

Factors Affecting Credit Risk Management of Legal Bankers Using Logit Regression Model and Maximum Likelihood Method;

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Summary

This research was carried out with the aim of identifying effective factors and developing a model for assessing the credit risk of legal clients of the Mellat Bank of Semnan province by "Logit Regression" method. For this purpose, qualitative and financial information of a random sample of 200 companies that had received credit facilities from the Mellat Bank Branch of Semnan Province during 2009-2010 was investigated. In this study, after examining the credit records of each sample, 36 explanatory variables including qualitative and financial variables were identified and examined. Among the existing variables, using Logit Regression analysis, 17 variables that have a significant effect on credit risk and the separation between the two groups of happy and ignorant customers, were chosen and the final model was fitted with them. According to statistical indices, these functions have significant and high validity in terms of coefficients and separation power. The results of the research, while indicating the confirmation of economic and financial theories about the factors affecting credit risk, indicate that the factors affecting the credit risk of the legal customers of the Mellat Bank of Semnan province have a common chapter with the factors affecting the credit risk of the legal customers of other banks (including the Agricultural Bank Export development)

Key words:

Credit Facility, Credit Risk, Failure to Refund Liabilities, Validation, Credit Scoring, Logit Regression Model, and Maximum Likelihood Method.

Introduction

A study of the performance of most countries shows that investment and the level of economic progress are closely related. Countries that have an effective pattern of allocating capital to different economic sectors often have economic progress and, as a result, greater social welfare.

Equipping and allocating investment resources to economic activities through the financial marketplace is that the market for bank credits is part of this market. This is done as the main role of the bank in the financial market through the granting of credit to customers. Therefore, one of the issues of importance

is the assessment and evaluation of credit risk (ie, the probability of failure to repay the granting of facilities by customers). Measuring this risk is of particular importance among the risks that the bank faces in its broader range of activities. Reducing and controlling risk is one of the important factors affecting the improvement of the credit process and consequently on the performance of banks and plays a fundamental role in the continuation of the facility and survival of banks and financial institutions. Examples of the importance of measuring this risk include:

a. Now the most important bank failure factor is credit risk. If the customer fails to repay his obligations in due time, the facility will be deferred to the bank and this will disrupt the distribution of bank credits and, as a result, disrupt the economy of the country;

B. Measuring credit risk by predicting losses of non-repayment of credits and creating a logical relationship between risk and return, allowing the optimization of the combination of credit portfolios, asset pricing and determining the economic capital of banks in order to reduce capital costs and maintain competitive power and provide some relative advantage to banks and credit institutions
Creates a

C. In Iran, on the one hand, the activities of banks are based on the rule of bankruptcy banking and based on Islamic contracts, so it is impossible to distinguish between the money market and the border capital. On the other hand, due to the economic structure of the country, the operations of the capital market (securities and stock market) and other non-bank networks have not made any significant progress, and therefore a significant share of investment from the banking market takes place. Therefore, the success of banks in these matters is of particular importance;

D In the Rabbi system, after the loan is paid, the bank's connection to the money is disconnected, and the bank, regardless of the type of economic activity, claims its principal and its subordinate money; therefore, with sufficient guarantees, there is no need for an accurate appraisal of the customer (and if Evaluations are better, in order to facilitate transactions and select customers (while in the Islamic Banking System the partner bank is the facility in the economic activities and most of the share of the person is considered as a guarantee. Therefore, considering the proprietary-lawful sources of valuation, the ability to repay the customer is very important.

With this in mind, what matters to the bank is that, before granting the facility, it is possible to assess the possibility of non-repayment by them and choose a group and make sure that they can be honored on time. It is possible to do this by a comprehensive system, structure and appropriate criteria. Today, banks use a wide range of credit risk assessment models for approval and payment of grant loans. By using objective criteria and past and present customer information, they provide customer credentials in the form of preparation of various types of information and expert reports and decision-making on sound pillars. . In the case of large loans, and with a small number of them, a precise appraisal of the applicant is feasible; therefore, in the case of medium and small loans, since the number of applicants is

high, a precise evaluation of each one is costly, and therefore requires a systematic evaluation and a model based on It can be used to determine and reduce credit risk.

Regardless of the importance of this issue, unfortunately, in our country, in the field of granting credit facilities to customers with a coherent and systematic process for determining credit risk, scoring, rating and also determining credit ceilings based on risk indicators, the indicators are based on the expert's assessment and the credit committee. Having an efficient risk model not only facilitates decision-making in the field of credit and bail, but also reduces the cost of exchanges, which will make the banking .system more efficient in allocating capital to different sectors of the economy

This paper first studies the literature on credit risk and then the factors affecting the credit risk of legal clients of Mellat bank in Semnan province using the logistic regression method. In this way, some qualitative characteristics (type of activity, history of deferred debt, etc.) And financial (some items of balance sheet, etc.) that affect the credit risk of the bank's customers.

A review of the subject literature

Credit Scoring Models

Credit scoring methods are performed quantitatively and qualitatively. The qualitative analysis of credit scoring depends on the ability and experience of the persons responsible for granting credit, but in the quantitative analysis, the prediction of non-repayment of the principal and the profitability of credit facilities depends on the estimated distribution function by quantitative methods. Most credit risk mitigation models have similar conceptual frameworks, but the differences that exist in implementing these models results from the way of estimating the main parameters of available information.

In the scoring system, multi-variable scoring can be used to predict the likelihood of non-repayment. Wide techniques in mathematics, statistics, econometrics, and research in operations in banks and credit institutions are used in this area, which are divided into two categories of nonparametric credit scoring models such as mathematical programming, tree classification (recursive division algorithms), closest neighborhood model, dynamics analysis process Hierarchical, Expert Systems, Artificial Neural Networks (ANNs) and Genetic Algorithms (GAS) and parametric credit scoring models such as linear probability model, audit analysis model, logit model, and probit model are classified. In developing credit risk measurement models, They play a role (Kiesferans, 2003.)

Now, research is being done by many scholars and credit institutes in order to design a precise credit risk model in line with the committee's research findings. In this paper, the logit model is used to investigate the factors affecting the credit risk of legal clients of Mellat bank in Semnan province.

.An overview of the development of scoring models



The history of credit risk assessment goes back to the era of invention and money creation. In the past, people were trying to take into account their financial capabilities in giving loans to various groups and individuals, but given that at that time the variables affecting the financial capability of individuals were very limited, the lenders, according to the previous understanding, People loaned. However, in all cases, the ability to pay and the ability to pay the borrower was considered as one of the factors contributing to the borrowing. Since 1909, when John Murray ranked and rated credit risk on bonds, some researchers noticed the great similarity of bonds and facilities granted and measured the risk of non-payment of principal and interest rates on loans. In this context, the study of Fisher (1936) as the first system for assessing credit demand and the "Dover" study (1941), which was conducted using "audit analysis" and based on Fisher's findings, can be considered as the founder of credit scoring systems in time Present cited In the late 1950s, more companies were keen to improve and improve credit scoring systems. The leading activity in this field was founded by the largest and most celebrated company Fair Isaac in 1956. Boss (1967) is the first person to use the computer to examine a large set of data from different angles and try to use sophisticated multivariate statistical tools that led to the improvement of precision models of credit scoring. Among other studies, the Beaver (1967) paper on the estimation of firms' success and failure using some of the financial indicators, Altman (1968), in the design of the Z-score model (audit analysis) to assess the success of companies, " Dicken (1972) on using the audit analysis method to evaluate the performance of companies by using 14 financial ratios as independent variables and also evaluating corporate performance using the same model (1989), Morgan (1994) in the design of the model Credit risk measurement, Troitsy (1998), in designing a risk-worth model for determining the potential for non-repayment density The

In the 1970s, several European and American banks went bankrupt, and the importance of the issue led other banks to seek to identify the causes of bankruptcy. Analysis of about 20 bankrupt banks revealed that in some cases the main reason for bankruptcy of high-risk loans was the economic crisis of that era. In 1986, Pemberton Way and Paul Wolker, former chairman of the WFTU and the Federal Reserve, met at an informal meeting on the risks of banks and the banks' minimum capital, which could be the beginning of the formation of credit risk and capital adequacy regulations.

In January 1998, after numerous negotiations between the Group of 10 member states, the Banking Supervision and Banking Supervision Committee (WAF) determined the method of calculating bank capital and the minimum amount of risk capital available to active banks in the international arena. The wing committee eventually determined the minimum ratio of capital to the total risk-adjusted assets for the first class capital, 4%, and for the total capital of 8%. According to the last instruction of this committee, in order to calculate the ratio of capital adequacy to the credit risk, other risks such as operational risk and market risk, and others should be considered. At the same time, only credit risk was considered first to calculate the adequacy of the capital.

Currently, many reputable rating agencies such as Modi, Standard and Poor, and KI. M He. "In determining the types of credit risk models and related methodologies, they carry out theoretical and practical work and use the methodology to rank companies, institutions and credit institutions.

research method

Model definition

In this paper, the credit risk of legal customers of the Mellat Bank of Semnan province is estimated using statistical method and econometric models. Therefore, it attempts to analyze the credit risk using regression models with qualitative dependent variable (logistic regression). The general form of the proposed model is as follows:

$$Y = F(X_1, X_2, X_3, \dots, X_n)$$

Where Y is the response variable and determines the status of the applicant, which is of a discrete nature, because the bank customers are classified into two categories in terms of credit risk: Group 1: "Happy Customers" means a group of bank customers who are reluctant to settle their obligations on time They are acting before the maturity of the installments. Group 2: "Bad Customers" means a group that does not meet the obligations of the facility in a timely manner. In this case, the variable Y will provide zero for happy customers and one for bad-paying customers.

To categorize and separate these two groups of customers, 36 variables were identified as explanatory or independent variables using the 5C method, which can be classified into two categories:

a. Qualitative and financial variables: The parameters that each customer gives to the bank for receiving the facility and is included in their credit file, such as the type of activity of the company (in four groups: industry, agriculture, construction, services and commerce), history of the company's activity, history of cooperation with Agricultural bank, type of guarantee (obligation, surety, documents and securities), history of past deferred debt to the bank, amount of loan, average 6-month turnover of the company with the bank, accumulation of 6-month payday debtor of the company Bank, Total accumulated experience of the 6-month account (accounts) of the company with the bank, cash, debtors, receivables, inventories Current assets, fixed assets, creditors (accounts payable), debt to banks (payables to banks), current debt, corporate capital, having or not having an audit report;

B. Financial ratios: Includes some financial ratios affecting credit risk and often used in financial research, such as current ratios, immediate ratios, cash ratios (cash to total assets), current asset ratios (current assets to total assets), ratios Current sales turnover (sales to outflow capital), total asset turnover ratio (sales to total assets), average receivables ($360 \times$ debtors to net sales), average inventory turnover (sales to inventory), current debt ratio Specifically, the ratio of debt (total debt to total assets), fixed asset to equity ratio, equity ratio (equity to total assets), return on equity ratio (Net profit to special value), return on assets (profit to total assets), profit margin ratio (net profit to net sales.)

In order to determine the optimal model, all of these variables entered the model and finally, variables that have a significant relationship with the dependent variable and the maximum difference between the two groups of customers were selected. The probability of occurrence of the phenomenon (here defective payment) (P) is assumed to be (Whitehead, 2004):

$$P_i = (y = 1) = \frac{1}{1 + e^{-\beta'X}} = \frac{e^{\beta'X}}{1 + e^{\beta'X}}$$

$$\frac{P}{1 - P} = e^{\beta'x} = e^{\beta_0 + \beta_1 X_1 + \dots + \beta_n X_n}$$

$$L = \ln\left(\frac{P}{1 - P}\right) = \beta'X$$

L (logarithm of odds ratio) is linear compared to the parameters and its value is obtained after estimating the coefficients by the maximum likelihood method. Thus, by estimating the coefficients, a model is obtained that each of its coefficients shows the value of the variable L (logarithm of chance for failure to payback) as an independent variable of the variable. Then, by calculating the probability of failure in the repayment of the relation 1, it is possible to classify the customers of the bank. Made It also shows the change in the odds ratio for one unit of change (Jamshidi, 2004). In the logit model, the effect of a unit of variation on the probability of occurrence of the desired event ((Y = 1) is obtained by the name of the final effect of the following equation:

$$ME = \frac{\partial P}{\partial X_1} = f(\beta'X)\beta_1 = \frac{\exp(\beta'X)}{(1 + \exp(\beta'X))^2} \times \beta_1$$

Therefore, in this model the amount of variation in probability depends on the probability of the initial and as a result of the initial values of all independent variables and coefficients. For example, if the final effect of the variable is equal to (-0.5), one increase in this variable will reduce the likelihood of occurrence of the phenomenon by 50% (Hashemi, 2004, p. 122). Using the 4-tensile relationship in the logit model, we obtain the following equation:

$$E = \frac{f(\beta'X)}{\partial X_1} \times \frac{X_1}{F(\beta'X)} = \frac{\exp(\beta'X)}{(1 + \exp(\beta'X))^2} \times \beta_1 \times \frac{X_1}{F(\beta'X)}$$

The elasticity of each variable shows that one percent change in the independent variable causes a multiplier of variation in the probability (ϵ) = Y. For example, if the elasticity of the variable is equal to (-0.75), that is, a 1 percent increase in this probability of occurrence of the phenomenon The view is reduced by 75% (Hashemi, 2004, p. 122).

The function of this regression is that in the first step, a model with multiple variables and statistics for all customers can be implemented that can be cross-sectional or panel, then independent variables are identified and the final model is compiled and the coefficients of the model are estimated. Then, given the coefficients obtained, each customer's information is included in the model and his score (which is between zero and one) is calculated. By comparing a customer's score with a "cut-off threshold", the bank decides whether or not to accept credit requests.

If the score is less than that, the applicant will be classified in the "good" category, otherwise he will be in the "bad" category. This classification based on the scores derived from the model can impose two types of costs for the wrong classification. First, the first type error (credit risk): when a "bad" applicant is mistakenly placed in the "good" group. . Second, type 2 error (business risk): When a "good" applicant mistakenly falls into the "bad" group.

According to the description of the first and second type errors, we can discuss the optimal amount of "threshold". In other words, the threshold can be set in such a way as to minimize the average of both types of credit and business risks. For this purpose, we can define the Expectancy Cost Relationship (EC) as follows:

$$EC = \alpha C_1(\text{Type1}) + (1 - \alpha) C_2(\text{Type2})$$

: The proportion of unprofitable customers in total customers; $1 - \alpha$ The α

share of happy customers from the total customer;; C_1 The costs of the first type error; C_2 The costs of the type II error; Type1: The probability of poor customer classification in the good customer class .((credit risk) and Type2: probability Good customer classifications in poor customer class (business risk

This relationship predicts the expected cost of the model used to scorecard the credit of the bank through two types of credit and business risk and, by minimizing it, the threshold is calculated.

Society and statistical sample

The statistical population of this paper is all legal credit customers at the level of Bank of Mellat Branch of Semnan province who have received credit facilities. Selection of the research sample was carried out as a random sample and the available database was not available and using the information received from the branches and collecting information about each customer - 36 primary variables - was manually completed and a questionnaire was completed from the bank branches. Therefore, after the inquiry from all branches of the Mellat Bank in Semnan province, the names of all legal clients who received credit from banks during the years 88 to 92 and 320 cases were randomly selected.

After reviewing the relevant information, 285 files were used with full information. From this set of 200 legal clients, randomized design was used to design the model and identify the effective variables, and the information of 85 customers (30% of the sample) was used to evaluate the efficiency and predictive

power (using non-model variables) as control data. Then, after estimating the model parameters, the dependent variable of this group is estimated and compared with the actual results. Of this sample, 200, 142 were customer satisfaction cases, and 58 were bad customers.

Research results

Model estimation results

Using the above sample, the variables listed for 200 clients of the Mellat Bank of Semnan province were prepared to enter the model. In order to achieve the optimal validation model, all variables were introduced into the model. In fitted models, the coefficients and the significance of the whole regression were statistically significant (LR statistic) for a statistically significant logit regression model (95% confidence level), lack The correlation between the variables and the absence of correction error in the model was investigated. Finally, after estimating different types of models in the optimal selective model, the following variables were identified as effective variables, in which all coefficients were significant at 95% confidence level (Table 1).

Table 1: Estimation of logit function coefficients

variable	coefficient	EXP(β)	Std. Error	Wald-test	Prob.
C	2.833898	17,01164	0.726606	15.2114 4	0.0001
(D1A)industrial	2.419500	11.24024	0.683032	12.5478 4	0.0004
(D1B)Agricultural activity)	2.560817	12.94639	0.792620	10.4382 4	0.0012
(D1C)Construction activity	2.597921	13.43578	1.232056	4.44622 1	0.0350
(X1)History of cooperation with the bank)	-0.302835	0.738721	0.110691	7.48495 1	0.0062
(D2)Having a debt) معوق	3.6110 84	37.00615	0.64629 2	31.2188 8	0.0000
(X2)Loan amount)	-7.34E-05	0.999927	2.57E -05	8.15004 2	0.0043
(X3)Calculate the average)	-0.000139	1	5.34E-05	6.77067 2	0.0093

(X4)Accounts payable)	0.000182	1	8.58E-05	4.505997	0.0338
(X5)Credit card turnover)	-8.48E-05	1	2.39E-05	12.63281	0.0004
(X6)Current assets	-6.15E-05	1	1.71E-05	12.89772	0.0003
(X7)Creditors)	4.22E-05	1	1.50E-05	7.903355	0.0049
(X8)Debt of banks)	2.22E-05	1	7.40E-06	9.012542	0.0027
(X9)Total debt	8.62E-06	1	3.06E-06	7.939085	0.0048
(X10)Current ratio)	-3.332600	0.0357	1.245935	7.154440	0.0075
(X11)Cash ratio)	-4.149015	0.01578	1.925782	4.641687	0.0312
Current capital (X12) ratio	0.001787	1.001789	0.000853	4.385263	0.0363
Ratio of Receivables Period (X13)	9.53E-05	1.000095	4.87E-05	3.831689	0.0503
Current debt ratio to special value (X14)	0.006354	1.006374	0.002605	5.950400	0.0147
Total debt ratio to (X15)total assets	1.804796	6.078731	0.550019	10.76717	0.001

In this way, the general form of the logit function or the logarithm of the probability of failure to repay the probability of non-repayment is as follows:

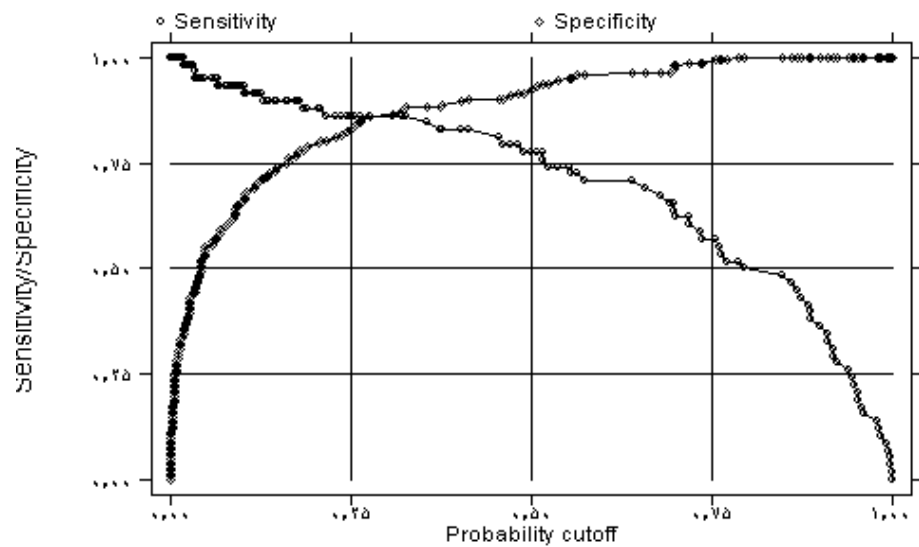
$$\begin{aligned} L\left(\frac{P}{1-P}\right) = & 2/8338 + 2/4195D_{1A} + 2/5608D_{1B} + 2/5979D_{1C} - \\ & 0/3028X_1 - 3/611D_2 - 0/0000734X_2 - 0/000139X_3 + \\ & 0/000182X_4 - 8/48E - 05X_5 - 6/15E - 05X_6 + \\ & 4/22E - 05X_7 + 2/22E - 05X_8 + 8/62E - 06X_9 - 3/3326X_{10} - \\ & 4/149X_{11} + 0/0017X_{12} \\ & 9.53E - 05X_{13} + 0/006354X_{14} + 1/8047X_{15} \end{aligned}$$

Calculate optimal threshold

By definition, the optimal threshold for a model (or probability in which the average credit and commercial risk of a model is minimized) is equal to the probability in which one of the following scenarios occurs: First, the sum of the degree of sensitivity and degree of diagnosis of the model will be maximized; 2) If the sensitivity of the model is more than 80%, the total sensitivity and degree of

detection will be maximized; third: the minimum value between the two values will be maximized for all observations; (4) If the importance of the degree of sensitivity of the α model is equal to its diagnostic value, Degree of detection $\times 1 + \text{degree of sensitivity} \times \alpha$) Maximum (Cyruslam, 2004.)

The numerical limit value can not be calculated directly, but according to the degree of sensitivity and diagnosis and the probability of occurrence of the desired outcome (in this case, the credit risk), for the total sample observations can be calculated. The amount of this limit will be calculated through one of the four methods above and in a manual manner. In this study, using the third method, the threshold value was calculated to be 0.3. In Fig. 1, the threshold is plotted by a graph in which the degree of sensitivity curve and the degree of diagnosis of the model are plotted against the probability of default in repayment of obligations.

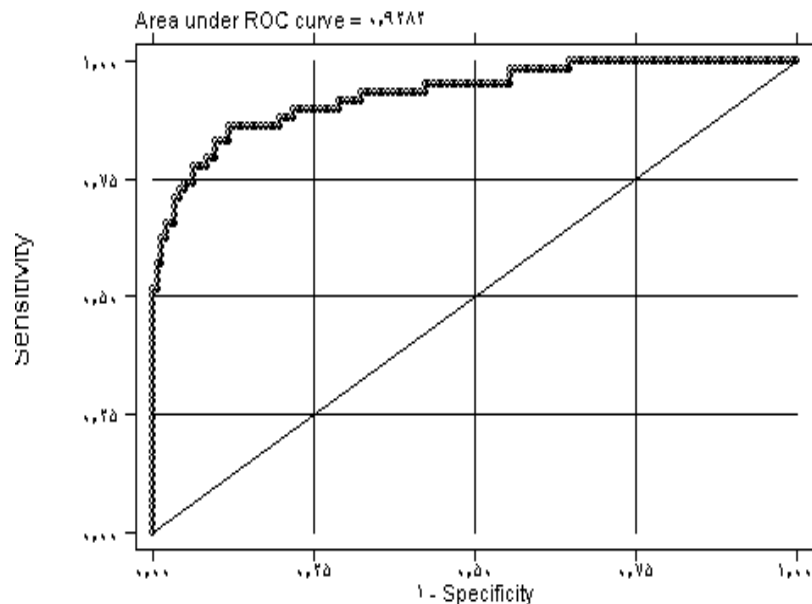


Graph 1: Degree of sensitivity and degree of diagnosis

In this chart, the vertical axis is the degree of sensitivity and degree of diagnosis and the horizontal axis of probability (credit risk). The curve drawn from the lower left to the upright is the degree of diagnostic curve and the curve from the top left to the right downwards is the degree of sensitivity curve. Now, if we look at the predictive power of the model again with respect to the new threshold (about 0.3), then the sensitivity of the model is 21.86% and the degree of recognition of the model is 62.68%. Also, credit risk is 13/38 percent and business risk will be 79/13 percent, which is almost equal.

.Studying the Separability of the Model

After calculating the degree of sensitivity and the degree of diagnosis of the model, the ROC curve is used to determine the separation power of the two groups (happy customers and illiterate customers) (Fig. 2). This curve is on the coordinate plate whose horizontal axis (one minus degree of diagnosis) and axis The vertical is the sensitivity of the model, from the point (0, 0) in the lower right corner to the point (1.1) in the upper right corner. The closer the curve to the upper left-hand corner (1.0), the greater the power of the model, will be in separation between the two groups. A good indicator of the surface model is below the ROC curve. The model that has the most separation power between the two groups (from pleasing and misleading customers), the surface below curve 1 and the model whose resolution is zero is below the curve of 0.5. As shown in Figure 2, the surface area under the ROC curve in the fitted model is 0.9282/03/0, and therefore, shows that the model has a high separation capability between the two groups



. Figure 2: ROC curve

Grouping customers in terms of credit risk

Today, in European and American countries, institutions such as French Coface are responsible for credit privileges. In the ranking method for credit scores that are set for rating agencies according to the standards of the Swiss wing committee for rating agencies, credit rating companies rank in 10 groups based on credit scores (probability of failure of the company to repay liabilities) during one year; each

rating (1 to 10) representative The average probability of failure to repay the company in that year. Considering this, it has been attempted to rank (rank) using a similar pattern to the legal clients of the Agricultural Bank, which are used in the sample of the research. This grouping is done according to the results obtained for the credit risk (privileges) of the legal customers and summarized in Table 6.

Table 6: Crediting Group Clients

Specifications	Percentage of sample size	Credit risk	group
The first group has the best quality in terms of profit and principal repayment and has .the lowest investment risk	48	0-0.1	1
The second group is of high quality, and the difference with the previous group is that their margins of security are not as wide as the previous one and its long-term risk is somewhat higher. Inside the group, they have a weaker perspective from top to .bottom	11	0.1-0.2	2
The third group has favorable conditions. In terms of paying the principal and profit, they have the right conditions, but they may be in trouble due to occurrence. Conditions get worse from top to bottom within the .group	5.5	00.2-0.3	3
The fourth group is considered moderate, and it seems adequate (in the present time) in terms of principal and profit reimbursement, but in the long run it may be difficult, in the group, from the top to .bottom, the situation worsens	3	00.3-0.4	4
The risk of this group is high and this group has some kind of uncertainty	4	0.4-0.5	5
This group is not in good condition in terms of guaranteeing the repayment of principal and profits of the facility and do not have .the characteristics of a good investment	4.5	00.5-0.6	6

In terms of repaying principal and profit there is no guarantee of good, either now or in the future, that this group is either in bad condition or that their repayment of .installments is facing a lot of dangers	4	00.6-0.7	7
This group is more likely to be at risk of close fueling and in bankruptcy than the .previous one	5	00.7-0.8	8
Compared to the previous group, they are in worse condition and most of their installments are dispensed	3.5	00.8-0.9	9
This group is in the worst condition in terms of paying the principal and profits of the facility, and repayment of their .installments is unlikely to be overcome	11	0.9-1	10

Conclusion

The results of the research can be summarized as follows: a. There is a significant statistical relation based on the variables in order to determine the status of the credit risk of the legal customers of the bank; b. Significance and significance of the coefficients of the independent variables of the model indicate the confirmation of economic and financial theories about the determinants of credit risk; Based on the qualitative and financial variables, legal persons of the Mellat Bank of the province of Semnan can be classified and scrutinized. Among the financial ratios, the cash ratio and current ratio have the highest share in customer segregation into two groups of high-risk companies and low risk companies; Factors Affecting Credit Risk of Customers of Bank Mellat of Semnan province have a large share of factors affecting the credit risk of legal customers of other banks (including the Agricultural Bank and Export Development).

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