | Connected Power Load is Extra *AND*<br>Contracted Power load is Extra *AND*<br>Cost per Unit is Sufficient *AND*<br>EB Deposit is *AND* Available *AND*<br>Stand by power is Not Required | Power Resources are *Good* |
| 65 | Integrity is Good *AND*<br>Involvement is Good *AND*<br>Financial Resources is excellent *AND*<br>Competence is Good *AND*<br>Leadership is Good *AND*<br>Organization Structure is Good | Management Commitment is *Good* |

[Table-2] shows sample rules randomly selected from a set of 250 rules for Trading sector.

*Table 2- Rules for Trading Sector*

| Trading Sector Assessment Rulebase | | |
|---|---|---|
| Rule No | IF Antecedent | Then Consequent |
| 9 | Competition is Good *AND*<br>Locational Advantage is Good *AND*<br>Commodities Traded is Good *AND*<br>Industry Profile is Good *AND*<br>Market Perception is Good | Business is the *Good*<br>Business Risk is *Minimum* |
| 37 | Interest Repayment is Excellent *AND*<br>No Transgressions in Account *AND*<br>Compliance of Sanction terms is Excellent *AND*<br>Turnover in Account is Excellent *AND*<br>Cheque/Bill Return is Excellent *AND*<br>Operation in Account is Excellent | Account behavior and Track Record is *Excellent* |
| 113 | Consistent growth in profit and sales for past three to five years | Earnings/ Growth trends are *Excellent* |

The Expert system analyses the client data using information from knowledgebases and CRF. Clients are classified credit worthy or not. Client's credit worthiness categories and the Standard Credit Ratings are shown in [Table-3].

*Table 3- Standard Credit Ratings*

| Credit Rate | Risk Level | Weight | Weight in % |
|---|---|---|---|
| AAA | Highest Safety | WAAA | >=95<100 |
| AA | High Safety | WAA | >=85< 95 |
| A | Adequate Safety | WA | >=80< 85 |
| BBB | Moderate Safety | WBBB | >=70< 79 |
| BB | Inadequate Safety | WBB | >=60< 70 |
| B | Substantial Risk | WB | >=55< 60 |
| C | High Risk | WC | >=50< 55 |
| D | Default | WD | < 50 |

### Results and Discussion

Authors have tested the expert system software using selected 500 real time samples with different credit ratings from banks and results are tabulated as shown in [Table-4], [Fig-7]. The results obtained from this CREES and the manual decisions are agreeing in many of the cases. The percentage of clients misjudged by the CREES is only (22/500)*100 =4.4%.

*Table 4- Results Comparison*

| S No | Client Risk Level | Manual Decisions | CREES Decisions | Relative Error % | No of Clients Misclassified |
|---|---|---|---|---|---|
| 1 | Highest Safety | 78 | 84 | 7.1 | 6 |
| 2 | High Safety | 70 | 74 | 5.4 | 4 |
| 3 | Moderate Safety | 90 | 87 | -3.4 | 3 |
| 4 | Adequate Risk | 91 | 94 | 3.1 | 3 |
| 5 | High Risk | 85 | 83 | -2.4 | 2 |
| 6 | Default | 86 | 82 | -4.8 | 4 |
| | Total | 500 | 500 | 5 | 22 |

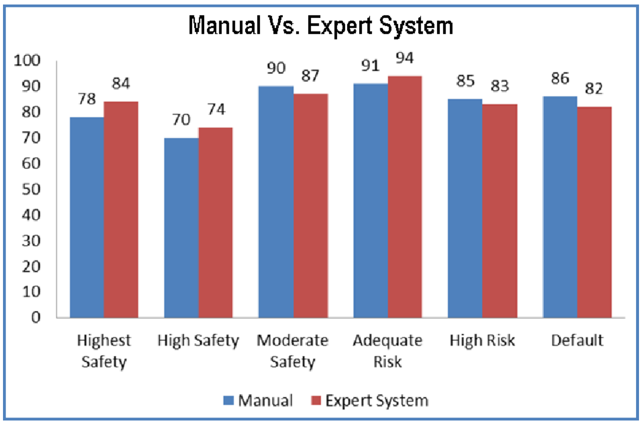


**Fig. 7-** Comparison of results Manual v/s CREES

The following is the Explanation Report generated by CREES for a sample client.

**Credit Risk Evaluation using Expert System**

**Trading Sector Client Credit Risk Assessment**

Client Id: C000000002

Application Id: A000000002

Client Name: XYZ Enterprises Bagalkot

**Trading Sector Client Credit Rating Scores**

Client Management Risk Score: 38.0

Client Business Risk Score: 38.0

Client Finance Risk Score: 58.0

**Trading Sector Standard Credit Risk Rating Scores**

Highest Safety Rating Maximum Score: 150.0

Highest Safety Rating Minimum Score: 145.0

High Safety Rating Maximum Score: 144.0

High Safety Rating Minimum Score: 139.0

Significant Safety Rating Maximum Score: 138.0

Significant Safety Rating Minimum Score: 133.0

Adequate Safety Rating Maximum Score: 132.0

Adequate Safety Rating Minimum Score: 127.0

Low Risk Rating Maximum Score: 126.0

Low Risk Rating Minimum Score: 121.0

High Risk Rating Maximum Score: 120.0

High Risk Rating Minimum Score: 115.0

Highest Risk Rating Maximum Score: 114.0

Highest Risk Rating Minimum Score: 107.0

Management Risk: Standard Excellent

Maximum Credit Score: 40.0

Management Risk: Standard Excellent

Minimum Credit Score: 35.0

Business Risk: Standard Excellent

Maximum Credit Score: 40.0

Business Risk: Standard Excellent

Maximum Credit Score: 35.0

Finance Risk: Standard Excellent

Maximum Credit Score: 60.0

Finance Risk: Standard Excellent

Maximum Credit Score: 55.0

Management Risk Rating is: Excellent

Business Risk Rating is: Excellent

Finance Risk Rating is: Excellent

Defuzzified Trading Sector Credit Score is: Excellent 148.40789783646014

**Credit Risk Rating Highest Safety- AAA**

**Manufacturing Sector Client Credit Risk Assessment**

Client Id: C000000001

Application Id: A000000001

Client Name: ABC Industries Mudol

1. Technical Feasibility Rating is - OK
2. Management Commitment Rating is - OK
3. Commercial Viability Rating is - OK
4. Financial Analysis Rating is - OK
5. Economic Analysis Rating is - OK

The Credit Risk Rating is: Adequate Safety- B

**References**


[1] Paul F. Smith (1964) *Measuring Risk on Consumer Installment Credit*.

[2] Rekha Jain (1989) *Expert Systems: A Management Perspective*.

[3] Williamson A.G. (1995) *Refining a Neural Network Credit Application Vetting System with a Genetic Algorithm*.

[4] Kasper Rozsbach (1998) *Bank Lending Policy, Credit Scoring and the Survival of Loans*.

[5] Sushmita Mitra, Yoichi Hayashi (2000) *Neuro-Fuzzy Rule Generation: Survey in Soft Computing Framework*.

[6] Markus Kern, Bernd Rudolph (2001) *A Comparative Analysis of Alternative Credit Risk Models-an Application on German Middle Market- Loan Portfolios*.

[7] Sreekantha D.K. and Kulkarni R.V. (2008) *International Journal of Intelligent Information Processing.,* 305-318.

[8] Shaomei Yang, Junyan Zhao (2009) *Second International Workshop on Knowledge Discovery and Data Mining, IEEE,* DOI 10.1109/WKDD.2009.62.

[9] Chakraborty R.C. (2010) *Hybrid Systems Integration of Neural Network, Fuzzy logic & Genetic Algorithm Course Lecture*.

[10] Shorouq Fathi Eletter, Saad Ghaleb Yaseen and Ghaleb Awad Elrefae (2010) *American Journal of Economics and Business Administration,* (1), 27-34.

[11] Amir E. Khandani, Adlar J. Kim and Andrew W. Lo (2010) *Consumer Credit Risk Models via Machine-Learning Algorithms*.

[12] Adel Lahsasna, Raja Noor Ainon and Teh Ying Wah (2010) *The International Arab Journal of Information Technology* 7(2), 115-123.

[13] Sreekantha D.K. and Kulkarni R.V. (2010) *International Journal Expert Systems the Journal of Knowledge Engineering*.

[14] Sreekantha D.K. and Kulkarni R.V. (2010) *International Journal of Technology and Applied Sciences the Journal of Graphic Era University*, 2(1).