Chapter 5:

Summary and Conclusion
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Risk and uncertainty have always existed in the essence of all the business and commercial activities. It contains a wide range of customers' services, fame, technology, security, human resources, market prices of goods and services, financing, legal affairs, personnel infractions, and definitely the institutes' strategies.

In the case of banks and financial institutes, credit risk is the most important factor which has to be managed. Although credit risk can be the result of different causes, these kinds of risks mainly arise from economical crisis, the companies' bankruptcy, lack of rules and regulations in the companies' accountancy and auditing process, the increase of off-balance sheet obligations, the devaluation of collaterals, and etc. A brief review on the essence of these causes shows that most of them are those which are out of the control of management of the banks and financial institutes. Therefore, in the process of their activities, the banks are affected by these factors. The lack of proper and trustworthy tools and procedures to prevent these dangers in the banks and financial institutes requires different risk management methods.

Because of the importance of credit risk in the banks and financial institutes and the role of the management of such risk, there has been much attention to the credit risk management, during the past few years.
Following such attention, different methods and tools have been introduced to such management in the banks and financial institutions, and have been repeatedly reviewed.

Although the given methods and tools have been effective in the situation of credit risk management in the banks, there has been a question remained that “Are the tools, methods, and models given and introduced, sufficient for the establishment of a full and comprehensive system of risk management?”. The aim of the research is mainly to study the existing methods and models of credit risk management in the banks, evaluate the studied models and methods, and in the end to present a comprehensive and effective model for credit risk management in the commercial banks.

This thesis comprises mainly five chapters. The first chapter deals with the generalities of the research, second chapter describes the relevant literature and theoretical background of the subject. Because of the importance of modeling in the present work, the methods and models of credit risk management have been separately explained in chapter three. The fourth chapter discusses the details of the presented model and also related calculation and estimation of the model for a commercial bank, and finally the fifth chapter deals with the summery of the study. These are being summarized as follows:

In the first chapter we have engaged ourselves in the generalities of the research, and we have mentioned that establishing a comprehensive and effective system of credit risk management in the banks can play an important role both in creating tools and facilities, and also in reviewing and reestablishing existing mechanism of identification, and evaluation of credit risk management and control. In this chapter we have also explained that the aim of this research is to give a clear definition of credit risk, and establishing a structure for designing an innovative system of credit risk management in commercial banks.
In the second chapter, literature and theoretical background of the subject has been issued. In this chapter, by reviewing the concepts of credit risk, we have mentioned the necessities and potential advantages of credit risk models. Credit risk models are intended to aid banks in quantifying, aggregating and managing risk across geographical and product lines. The outputs of these models also play increasingly important roles in banks' risk management and performance measurement processes, including performance-based compensation, customer profitability analysis, risk-based pricing and, to a lesser (but growing) degree, active portfolio management and capital structure decisions (Reto R. Gallati, 2003).

Then, we have defined the subjects such as expected loss, economic capital, default, exposure at default, and loss given default. As we continue the second chapter, we have mentioned the methods and importance of credit risk modeling. In the same framework, we have also explained the concept and method of estimating the recovering rate. In the end, methods and techniques of credit risk mitigation in the banks have been issued. Collateral, Third-Party Protections, Guarantees, and Support are main techniques for credit risk mitigation.

In chapter three, due to the importance of modeling in the present study, which in other words forms the main part of this research, the methods and models of credit risk management have been explained, and defined separately with mentioning the smallest details.

In chapter three, at first we have mentioned the credit risk modeling, and then the structural approach, and reduced form approaches have been explained in details. The second part of this chapter has allocated to the credit risk models which are known as commercial credit risk models as well. In this part, the concepts, details, model making and the application of four models: Creditportfolioview, Creditrisk™, KMV, and CreditMetrics™ have been explained.
The fourth chapter of this thesis is about the details of the model presented by the researcher and the model making theories in addition to the related calculation and estimation for a commercial bank. The aim of such estimation is to present an applicable example for the model given. The fourth chapter is consisted of three separate parts, and at the same time related. These parts are credit scoring, exposure limits and capital requirements. The major results of fourth chapter can be categorized in two parts, which has been carried out as follows:

A. The main finding of this thesis is to design a comprehensive and effective model for managing different aspects of credit risk in a commercial bank.

As we know, the general and recognized models of credit risk management are mostly concentrated on a complex of different aspects of existing risks in the banks. Most of these models have concentrated on the subject of the customers’ “Credit scoring”, and different model have been presented in the same field. These models have the duty of filtering the customers, in a way that customers asking for facilities are scored according to the predicted criteria which are effective for recognizing the credit situation of customers. Here we can mention criteria 5c.

Other groups of models are engaged in “exposure limits”, and its structure and framework. The aim of such models which are mostly experimental is to find the acceptable and optimum limits for credit exposures across geographical and product lines. Finally, the third groups of models intend to calculate the “capital requirements” in the banks, so that they can cover the deriving risks from the banks procedures. In any case what is important here is that the mentioned models and patterns are minor ones, and each of them manages a part of credit risk aspects. The aim of the present study is to give a comprehensive and applicable model for managing all the credit risk management’s aspects and dimensions in the banks. The following diagram shows the general framework of the proposed model.
As it is shown in the above figure, customers' credit scoring is the most important part of credit risk management in the banks. As the first of credit risk management, the banks have to have a developed system of recognizing and assigning rates and scores for their customers’ credit. Getting to know the credit standing of the customers, will give the banks a chance to determine the amount and level of their transactions according to their customer’s situation. Thus, the banks, by having true recognition of their customer’s credit situation, and also regulating the level of transactions and the amount of the facilities given plus deciding about the amount and the kind of collateral received from their customers on the basis of the risk sustained on the banks, can prevent the unexpected risks. This subject is a part of the proposed model.

The second part of the proposed model is related to determining the optimum level of the exposure limits of credit pillars in the banks. As it is quite obvious, the risk and loss implemented on the banks are the result of the quality and quantity of the facilities granted to the customers. If the banks do not benefit from a system for determining the optimum limit of authorization in granting facilities, then some of the credit pillar may sustain irreparable damages to the banks. For this purpose, the banks should have a system that through determining the amount of authorization of the banks credit pillars in granting facilities, can prevent irreparable damages to the banks, and therefore another part of credit risk management will be effective in the banks. In any case, this fact has been
accepted that designing the tools and methods of credit risk management in the banks will help the banks to reduce the risks sustained, but we should notice that these risks will never be omitted completely. This means that even by having developed an innovative model of customers’ credit rating, or determining the limits of credit authorization, there will still be an amount of risk sustained on the banks. The important point in here is that the banks have to have a system for determining the necessary reserves for covering and compensating these risks. In the proposed model, this subject has been taken into consideration, and determining the economic capital for the banks has been propounded as the third part of the proposed model of a comprehensive risk management.

The three mentioned parts are considered as the main parts of the proposed model. The important fact here is that the mentioned part should be related together from the input and output variables point of view. In this model, we can clearly observe this connection, in such a way that some of the output variables of the exposure limits of credit pillars are actually the output variables of customers’ credit rating. The following figure shows the parts, process, and the connection of variables in the proposed model.
As it can be observed in the above figure, the proposed model of credit risk management has three completely separated parts. However, these parts from the view point of input and output variables have an internal connection.

In order to design and estimate the model's coefficient, necessary data from some of credit files have been collected. Collecting data from these files can differ depending on the model chosen. By considering the known criteria for measuring the customer's credit, we have used 5C criteria, in order to collect data from the credit files. Then the mentioned data have been entered into the logit model and the related coefficients are estimated. Through using such model, the bank can estimate the credit score of each of its customers, and then put these scores in different categories, and as a result rate the bank's credit customers. This process has been introduced as step one in the above figure. In step two, in order to estimate the probability of default of all the loans given to the bank's credit customers, the data related will be entered into the designed model, and the output will be the calculations related to the probability of default of customers.

In the second part which is related to the designing and related estimating of the exposure limits of credit pillars, the input variables which consist of initial data matrix, resources' growth rate, and categorized customer's PD's is processed according to the designed model. The result of the model's process is in fact the estimation and determination of the optimum exposure limits of credit pillars.

In the third part, the capital requirements for covering the risks derived from the bank's activities is estimated. As it has been mentioned previously, the amount of the loans given by each of the credit pillars has been considered as value at risk. On the other hand, by using credit scoring model we can estimate the average default rate, or in other words $\mu = \Sigma \rho_i$ for each of the credit pillars. By having these two groups of variable, and through using Credit Risk$^+$ model, we can estimate and evaluate the required capital for the banks.
B. Second group of findings are the calculated results of running proposed model for POST BANK OF IRAN, which are as follows:

I. In order to set a proper framework for credit scoring of customers, we have applied the logit model. In definition of Logit model, there is a clear theory, and that is there maybe the possibility that the estimated probability is placed out of the gap of Zero (0) and one (1), so we have to solve this problem through finding a proper change which guarantees the placement of the estimation between this gaps. Assembled distributing functions can cause a chain of changes which can place P in below mentioned equation in the gap between 0 and 1, while it can keep its even characteristic as well. We assume that logistic distribution has been chosen to say about choosing probability; the logit function will be as follow:

\[ p = \phi(b'x) = \frac{1}{1 + e^{-b'x}} \]

Or in a different form:

\[ p = \frac{e^{b_1x_1 + \cdots + b_kx_k}}{1 + e^{b_1x_1 + \cdots + b_kx_k}} \]

logistic distributing function contrary to normal distributing function has a closed form, therefore it makes logit model’s calculating far easier than probit, so as a result computerizing, executing and usage is relative cost effective. However, the estimated outputs of logit model and fitted equation are as follows:
Estimation Command:

BINARY (D=L) P C MCU TC TT SF CO

Estimation Equation:

\[ P = 1 - \text{LOGIT}\left(- (C(1) + C(2) \cdot MCU + C(3) \cdot TC + C(4) \cdot TT + C(5) \cdot SF + C(6) \cdot CO)\right) \]

Substituted Coefficients:

\[ P = 1 - \text{LOGIT}\left(- (-0.06519253786 - 2.365725268 \cdot MCU + 3.081263388 \cdot TC - 0.09807636054 \cdot TT + 0.1214929986 \cdot SF + 1.068573229 \cdot CO)\right) \]

Dependent Variable: P
Method: ML - Binary Logit (Quadratic hill climbing)
Date: 10/03/08 Time: 02:21
Sample: 1 400
Included observations: 400
Convergence achieved after 5 iterations
Covariance matrix computed using second derivatives

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>z-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.065193</td>
<td>0.473005</td>
<td>-0.137826</td>
<td>0.8904</td>
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<tr>
<td>MCU</td>
<td>-2.365725</td>
<td>0.355854</td>
<td>-6.648016</td>
<td>0.0000</td>
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<td>TC</td>
<td>3.081263</td>
<td>0.328883</td>
<td>9.368873</td>
<td>0.0000</td>
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<tr>
<td>TT</td>
<td>-0.098076</td>
<td>0.031823</td>
<td>-3.081896</td>
<td>0.0021</td>
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<tr>
<td>SF</td>
<td>0.121493</td>
<td>0.057062</td>
<td>2.129154</td>
<td>0.0332</td>
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<tr>
<td>CO</td>
<td>1.068573</td>
<td>0.324506</td>
<td>3.292923</td>
<td>0.0010</td>
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</table>

Mean dependent var 0.490000  S.D. dependent var 0.500526
S.E. of regression 0.329413  Akaike info criterion 0.724404
Sum squared resid 42.75407  Schwarz criterion 0.784276
Log likelihood -138.8807  Hannan-Quinn criter. 0.748114
Rest. log likelihood -277.1789  Avg. log likelihood -0.347202
LR statistic (5 df) 276.5963  McFadden R-squared 0.498949
Probability(LR stat) 0.000000

Obs with Dep=0 204  Obs with Dep=1 196  Total obs 400

\[ P(Y=1|X) = \frac{1}{1+e^{(-0.065-2.366X_1+3.08X_2-0.098X_3+0.121X_4+1.068X_5)}} \]
II. We have used Mc Fadden R-squared statistic for accuracy test of estimated model. McFadden’s R2 statistic is as follow:

\[
Mc - fadden's - R^2 = 1 - \frac{LL(\alpha, \beta)}{LL(\alpha)} = 1 - \left[ \frac{-2LL(\alpha, \beta)}{-2LL(\alpha)} \right]
\]

Value of this criterion for our regression is 0.49 which shows that our estimation has been done properly.

III. The meaningfulness of each regression coefficients is studied by statistics Z. All of Z- statistics for model’s variable are higher than value 2. By considering meaningfulness level of 5%, all of coefficients are meaningful and acceptable.

In order to test the overall meaningfulness of regression, we have applied Value and probability of LR-Statistic. This test is completely similar to statistics F in linear regression models, and it tests the general meaningfulness of the regression, in a way that it tests the theory of absence of \( \beta_i \) for the regression coefficient except the width of the matrix which is estimated as \(-2(L - L)\). Value of this statistic is 276.6 and probability of LR is zero (0.0000). As a result the theory of absence is meaningless for the whole regression, or in other words the regression itself is meaningful.

IV. The exit of logit model is between 0, and 1. In order to determine who’s received facilities in future will be defaulted and whose will be liquidated, we need a threshold. In the case of our model the threshold limit of 0.5 has been obtained.

V. By using Misclassification Matrix, we have calculated Credit and commercial risk as follow:
Logistic model for $y$

<table>
<thead>
<tr>
<th>Classified</th>
<th>$D$</th>
<th>$\sim D$</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>169</td>
<td>30</td>
<td>199</td>
</tr>
<tr>
<td>-</td>
<td>27</td>
<td>174</td>
<td>201</td>
</tr>
<tr>
<td>Total</td>
<td>196</td>
<td>204</td>
<td>400</td>
</tr>
</tbody>
</table>

Classified + if predicted $Pr(D) \geq .5$

True $D$ defined as $y \approx 0$

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<table>
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<tbody>
<tr>
<td>Sensitivity</td>
<td>$Pr(+</td>
<td>D)$</td>
</tr>
<tr>
<td>Specificity</td>
<td>$Pr(-</td>
<td>\sim D)$</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>$Pr( D</td>
<td>+)$</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>$Pr(\sim D</td>
<td>-)$</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>False + rate for true $\sim D$</td>
<td>$Pr(+</td>
<td>\sim D)$</td>
</tr>
<tr>
<td>False - rate for true $D$</td>
<td>$Pr(-</td>
<td>D)$</td>
</tr>
<tr>
<td>False + rate for classified +</td>
<td>$Pr(\sim D</td>
<td>+)$</td>
</tr>
<tr>
<td>False - rate for classified -</td>
<td>$Pr( D</td>
<td>-)$</td>
</tr>
</tbody>
</table>

Correctly classified 85.75%

Credit risk (error type 1) = (1-sensitivity) = \[
\frac{C}{C + A} = \frac{27}{27 + 169} = \frac{27}{196} = 0.137
\]

Commercial risks (error type 2) = (1- Specificity) = \[
\frac{B}{B + D} = \frac{30}{30 + 174} = \frac{30}{204} = 0.147
\]
VI. One of they better criteria used in classification of the models is “Roc curve”. If one model with the classification power of “0”, the “area” under “Roc” curve of “0.5” and the best area under curve of it is “1.0”, the area level for our model has been calculated as “0.93” as follows:

![ROC Curve Image]

VII. After estimation of logit model and its different accuracy tests, which are mentioned above (articles I to VI), establishing credit groups and ranking the customers is the most important phase. Result of calculations and Percentages of different credit scored customers are as follows:

- Very good customers = 14.1%
- Average customers = 22.9%
- Unacceptable customers = 7.6%
- Good customers = 44.5%
- High risk customers = 10.9%

VIII. By considering the risk of credit customers in each area and the inflation rate, and also considering the competition between banks and the market share of them, the proposed model for determining exposure limits can be as follow:
\[ a_i = \left(1 - \frac{p_i}{b}\right) \times (1 + gd_i) \cdot a_D \]

By using this model, optimal exposure limits will be calculated for all credit pillars.

**IX.** The expected loss of PBI’s credit portfolio is equal to 122 billion rials. And in the chosen 99% percentile, credit portfolio loss (the Incremental Credit Reserve) is equal to 581 Billion Rials. Therefore, the extra capital requirements for covering all the losses in the level of 99% under the Credit Risk^+ model is equal to (581-122) = 459 Billion rials. This amount of capital is known as *Economic Capital.*

Capital requirements for covering Expected loss and Economic capital in Post Bank of Iran

![Diagram showing Expected Loss and Economic Capital](image)