Assessment of Credit Risk Management and Managerial Efficiency of Banks Using Data Envelopment Analysis (DEA) Network

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ABSTRACT: Banking industry by providing credit facilities to other industries, plays an important role in the economy stems. Managers in the industry has been designed to increase the efficiency of lending, credit rating and ability to repay principal and interest for each customer's credit limit. The aim of this study is to evaluate credit risk management and performance management of the 19 banks supervised by the Central Bank of Tehran, Arak and Boroujerd cities. The study of network DEA models (with and without notice to the Credit Risk Management) has been designed to assess the studied Banks. To collect data for this study 10 branches of banks were randomly selected and the importance of credit risk management and assessment questionnaire is completed by branch managers. Data analysis was performed using DEA Solver Software. The results suggest that attention to credit risk management in the banking industry affect on performance of banks.

Keywords: Credit risk management, performance management, network and data envelopment analysis (DEA), the banking industry.

INTRODUCTION

Banking system plays an important role in economy, because in addition to this, banks act as mediators of funds in monetary market and due to the inadequate development of the capital market they play an essential role in financing and long and mid-term economic plans. In general it can be stated that the most important activities of banks is collection and allocation of financial resources to different sectors of the economy (George and Shoury, 1987). But it should be noted that this funding on the one hand, the bank needs to provide facilities and these funds meet the needs of banking facilities, on the other hand, banks that have limited financial resources, should optimally allocate the means to provide services which means the efficiency level of the firm. Based on the economic theories, efficiency is a result of optimizing the production and allocation of resources. Equipping and allocation of investment resources in economic activities are done through financial markets that credit market is part of this market. Hence role of the banking system in the process of economic development of countries to mobilize financial resources for the implementation of projects, providing working capital, mortgage loans, reducing the basic needs of the population and prevent the deepening of economic, investment and employment, is so important that maintaining the

financial health of banks must be the first priority of the national economy of countries. It should be noted that the financial and banking system, according to its own characteristics, are facing with a variety of risks, including credit risk, liquidity risk and market risk. So identifying and controlling the amount and rate of each of these risks is important in its own place (Mehrara and Mehranfar, 2013). With the continuous and dynamic development of the credit industry every day, the industry plays a more important role in the national economy and creditors are using new tools and technologies for developing credit management process. Validation and assessment of the repayment capacity of clients using advanced statistical techniques and methods are among the efforts that have been done in this area. Accreditation means the assessment of repayment capacity of the loan applicant and the likelihood of repayment of the financial facilities and funds received by them .The model for measuring credit risk rating was performed on the bonds in 1909 by John Murray. Given the importance of credit risk in the banking industry, in this study we tried to evaluate the credit risk management activities and performance management in banks and then using the data envelopment analysis model for ranking of database network is performed with or without paying attention to indicators of credit risk management.

THEORETICAL FRAMEWORK AND RESEARCH BACKGROUND

A. Risk and Credit Risk Management

The word "risk" refers to the probability of happening of danger, injury, income fall and loss. Risk means uncertainty about the outcome of a case in the future or unexpected events, which usually is a change in the assets, or debts. In general, risk means the probability of loss arising from uncertainty in the lack of certainty in the full knowledge and accurate and comprehensive understanding of the world around us. Risk phenomena in many areas of application can be propounded and banks are one of the main areas that are crucial to the economy because they are considered important in this scope (Mehrara & Mehranfar, 2013). Due to the variety of banking activities, researchers and scholars have no consensus on the types of risks in banking operations. Some experts believe credit risk, interest rate risk and liquidity risk are among the risks of the banking operations while others contend that market risk, credit risk, liquidity risk, operational risk, legal risk and risk factors are among the most important human-risk banking operations (Mirzaei & coworkers, 2011). Figure 1 shows range of risks in the banking industry.
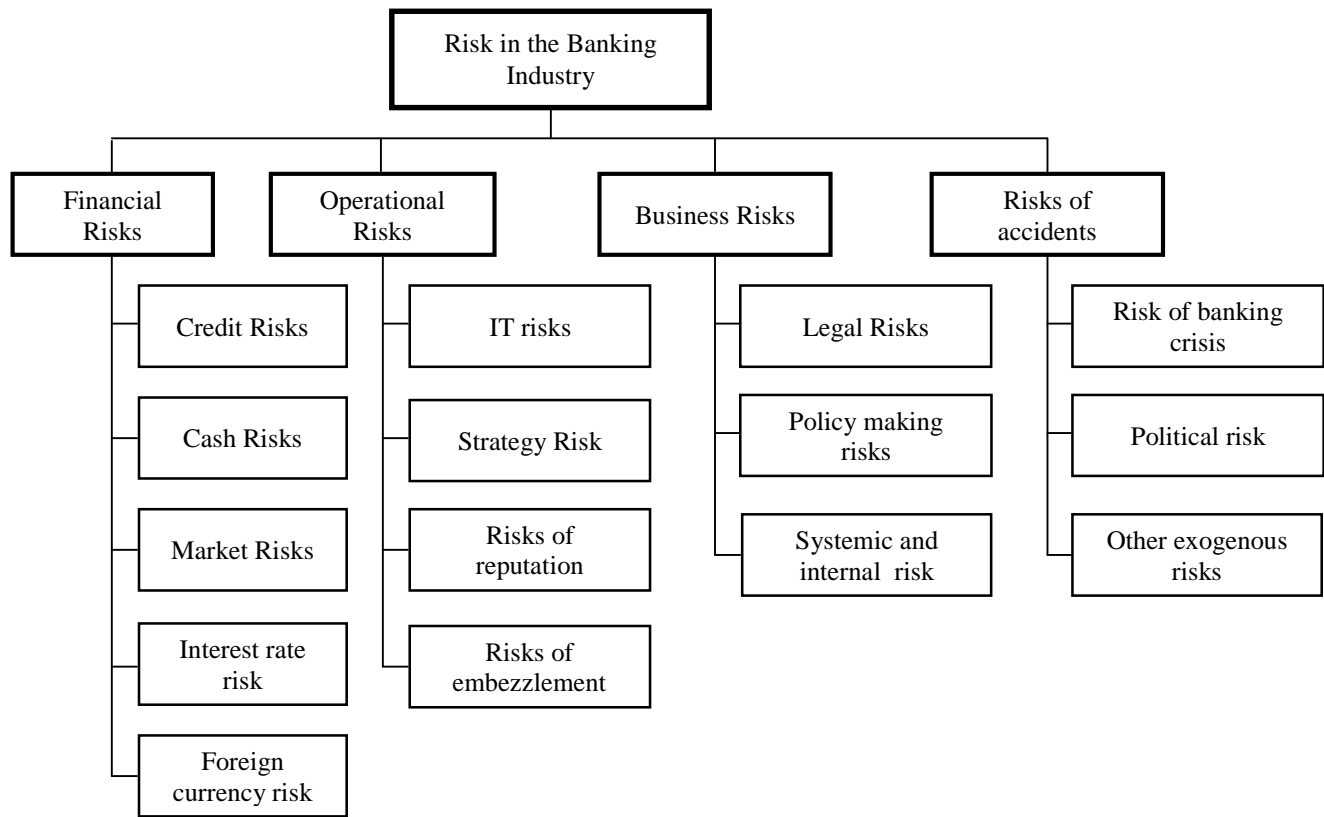

Fig. 1. Shows the scope of risk in the Banking Industry.

Providing financial facilities is considered as one of the most important activities in the banking system. In other words, banks intend to grant loans to those companies that have a low risk of return and can return proportional to profit facilities. This is attained when the banks are able to identify their credit customers (natural or legal) and Classify them based on the ability and inclination towards full and timely repayment (John et al 1998). For granting the facilities, credit rating and ability to repay principal and interest amount of credit should be determined for facility recipient. The likelihood that the borrower fails to repay the loan is called credit risk, or the risk of non-repayment (Sinky & Joseph, 1992). Credit risk is of the oldest and largest of risks which exist in transactions and means the risk of losing the granted credit by failure to pay the debts by borrowers (Oryani 1984). In other words credit risks means repayments of customers to banks about received facilities may be done with postponements or even not received at all and this can cause some problems for cash flow and liquidity management (Shamsodini, 2010). It is evident that prevailing in credit risk is associated with economic mechanisms. Consequently, most banks consider internal rating system for borrowers.

On the subject of credit risk, management risk becomes significant. Credit risk management is a process through which the losses from defaulted loans over the business cycle can be calculated quantitatively including the following steps: (i) Calculation of avoiding payment of consumer loans by means of quantitative models (ii) Calculation of payment avoidance using statistical models. (iii) Evaluation of the model using data from past periods. According to Switzerland Basel Committee the objective of credit risk management is to optimize the modified efficiency of the bank based on credit risk and also controlling the danger of credit risk through accepted parameters. Today, most banks and financial and credit institutions are somehow involved in credit granting. Usually one of the methods according to their circumstances and the surrounding community is selected for credit ranking .With regard to observations, most banks over the country use Judgment method to determine the credit risk of customers. In this way, management uses its judgment and logic, the final decision making and this decision may noy be close to reality as it should be. Hence the authors suggest that bank managers use quantitative models for their credit risk rating. Most quantitative models of credit risk have similar conceptual framework and the significant difference of these models refer to the method of estimation of basic parameters of available information. Generally the credit risk measurement techniques can be divided into two main groups (Kiss, 2013). (i) parametric credit scoring (as Liner probability model, Logit model, Probit model discriminate analysis model) and (ii) Non parametric credit scoring models (as mathematical planning, tree classification), classification trees (recursive partitioning algorithms) nearest neighbors model, analytical hierarchy process (AHP), expert system, artificial neural network, genetic algorithm. But in the meantime, the DEA considered several aspects that include: (i) Data envelopment a analysis method (DEA), this is an easy and simple approach and for its specific performance this method can obtain an accurate credit decision based on trust and satisfaction attract our customers (Mehrgan 2004). (ii) In this technique there is no need to assign weights to the criteria (data output), because DEA automatically creates the associated weights, removing the allocation of weights gives more momentum to the performance evaluation process (Cheng et al 2007).

Unlike parametric methods, with making averages comparing with units of the best performance reaches the set of units under study. DEA optimize each of the observations in comparison with efficient frontier and all observations are collected and used to measure efficiency stems. 4) the last advantage of this method is using practical date and information. Unlike the well-known methods such as multiple discriminant analysis, logistic regression and neural networks that require rank-rating data for the purpose of predictions, uses the actual data collection and practical approach to data envelopment analysis (input-output).

B. Data envelopment analysis
Data envelopment analysis is a technique to calculate the relative efficiency of a set of homogeneous decision making units which is done using mathematical programming. The term "relative" is for this reason that performance is result of comparing units with each other . When we say that the decision-making unit is Pth of performance it means that the unit is working well and using good resource. In data envelopment analysis there is no need to assign weights to the inputs and outputs because this method determine the weights. In other words, for every single decision it considers most favorable set of weights *i.e* the set of weights relative efficiency of decision making units without increasing the performance ratio of the maximum decision. In other words, it helps decision makers to categorize in the efficient and inefficient decision making units into two groups. One of the features of data envelopment analysis is the structure of return to scale. According to this, the technique is divided to CCR and BCC . Return to scale can be constant or variable. Constant return to scale means that an increase in output leads to increased proportionally to the amount of input. In the variable return to scale, output increases more or less than the increase in input. CCR model, is one of the models of constant returns to scale. Using the constant returns to scale model, is suitable when all the conditions of competition and restrictions are the same for all units. Farrell in relative measurement units to construct a virtual single unit focused on total harmonious unit. And as a means for measuring the technical efficiency, suggested the following relationship:

Efficiency = Total weighted out/ Total weighted

If the goal is to evaluate the efficacy of n units, each having m input and s output, Efficiency of the j-th (j = 1,2, ..., n) is computed as follows:

$$\text{Efficiency of the j-th} = \frac{\sum_{r=1}^{s} u_r \, y_{rj}}{\sum_{i=1}^{m} v_i \, x_{ij}}$$

That:
X_{ij}= The i-th input to the j-th unit (i = 1, 2, ..., m)
Y_{rj}= I j-th unit of output r (r = 1, 2, ..., s)
U_r= weight given to r output (r th output prices)
V_i= Weight given to input i th (i is an entrance fee)

The important matter in the above relation is that this performance evaluation tool requires a set of weights that will be used for all units under study two points should be noted in this relation. First, the value of inputs and outputs can be different and difficult to measure. On the other hand it is possible to organize their operations in a manner different units that outputs are provided with different values so they need different weights in measuring the performance. Charnz, Cooper and Rhodes recognized the above problems and to solve this allocated inputs and outputs to this model and proposed the units that can accept weights that are more suitable and clear comparing to other units.

Under these conditions, the model for the evaluation of the unit under study, then we call it a zero units, is obtained by Solving the following linear programming model which is called the CCR model. Suppose there are n units are available for the model and the goal is evaluating the performance of the unit under study (single zero) or a decision making unit. The inputs $x_{10}, x_{20}, ..., x_{mo}$ To produce outputs use $y_{10}, y_{20}, ..., y_{so}$. If the weights assigned to the outputs of $u_1, u_2, ..., u_s$ and the weights assigned to the inputs with $v_1, v_2, ..., v_m$ The maximum deduction shall be shown below

$$\frac{\sum_{r=1}^{s} u_r \, y_{r0}}{\sum_{i=1}^{m} v_i \, x_{i0}}$$

This operation must be performed for other units. Thus, the mathematical model for each unit (j=1, 2, ..., n) is as follow :

$$Max Z_0 \approx \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}}$$

$$St: \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1 u_r , v_i \ge 0$$

Wights are the variable of above problem and the answer calculate the most appropriate amounts for weights of zero units and performance (Alam Tabriz & Mohammed Rahimi, 2010).

RESEARCH QUESTIONS

1. How the risk management activities and performance management in banks would be?
2. How the rated banks with respect to credit risk management index using data envelopment analysis network would be?
3. How the rated banks with respect to credit risk management index using data envelopment analysis network would be?

RESEARCH METHODOLOGY

The present study is based on the outcome or target, is of application research and in terms of method belongs to descriptive researches.

In this study, literature studies were used in order to form the basis of definitions and theoretical concepts. Also, in order to extract facts and figures required by banks we used experimental method (Using the database of the Central Bank). In order to collect the required data in relation to the Bank's risk management field method was used. The population of the study are the Banks supervised by the Central Bank of Iran. Given the possibility to extract the required data from the data banks, of 28 public and private banks operating in the country, A total of 19 banks (Ansar, Iran Zamin, Parsian, Pasargad, Post Bank, Tejarat, Tose Saderat, Hekmat Iranian, Day, Saman, Sepah, Sina, Shahr, Saderat, Mehre Iran, Gardeshgari, Mellat and Meli) have been studied. Also the questionnaire of calculating the risk management, from 10 branch offices in the cities of Tehran, Arak and Borujerd been completed.

For the purpose collecting data in this research, data tables and profit and loss statements of banks were used and Credit Risk Management Questionnaire of Khalil Araghi was also used. This questionnaire measure the amount importance of bank managers toward factors as 1) Screening and monitoring, 2) establish a long term relationship with our customers, 3) loan commitments, 4) security, 5) compensating balance requirements, and 6) rationing. The questionnaire included 11 questions with 5 scales the sum of responses to questions from a moderator, and the score would be the one that He would obtain in the credit risk management.

The scores range would be from 11 to 55. Finally, the mean score for managers of bank branches are considered as the final score. The resulted score indicate the importance that bank managers consider for the credit risk. That is, the higher the score, the higher accuracy of the directors of that bank examination for the customers credit risk .For analyzing the data of this research we used DEA and DEA Solver software. In this study, two models are provided to measure the effectiveness of each bank. The first model, measures each of the bank's management efficiency, regardless of the risk management (figure 2) and the second model, measures the performance of each of the bank's management with respect to risk management (Figure 3). Thus, using a three-stage model with fixed inputs and outputs, each of the banks' performance is measured. Criteria used as input and output in both models, is considered according to Matthews Studies (2013). Figure 2 shows the three-step model for measuring the management performance, regardless of the risk management.
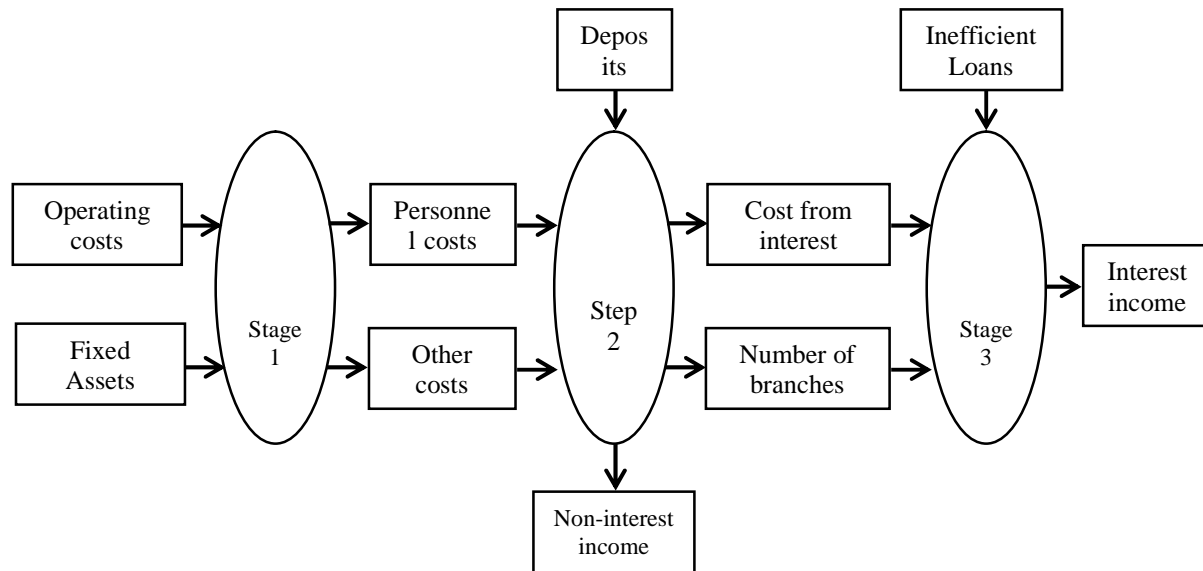

Fig. 2. Three-stage DEA model of the network, regardless of the credit risk management index.

As can be seen in figure 2, The main inputs (operating expenses, fixed assets and deposits) and the final outputs (interest income and non-interest income) exist. Firstly, operating expenses and fixed assets are used to create a time and materials (computers, construction, electricity, etc). Personnel costs and other operating costs, intermediate outputs are in the first stage and intermediate inputs are in the second stage of production. The input of the second stage are combined with deposits to make the interest costs related to the number of branches (Output of the second stage and the main inputs in third stage). Banks need for workforce, materials and supplies as initial inputs to achieve the profits from lending and banking services. Interest on deposits, is a tool to attract deposits by banks, so It is viewed as an input in the second stage. Bank branches are located in areas that attract business customers for paying bank services and deposit services and loans. Furthermore, in combination with primary and intermediate inputs produced in the second stage, banks charge fees for financial services to their customers. These fees are non-interest income produced as a final output. Costs arising from interest and number of branches, intermediate inputs of production are interest income in the third stage (final output of second stage). On the other hand, the output of inefficient loans is included as the main input in the final stage. Finally the main product of a bank, are the loans that the credit quality of them are extracted from type and quality of credit. It should be noted that in each stage of the network model an output-oriented CCR model is analyzed. Three-step model for measuring management performance, With regard to the risk management, First and second steps are exactly the same as the previous model, but in the third, the risk management score in each of the banks which achieved by the extend of bank managements notice to risk management questionnaire based on risk management criteria, is included as one of the main inputs of the third stage. And the efficiency of banks is measured with respect to the new input (Fig. 3).

Note that in the models mentioned above, the average output stages can be considered as an overall output and the final ranking is done on this basis.
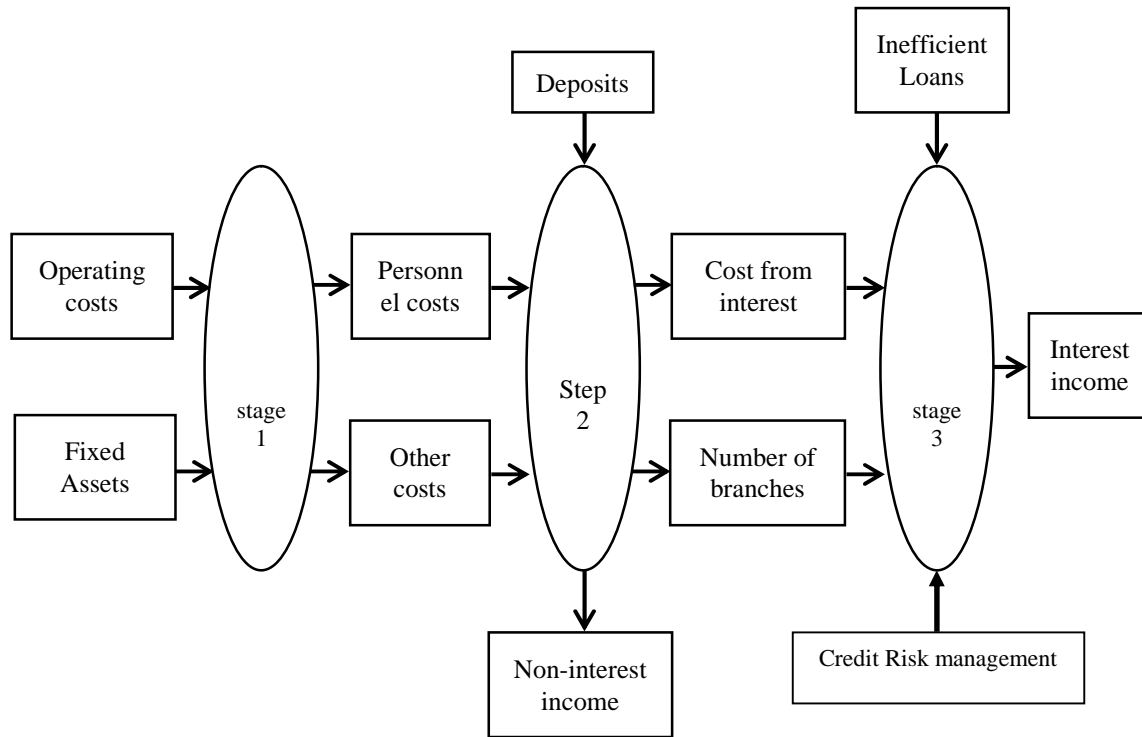
Fig. 3. Three-stage DEA model network model with input of credit risk management.

RESULTS AND FINDINGS

The first question is: How the score of managerial efficiency and banks' risk management activities would be? In order to calculate the risk management activities and performance management in banks, A questionnaire, completed by the management bank branches or banks' credit management, was used .In this questionnaire the extent of importance that management considers for credit risk activities is evaluated and scored. In this way, each of the activities is posed in the form of a question and a rating is assigned to it using Likert Scale. Finally, the average of each bank branch management comments is computed and will be considered as the final score for each question. Finally Total achieved scores from questions is approved as the bank's risk management activities. The score of bank's credit risk management activities is shown in Table 1.

Table 1. The score of the credit risk management activities.

Banks	The score of credit risk management activities
Ansar	42.5
Iranzamin	39
Parsian	42.5
Pasargad	37.5
Postbank	43.5
Tejarat	41
Tosee Saderat	34
Hekmat Iranian	42
Day	40.17
Saman	41
Sepah	40
Sarmayeh	37
Sina	37.5
Shahr	43
Saderat	36
Mehre Iran	38
Gardeshgari	38.5
Mellat	44.57
Meli	37.17

According to the score of Bank's credit risk management activities that are shown in Table 1, Bank Mellat, has the highest point and Tosee Saderat lowest points.

The Second question of research:
How would be the rating of banks with respect to credit risk management index using data envelopment analysis network?

In order to rank the banks using DEA a three-stage model is used (Figure 2). In this model, at each stage, and output measures as intended criteria as input and output are considered. Results of analysis in each step, is obtained with help of output-oriented CCR model. And finally the average results of the three stages is calculated and the final ranking is done. Table 2 shows the scores obtained in each stage and finally the rating of each bank is done regardless of credit risk management index.

Table 2. Shows the rating and ranking of bank units regardless of credit risk management index.

Bank	Step 1 score	Step 2 score	Step 3 score	Final Score	Final Rating
Ansar	0.303376	0.601279	0.929095	0.611249886	11
Iran Zamin	1	1	0.444007	0.814669	1
Parsin	0.270655	0.422845	1	0.564499737	14
Pasargad	0.296557	1	1	0.765518982	3
Post Bank	0.599203	1	0.17733	0.592177622	12
Tejarat	1	0.407297	0.652924	0.686740154	8
Tosee Saderat	0.314447	1	0.27501	0.529818989	17
Hekmat Iranian	0.169501	1	1	0.723166981	6
Day	0.106586	1	1	0.702195426	7
Saman	1	0.55361	0.711049	0.754886275	4
Sepah	0.884678	0.484192	0.266702	0.545190706	16
Sarmayeh	0.269689	1	0.397759	0.555815939	15
Sina	0.433536	0.828107	1	0.753881072	5
Shahr	0.241186	0.61639	1	0.619192071	10
Saderat	1	0.664076	0.241053	0.635043005	9
Mehre Iran	0.487858	1	0	0.495952581	19
Gardeshgari	0.36276	1	1	0.787586596	2
Mellat	0.699932	0.596257	0.26378	0.51998946	18
Melli	0.863386	0.606602	0.268068	0.579351723	13

As can be seen in table 2, With the final score obtained for each of the banks surveyed, the banks Iran Zamin, Gardeshgari and Pasargad have the most performance and Tosee Saderat, Mellat and Mehr Iran have the lowest performance. This rating is done while the extend of credit risk management notced by the banks is not considered.

The third question of the research:
How would be the rating of banks with respect to credit risk management index using data envelopment analysis network?

Indicator of credit risk management in the third stage DEA model network, entered the model as an input (Fig. 3). So The results obtained in steps 1 and 2 are unchanged and the third part of the analysis with regard to the management of credit risk is assessed again. Table 3 shows the scores obtained in each stage and finally score and rating of each bank with respect to credit risk management index.

Table 3. Score and rating of bank units with respect to credit risk management index.

Bank	Step 1 score	Step 2 score	Step 3 score	Final Score	Final Rating
Ansar	0.303376	0.601279	1	0.634885006	12
Iran Zamin	1	1	0.771515	0.923838255	1
Parsin	0.270655	0.422845	1	0.564499737	17
Pasargad	0.296557	1	1	0.765518982	6
Post Bank	0.599203	1	0.181565	0.593589253	15
Tejarat	1	0.407297	1	0.802432219	4
Tosee Saderat	0.314447	1	0.286863	0.533769937	18
Hekmat Iranian	0.169501	1	1	0.723166981	10
Day	0.106586	1	1	0.702195426	11
Saman	1	0.55361	0.711049	0.754886275	7
Sepah	0.884678	0.484192	0.517699	0.628856657	13
Sarmayeh	0.269689	1	0.485347	0.58501199	16
Sina	0.433536	0.828107	1	0.753881072	8
Shahr	0.241186	0.61639	1	0.619192071	14
Saderat	1	0.664076	0.774288	0.812788097	3
Mehre Iran	0.487858	1	0	0.495952581	19
Gardeshgari	0.36276	1	1	0.787586596	5
Mellat	0.699932	0.596257	0.87766	0.724616145	9
Melli	0.863386	0.606602	1	0.82332921	2

According to Table 3, it is observed that the final ranking of each of the banks surveyed the banks namely Iran Zamin, Mellat, Saderat have the highest performance and Tosee Saderat, Parsian and Mehre Iran have the lowest performance. This scoring is ion condition that the extend of credit risk management noticed considered by banks' managers is also taken into account.

DISCUSSION AND CONCLUSION

The aim of this study is to evaluate banks' risk management, managerial efficiency using data envelopment analysis network In other words, this study is an attempt to rank the banks based on risk management by managers. According to the obtained results in this study, the highest score of risk management activities belongs to banks. And most banks try to minimize the credit risk of lending to customers of its entities. On the other hand banks in the ranking of network data envelopment analysis model network with respect to credit risk management implies that banks of Iran Zamin, Mellat, Saderat have the highest performance. The interpretation of the results can be paraphrased as the managers of these banks, check the accounts and savings of customers data before loans are paid. However these managers to ensure the repayment of loans granted, seek an acceptable pledge from individual or legal entities who have taken the loans. Given that those requesting the loan are of natural or legal entities. Bank managers prior to the lending loans, try to find information about the method of financing, wages, bank accounts and assets of individuals who are applying for a loan.

Also, if the loan applicant, is a legal client, managers before lending the loan try to review the company's profit and loss statement, statement of income, assets and liabilities of the company.

On the other hand the importance of credit risk management by banks of Iran Zamin, Mellat and you can keep some of the funds to repay the loan in default if the borrower's account deduced. Generally managers that risk management is of high importance for them In addition, special attention to the above issues, the give importance to "Control of financial ratios (as ratio of instantaneous, average repayment period and inventory turnover) After spending the loan to companies to avoid spending load in risky activities" "Careful study of how to collect the checks used by the customer before the loan payments". And "lack of lending to high values even if the borrower is willing to pay a higher interest rate". In General the researcher suggests that banks have to make a decision about granting credit to customers, indicators like 1) The code for the client to receive the credit loans, 2) Inquiry the central bank and the banking system to assess the obligations and liabilities of all banks, 3) Credit questionnaires filled out by employees of the credit cycle, 4) Surveying financial statements and tax, 5) evaluation of the bail, 6) average of the account balance of customer in the branch and 7) Understanding the customer which obtained in a long run.

REFERENCES

Jalali Naini, Amir; Sasan, Gohar Pedtram; Asadipour, Nima, (1385), "Studying the role and importance of risk-based supervision in the banking system and comparing it with adaptive supervision", the collection of the Seventeenth International Conference articles on Islamic Banking.

George and Council, (1987), resource allocation, Tehran: the papyrus.

Shamsodini, Arash, (2003), "Credit Risk Management Principles", Summer Journal of Banking.

Alamtabriz, Akbar and Mohammed Rahimi, Alireza (2009) "Approach to Production and Operations Management In evaluating and improving business processes". Tehran: commercial publishing company.

Oryani, Behroz, (2005), "Rating of credit risk of legal customers based on data envelopment analysis", Thesis, BuAlisina University, *Faculty of Literature and Humanities, Department of Economics*.

Mehrara, Mohammed and Mehranfar, Mina, (2013), "Macroeconomic factors and bank performance in risk management", *Journal of Economic Modeling*, Vol. **VII**, No. 1, row 21, pp 21-37.

Mehrgan, Mohammedreza, (2003), "Quantitative models for performance assessment organizations, Tehran: Tehran University Press".

Mirzaee, Hasan; Nazarian, Farzad; Baghery , Reza, (2011), "Credit Risk factors affecting bank legal entities (Case Study Melli Bank of Iran, Tehran, Iran*)", Journal of Economic Research*, Vol. **XIX**, No. 58, pp 67-98.

John B. C., Edward I. A., Paul N.; "Management credit risk: The next grate financial challenge", John Wiley & Sons, N.Y, 1998.

Sinky Jr. Joseph F; "Commercial bank financial management"; 4th Edition; Macmilla, 1999.

Kiss F. "Credit rating process from a knowledge management prospective"; *Budapest University of Technology and Economics*, 2003.

Cheng EWL., Chaing YH., Tang BS.; "Alternative approach to credit Rating by DEA: evaluating borrowers with respect to PFI project"; *Journal of Building and Environment*, Vol. **42**, 2007.

Min JH. , Lee YC.; "A practical approach to credit Rating"; *Journal of Expert Systems With Applications*; doi:10.1016/j.eswa, 08.070, 2007.