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Analyzing credit risk management methods in order to increasing profitability in public and private banks[1]

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Abstract. Banking is practice or profession as old as the man existence. Banks have the duty of safeguarding money and providing valuable financial services for their customers. Granting loan is one of the main financial activities of banks, which involves huge amount of risks to the borrower and the lender. The risk of not fulfilling the obligation by the borrower on due date can put the bank on bankruptcy risk. Iranian banks face several risk and challenges that among them credit risk is the most concern of banking regulators because this risk can easily lead to bank failure. The problem of inappropriate risk management in Iranian banks is a big challenge for them. Lack of sound credit policies, structure and management make trouble for them. And also the lack of an appropriate credit risk method which can help them in managing loan providing procedure can be seen. Therefore, the credit risk management and method for Iranian banks should be researched.

Key words. Credit risk, risk management, public and private banks, profitability, credit methods.

1. Literature review

The study has a look at how Iranian banks manage their credit risk and what is the impact of this managing on their profitability. Therefore, it has a fast look at risks, credit risk and its management in banking industry, as well as risk exposures and methods, models, assessment tools which are appropriate for Iranian banks [1].

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It also has study on profitability and its financial indicators.

Regarding to credit risk importance among different activities of bank, it seems that in banks of Iran there is no proper action to manage the credit risk indicators. So that, one of the difficulties of Iran's credit and banking system is the ever increasing of outstanding claims of the companies which used the bank loan facilities and now are not able to repay those loan facilities [1].

The current financial problems show that Iranian banks have not adequate credit risk management and this credit risk omission or neglect can push them to the financial failure [2]. Therefore nowadays, it seems necessary to work more on this matter with the focus on risk measurement and assessment. Searching the previous studies shows that majority of risk management studies are about the banks of US, UK and some other developed countries which can be because of availability of data while less studies are done on credit performance of Iranian banks, so it was a motivation to work in this era. The deeper research in the banks of Iran shows that they prefer to employ less technically risk measurement techniques, and in case of using more advanced credit risk techniques there is a big gap between what they do and what should be done, and the methods are not employed properly that can achieve the useful result [3].

2. Problem statement and research questions

Banking is a vital part of any economy with diversity of activities, but this diversification creates more risk for the banks. Among the various risks the banks face with, granting loan can be considered as the riskiest one. Banking business in Iran is very risky because more than 85 % of their liability is deposits from depositors [4].

The principal concern of this research is to clarify:

- What is the credit risk technique used by Melli and Parsian banks.
- What are their current credit risk method problems and weaknesses.
- What are the most affecting financial indicators on their profitability when measured by ROE and ROA.

2.1. Expanding risk and risk management apply in bank sector

Risk is the probability of the adverse result, and risk management is the prediction and control of these adverse results in order to minimize the loss and maximize the company value [5]. In general risk is the loss probability through lack of assurance in doing the affairs because of lack of proper information and also lack of appropriate recognition of environment. In most cases this lack of assurance cause lag between predicted result and achieved result, this lag creates expenses and risks[6].

The word "risk management" was stated by Henry Fayol in 1916 for the first time, but it became conceptualized when the book "Risk Management: A New Phase of

Fig. 1. Sequence and causes of risk

Cost Control" published by Russell Gallagher in 1956 [6]. In bank or any financial markets risk is the probable loss in the process of loaning or investment.

As the risk is the inevitable section of the human's life and society, banks are also face different kinds of risks in their financial and operational activities as the financial part of the society [7].

The Islamic banking is growing rapidly and getting more importance in the global financial system [8]. With the growing interests to search for the alternative to the conventional banking system in the post-2007/2008 global crisis, coupled with large potential customers' base of over one billion Muslim population worldwide, the demand for the industry is expected to strengthen and grow even more rapidly [9].

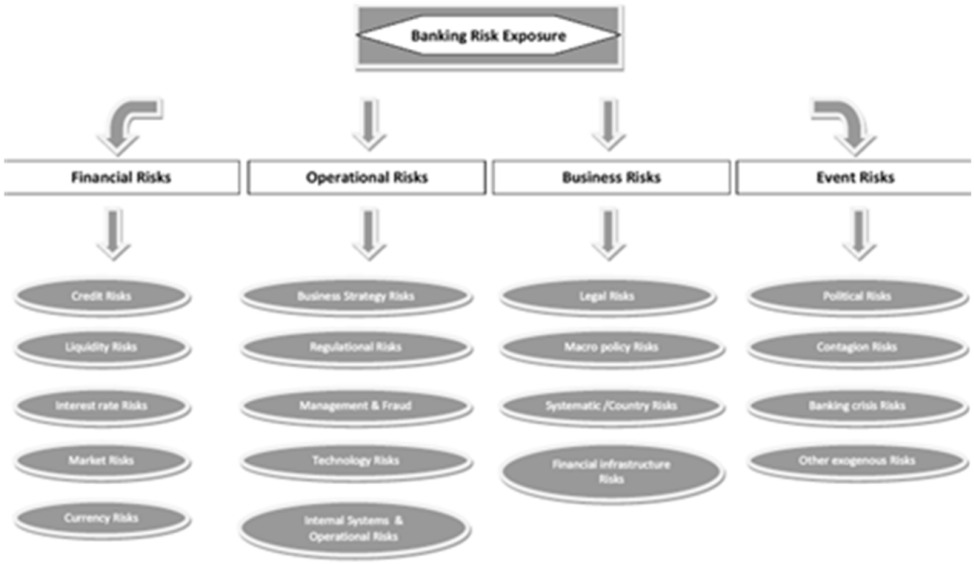

Fig. 2. Banking risk chart

2.2. Banking structure of Iran

In today's world the sound banking industry in both public and private sector is essential to increase the economic level of any country. Iran's financial sector include private banks, public banks and, financial and credit institutions competing

in the same market [10]. The main commercial operations are performed by public and private banks and customers obtain most of their banking services from these two sectors [10]. Public banks are government controlled banks in Iran and the government has a major holding. These banks which have dominated majority of deposits and advances in the banking industry are divided into two categories of commercial banks and specialized banks [11].

3. Analysis of existing credit risk method of Melli bank

In multi-variable regression the method of the smallest sum of squares error is used that minimizes the difference between estimated values and real values of dependent variable [12]. Because of nonlinear function in logistic conversion the method of maximum likelihood is used. However, coefficient estimation is similar to normal regression in many ways.

$$P_t = P_r\left(y_t = 1|\Omega_t\right) = \left(y_t|\Omega_t\right) . \tag{1}$$

In the binary choice model the ultimate goal is the modeling a conditional expect. So, it's obvious that a linear regression is unable to give the correct and compelling answer to binary choice variables. In linear regressions the amount $E\left(Y_t|\,\Omega_t\right)$ is equal to $X_t\beta$, but $E\left(Y_t|\,\Omega_t\right)$ is a probability while $X_t\beta$ is not necessarily a probability. In binary choice models a transfer function is used. Suppose that $F(X)$ is a transfer function with the following properties:

$$F\left(-\infty\right) = 0, \quad F\left(+\infty\right) = 1, \quad f_{(x)} = \frac{\partial F_{(x)}}{\partial x} > 0\,. \tag{2}$$

In binary choice model that we will review, the transfer function $F(X)$ is applied on an index function which is dependent on the effective factors and independent variables of the model. The index function is a simple function with regression function specifications. Thus, a general definition of a function with binary choice in dependent variable is

$$E\left(Y_t|\,\Omega_t\right) = F\left(h\left(X_t\beta\right)\right) .$$

where $h\left(X_t\beta\right)$ is the same index function. A usable but limiting assumption is that we suppose the index function in the linear form of $Xt\beta$, so that

$$E\left(Y_t|\,\Omega_t\right) = F\left(X_t\beta\right) . \tag{3}$$

where the conditional expect amount of Y_t is equal to a nonlinear transformation of $X_t\beta$ although $X_t\beta$ can choose any amount, but $F\left(X_tB\right)$ can only be between zero and one. Because of nonlinearity of function $F\left(X_tB\right)$, any change in elements of X_t that is the mean X_{ti}, has nonlinear effect on $E\left(Y_t|\,\Omega_t\right)$ if we suppose that $p_t = E\left(Y_t|\,\Omega_t\right)$. Then any change in elements of X_t have the following effects on probability:

$$\frac{\partial P_t}{\partial x_{ti}} = \frac{\partial F\left(X_tB\right)}{\partial X_{ti}} = f\left(X_t\beta\right)\beta_i\,. \tag{4}$$

For most applied functions the quantity $F(X_tB)$ reached the maximum at zero and it decreases with increase or decrease in X_tB. So, what is gained from the equation (4) is that the effect of one unit change in independent variable on probability of the event. In practice, with applying dependent variable in binary choice, generally two types of specific transfer function $F(.)$ is used. The result of these function are logit and probit models [12].

At the moment the method of maximum likelihood is the common way to estimate the binary choice models. Regarding to this model, $F(X_tB)$ is the probability of event $Y_t = 1$ and $1 - F(X_t\beta)$ is the event probability of $Y_t = 0$. So, with using the maximum likelihood logarithm we have [13]

$$\ell(y, \beta) = [_{t=1}^{n} [(\log(F(X_t\beta))) + (1 - y_t)\log(1 - F(X_t\beta))] . \tag{5}$$

Generally this is a concave function because $\log(1 - F(X_t\beta))$ and $\log(F(X_t\beta))$ are concave in all amounts of X. Using likelihood function for these models it is very simple to determine the maximum by the numerical methods easily. First, time condition for maximizing the equation (3–6) is

$$[_{t=1}^{n} \frac{(y_t - F_t) f_t X_{ti}}{F_t(1 - F_t)} = 0, \quad i = 1.....k , \tag{6}$$

where $F_t = F(Xt\beta)$, $f_t = f(Xt\beta)$ and β that is estimating vector in the ML method.

Of course, it is noteworthy that the equation (7) expresses the first time condition for a general estimate of least squares in a first time regression model [15]

$$Y_t = F(X_t\beta) + e_t , \tag{7}$$

and the variance of errors in equation (9) is obtained as

$$\begin{aligned} E(e_t^2) &= E(y_t - F(X_t\beta))^2 \\ &= F(X_t\beta)(1 - F(X_t\beta))^2 + (1 - F(X_t\beta))F(X_t\beta)^2 \\ &= F(X_t\beta)(1 - F(X_t\beta)) . \end{aligned}$$

The only way to get ML estimate in binary choice model is the least square model which is weighted again in the equation (8) frequently. We consider the fact that ML is equal to weighted NLS in binary choice models [16]. In logic model $\Psi(X_t\beta)$ is simplified to $\lambda(X_t\beta)$. This asymptotic covariance matrix is obtained by inverting the data matrix. The data matrix is written as

$$J(\beta) = \frac{1}{nx'\psi(\beta)x} . \tag{8}$$

In practical issues of binary choice models the first time conditions is not necessary obtained the unique result [17]. This condition occurs when the given data is not able to provide the sufficient information to determine the effective elements of the model or linear combination between some of independent variables.

Then there is the assurance that there is $f(x_t\beta) \to 1$ for all observations of

$Y_t = 1$ and for all observations $Y_t = 0$ and $f(x_t\beta) \to 0$. So, the likelihood function goes to zero but, consider that zero is the high limit for this function [18]. When Zt is the linear combination of a constant number and an independent variable, it is called full classifier variable, because Yt can be completely divided to zero and one groups [19].

For example see the following function:

$$y_t = x_t + u_t \qquad u_t \approx \text{NID}(0,1) \ ,$$

$$\begin{cases} y_t = 1 & \text{if} \quad y_t^{\bullet} > 0, \\ y_t = 0 & \text{if} \quad y_t^{\bullet} \leq 0. \end{cases} \tag{9}$$

This model is shown as

$$E(y_t|x_t) = \phi(\beta_0 + \beta 0_1 x_2) \ . \tag{10}$$

In regression models this is common to test the null hypothesis of deviations by using the statistics F.

3.1. Least squares method

For the compatible matrix the numerical value a_{ij} is equal to W_i/W_j. But in practice, it happens rarely, and generally A is an incompatible matrix. In least squares method W_i and W_j are determined in a manner calculated to minimize the sum of squares differences [20]. In other words, it can generally be said that:

$$\text{In compatible form (for each } i,j) \quad W_i = a_{ij} W_j \ ,$$

$$\text{In incompatible form (at least for one } i,j) \quad W_i \neq a_{ij} W_j \ .$$

For calculating W_i and W_j, the following nonlinear programming should be used

$$\min(z) = \sum_{i=1}^{n} \sum_{j=1}^{n} (\alpha_{ij} W_j - W_i)^2 \ ,$$

$$\text{s.t.} : \sum_{i=1}^{n} W_i = 1 \ . \tag{11}$$

It is worth mentioning that in the above nonlinear programming the limitation of $w_i \leq 0$ has to be considered. The problem can be solved without taking into account this limitation [20].

3.2. Fuzzy analytic hierarchy process (FAHP)

This model is developed model of Analytic Hierarchy Process (AHP) based on Fuzzy set theory. So, before stating the FAHP, it seems necessary to mention the

main initial points about fuzzy sets and numbers [21].

In practice generally working with triangular fuzzy numbers is easier because of their simplicity of calculation. And also, the triangular fuzzy numbers are appropriate to show and process data in a fuzzy environment [21]. The FAHP approach of this project is applying the triangular fuzzy numbers to overcome the deficiencies of AHP model. In general, $M \in F(R)$ is called a triangular fuzzy number if

1. There is $X_0 \in R$, so that $\mu_M(x_0) = 1$.

2. For each $\alpha \in [0,1]$, $A\alpha$ is defined as

$$A\alpha = [x\,,\ \mu_{A\alpha}(x) \geq a]\ . \tag{12}$$

Here $F(R)$ shows all fuzzy sets and R states the real number set. A fuzzy number of M on R is called a triangular fuzzy number if its date function of $\mu_M(x) : R \to [0,1]$ is equal to the following equation:

$$\mu_{M(X)} = \left\{ \begin{array}{ll} \frac{x}{m-1} - \frac{1}{m-1}, x \in [l,m] \\ \frac{x}{m-u} - \frac{u}{m-u}, x \in [m,u] \\ 0 \qquad\quad \text{otherwise,} \end{array} \right\}$$

$$1.\quad (l_1,m_1,u_1) \oplus (l_2,m_2,u_2) = (l_1+l_2, m_1+m_2, u_1+u_2)\ . \tag{13}$$

$$2.\quad (l_1,m_1,u_1) \otimes (l_2,m_2,u_2) = (l_1,l_2,m_1,m_2,u_1,u_2)\ . \tag{14}$$

In this research the FAHP is used on extent analysis which applies triangular fuzzy numbers. The process of the FAHP based on extent analysis is as follows:

Suppose that $X = \{x_1, x_2, ..., x_n\}$ is an object collection and $G = (g_1, g_2, ..., g_m)$ is the goal set[22].

3.3. Calculation of relative importance vector (weights) of the elements

If A is a pair comparison matrix for the fuzzy numbers, that $=$ () and $L =$, for achieving weight vector estimations under each criterion the principle of fuzzy number comparison is considered.

Definition: if we have two triangular fuzzy numbers from $M_1 =$ and $M_2 =$, $M_1 \geq M_2$ is defined by the following equation:

$$V(M_1 \geq M_2) \sup\left[\min\left(\mu_{M_1}(x), \mu_{M_2}(y)\right)\right],\ x \geq y\,. \tag{15}$$

When there is a pair of (x,y), if $x \geq y$ and $\mu_{M_1}(x) = \mu_{M_2}(y) = 1$, then we have $(M_1 \geq M_2) = 1$, because $M_1$and M_2 are the convex fuzzy numbers. Therefore we have

$$V(M_1 \geq M_2) = \mathrm{hgt}(M_1 \cap M_2) = \mu_{M_1}\,. \tag{16}$$

By extending the equation (4-20), the equation (4-21) is achieved

$$V\left(M_1 \geq M_2\right) = \begin{cases} 1 & \text{if } M_1 \geq M_2, \\ 0 & \text{if } \ell_2 \geq u_1, \\ \frac{\ell_1 - u_2}{(m_1 \geq u_2)} & \text{otherwise.} \end{cases} . \tag{17}$$

Symbol d is equal to width of the highest point of intersection D between μ_{M_1} and μ_{M_2}. To compare M_1 and M_2, both values of $V\left(M_1 \geq M_2\right)$ and $V\left(M_1 \geq M_2\right)$ are required [24].

Definition: the possibility of one convex fuzzy number is bigger than kth convex fuzzy number of M_i, in which $i = 1, 2, \ldots, k$ is defined by the following equation [24]:

$$V\left(M \geq M_1, M_2, \ldots., M_k\right) =$$

$$= V\left[\left(M \geq M_1\right) and \left(M \geq M_2\right) \text{ and } \ldots. \text{ and } \left(M \geq M_k\right)\right] =$$

$$= \min V\left(M \geq M_i\right), \; i = 1, 2, \ldots, k\,. \tag{18}$$

If we have

$$d'\left(A_i\right) = \min V\left(s_i \geq s_k\right), \tag{19}$$

where $k \neq i$ and $k = 1, 2, \ldots, n$, the weight vector is obtained from the equation the previous equation

$$w' = \left(d'\left(A_1\right), d'\left(A_2\right), \ldots., d'\left(A_n\right)\right)^{\mathrm{T}} . \tag{20}$$

Here, $A_i (i = 1, 2, \ldots, k)$ are n-elements [24].

By normalization, the normalized weigh vectors are obtained from the following formula:

$$w = \left(d\left(A_1\right), d\left(A_2\right), \ldots., d\left(A_n\right)\right)^{\mathrm{T}} , \tag{21}$$

where w is a fuzzy number [25].

3.4. Expanding higher order neural network (HONN) as a credit model for increasing profitability

In the recent years various species of HONN were developed. HONN uses more correlation of input neurons to set up the features in a better way, which usually lead to production of more numbers of training weights, in such a way that the degree of model will increase and so, the number of applied parameters will increase too [25]. Much efforts are done in different area to reduce the numbers of parameters, finally two major forms of HONN is considered, the sigma-pi network which is known as navigation processing unit, and pi-sigma (PSN) [22]. The HPU models need more training parameters for updating that more numbers of parameters prolong the period of the project.

HONN model 1b is

$$z = \sum_{ij=0}^{n} a_{ij}^{o} \left\{ a_{ij}^{kx} \cdot f_{x_1}^{i} \ \left(a_i^{x_1} x_1 \right) \right\} \cdot \left\{ \left(a_{ij}^{hx_2} \ \cdot f_{x_2}^{j} \ \left(a_j^{x_2} x_2 \right) \right\} \right. . \tag{22}$$

HONN model 1 is

$$z = \sum_{i,j=0}^{n} a_{ij}^{o} \cdot \left\{ f_{x_1}^{i} \ \left(a_i^{x_1} x_1 \right) \right\} \cdot \left\{ f_{x_2}^{j} \ \left(a_j^{x_2} x_2 \right) \right\} . \tag{23}$$

HONN model 0 is

$$z = \sum_{i,j=0}^{n} a_{ij}^{o} \cdot \left\{ f_{x_1}^{i} \ \left(x_1 \right) \right\} \cdot \left\{ f_{x_2}^{j} \ \left(x_2 \right) \right\} . \tag{24}$$

The model 1b has three layers of weights which must be changed during the period of project, the model 1 has two layers and model 0 has one flexible weight. For the models 1, 1b and 0 there is Z output, where X_1 and X_2 are two inputs of HONN, a_{ij}^{o} is the output layer weight, a_{ij}^{kx} and $a_{ij}^{hx_2}$ are the second layer weights and $a_i^{x_1}$ and $a_j^{x_2}$ are the first layer weights [26]. The neuron function of the first hidden can be any nonlinear function, and for the formula of (18), (19), and (20) the values of k and j can change from 0 to n, where n is an integer. By HONN any nonlinear function can be estimated [26]. The training algorithm makes the updated weights for each different model. Then as it is usual in most training algorithm of neural networks the weight setting is happened reversely.

Briefly the HHONN training algorithm is as follows:

1. Initial valuating of N_1 , $N_2^{(1)}$, $N_2^{(2)}, N_3$, N_4 with zero amount and model degree set in the form of $N = [N_1 \ N_2^{(1)} \ N_2^{(2)} N_3 \ N_4]$.

2. To add a unit to the model degree (N), For example when the first degree is [00001], the next degrees will be [00010], [00011], [00100], and [00101].

3. Weight setting for the new model.

4. Updating the weights through using the equations (19) and (21). Calculating the regression coefficient of determination and mean square error for training data and validation data.

5. It is the end of algorithm when the value of regression coefficient of determination for validation data is desired otherwise, go back to the second level. In equations (19) and (21) the improved weights are less than the main weights when the gradient is positive, and these weights are more than main weights when the gradient is negative. thus, according to training formulas after updating the weights, the model HHONN goes to the minimum difference between desired output and the real output.

4. Conclusion

The proposed hybrid model consists of fuzzy analytic hierarchy process for initial weighting of each criterion according to the expert, genetic algorithm and high- order neural network algorithm for final weighting, and training model according to the historical data. The mentioned model has been performed on the collected data 200 times by selecting different samples for training, validation and test. The average of regression coefficient determination of this model for the test data has been obtained as 84 %. But, the number of sentences of this model was 34 and it could not be used as a white box model. To solve this problem as explained before the genetic algorithm was used to reduce the degree of model's difficulty and move to make a white box model.Therefore, we reduced the accuracy of model by using the genetic algorithm to reach an open box model and reduced the degree of model difficulty.

The profitability part of research tried to assess the impact of credit risk management on profitability of the Iranian commercial cases banks, based on ROE and ROA and, credit risk indicators for the years (2009–2013). The analysis results when the indicators measured by ROE show that non-performing loan have positive impact on the banks profitability which means that it is necessary for Iranian commercial banks to work hard in managing credit risk to minimize the number of unpaid loans. It also shows that three other financial indicators analyzed in this part of research has no significant impact on profitability of Iranian banks when measure by ROE. Measuring the indicators by ROA concluded that Iranian commercial banks are negatively affected by Non-performing loans/Gross loans ratio, where credit interest/Credit facilities ratio and CAR has no impact on profitability which negatively affected by leverage ratio. So, they should pay more attention to their debt, because higher leverage will increase the liability and debt services of bank which can negatively impact on its profitability.

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