An analysis of credit risk for commercial banks in China

by

Yidan Luo

A research project submitted in partial fulfillment of

the requirements for the degree of Master of Finance

Saint Mary's University

Written for MFIN 6692.0 under the direction of

Dr. J. Colin Dodds

Approved: Dr. J. Colin Dodds
Faculty Advisor

Approved: Dr. Francis Boabang
MFIN Director

Date: September 3, 2013

An analysis of credit risk for commercial banks in China

by

Yidan Luo

A research project submitted in partial fulfillment of

the requirements for the degree of Master of Finance

Saint Mary's University

Written for MFIN 6692.0 under the direction of

Dr. J. Colin Dodds

Approved: _____
Faculty Advisor

Approved: _____
MFIN Director

Date: _____

Acknowledgements

I would like to thank Dr. Colin Dodds for all his help and advice in completing this project. I would also like to thank Dr. Francis Boabang for giving me advice on the choice of topic and models to be used. Lastly, I would like to express my appreciation to my family and friends for their help, encouragement, and especially their support.

Abstract

An analysis of credit risk for commercial banks in China

by

Yidan Luo

Credit risk is the greatest and essential risk of a commercial bank, but also it is one of the core elements that the commercial bank should control in its operations. The research on the credit risk management of commercial bank can help guarantee security, control the credit risk effectively with a minimum loss and take preventive measures.

From December 11, 2006, China's financial industry transformed into the full-open period, China began to open foreign bank RMB business on Chinese citizens, remove the restrictions on areas and other non-prudential restrictions, and to keep promises that we made to give national treatment to foreign banks when China entered into the World Trade Organization. This also means that China's commercial bank and foreign bank will compete on the same playing field. But it's necessary to recognize that great gap between China's commercial banks and foreign banks on capital size, management technology, product innovation and risk management, particularly, the commercial bank's credit risk management. This study is based on this background and explores this theme of commercial bank's credit risk management.

Table of Contents

List of Tables

Chapter 1: Introduction

1.1 Purpose of Study

Credit risk is the biggest and the most important risk for China's commercial banks. This paper aims to analyze their credit risk. Our premise is that the credit decisions in China's banking system are insufficient and this will attempt to build a suitable credit risk management theory system and improve its credit risk prevention and management mechanisms. Key to this is to have a robust system of identification, measurement and warning analysis of credit risk.

1.2 Background

Since the 1980s, economic globalization and financial liberalization have spread all over the world. With financial deregulation and the rapid development of information technology, financial innovation and other factors, financial theory and financial practice have changed the landscape of the financial sector. These developments and changes provide not only good opportunities for banks and the financial markets, but now there are the increasingly serious financial risks both institutionally and systematically.

Mexico's economic crisis at the end of 1994 affected Latin America, Asia and even the whole world and the Asian financial crisis in 1997 did huge damage to the Southeast Asian countries. In the beginning of the 2007, financial crisis caused by the U.S. subprime mortgage market turmoil, it led to a tsunami that saw bank failures,

investment funds were forced to close by March 2009, the stock market has seen dramatic drops.

The crisis first hit in August 2007, and then it spread throughout the world's major financial markets such as the United States, the European Union and Japan. Six financial institutions in China, Bank of China, Industrial and Commercial Bank of China, Bank of Communications, China Construction Bank, China Merchants Bank and China CITIC Bank had bought subprime mortgages. According to the estimation of U.S. financial institutions, these six banks lost about 4.9 billion Renminbi (RMB) in total.

At the same time, there had been a lot of financial crisis events within China. On February 1998, China Rural Development Trust and Investment Corporation took huge losses and it was closed by the central bank. In the same year in June, the Hainan Development Bank found it difficult to sustain its own business because of huge non-performing loans. It was shut down by the central bank.

Since China joined the World Trade Organization (WTO), in order to improve China’s commercial banks are international competitiveness and to meet the requirements of the New Basel Accord (Basel II), China adopted many measures to strengthen risk management and optimize the asset structure. But for China's commercial banks, credit risk is a constraint to their operational effectiveness and development and it has still not been effectively controlled and resolved. China's commercial banks are still faced with great credit risk. The high proportion of non-performing loans (NPLs) of commercial banks greatly weakens the liquidity and

solvency of commercial banks. Moreover, bad loans and overdue loans have become a serious problem for them.

1.3 Need for Study

Credit risk is one of the core elements that needs to be controlled by a bank and its management could guarantee the bank's business to get the best results with minimum loss. Meanwhile, it can also help to provide a more scientific and rational use of funds, improve efficiency and minimize the occurrence of credit risk. It would contribute to build the regular operation of the entire commercial banking system, maintain financial stability and promote the healthy development of the national economy.

Banks are no stranger to risk taking as they are responsible for a variety of risks through their operations, such as credit risk, liquidity risk, market risk, operational risk and so on. Among these, credit risk is the most important factor to cause a potential loss. The quality of credit risk management directly affects the bank itself and the stability of the entire financial system.

For a very long time credit risk was the main risk of commercial banks. But with financial liberalization, market risks have increasingly attracted people’s attention. However, the situation for credit risk as the most important risk for commercial banks doesn’t change. With increasing competition, new financial instruments and more funds entering financial institutions and markets, credit risk becomes easier to spread.

The research on commercial bank credit risk management has significance to other financial institutions. With the emergence of multifunction institutions increasingly cross border with more cross-business, credit risk becomes the major challenge for all financial institutions. Lessons learnt in banks have a high value for other financial institutions.

On December 11, 2006 China's financial door was opened to financial institutions of the world, but compared with developed countries, financial institutions in China are equipped to be effective in credit risk management. In order to compete with foreign competitors, commercial banks in China need to study advanced risk management techniques, combined with China's actual situation and develop appropriate risk management methods.

1.4 Commercial Bank Credit Risk Management Methods

The paper uses normative analysis and the combination of qualitative and quantitative analysis methods to undertake the research on the key topic.The normative analysis is based on value judgments, raising standards of analysis, understanding what the theoretical models tell as to find ways to meet these standards. The normative analysis is a focus on "what ought to be" in economic matters.

The quantitative analysis method however, focuses on a range of data that can be used to develop timely and effective credit risk management. This paper will introduce several models to develop, analyze and perfect processes of commercial

bank credit risk.

Chapter 2: Literature Review

Bank credit risk management is a method of risk identification, measurement and control. It is a scientific management method which reduces the variety of adverse consequences caused by risk to a minimum amount with minimal cost.

2.1 Foreign Research

Western commercial banking has more than 300 years of history. This long process of historical development laid a solid theoretical foundation to banking practices.

2.1.1 Information Asymmetry

Studies of credit risk have been mostly from the perspective of information asymmetry. From the 1970s, economists began to use game theory and incomplete contract theory to study credit relations between banks and enterprises.

With the appearance of information economics, people began to turn their attention to the problem of information asymmetry. From this perspective, credit risk is concentrated on two issues: one is the moral hazard, the other one is the adverse selection. Arrow (1964) introduced moral hazard into management study and Stiglitz and Weiss (1981) first studied adverse selection in credit markets.

2.1.2 Credit Rationing

In the 1960s, academics began to turn to analyzing credit rationing through a micro-economic perspective.

Freimer and Gordon (1965) first established a credit rationing model and it assumes a rational lender will make their repayment of the loan according to the best possible outcome of the investment projects. Jeffee and Russell (1976) established a credit rationing model based on the moral hazard of a competitive consumer credit model. The main feature of this model is that when some borrowers are given more loans than others, the likelihood of their default will increase.

Stiglitz and Weiss (1981) developed a credit rationing investment lending model that includes both moral hazard and adverse selection. The character of moral hazard arises in this model is because at higher interest rates, the borrower will choose a higher risk project. The adverse selection feature arises is because at higher interest rates, some borrowers relatively ‘safe’ investment become unprofitable, therefore causing a higher risk to the loan.

2.1.3 Loan Contracts Research

In the 1980s, researchers began to concentrate on loan contracts research. Bester (1985) thought that when lenders use both interest rates and collateral requirements as incentives for borrowers, it will be possible exist a loan contract which lenders will select harmful risk.

Scharfstein and Stein (1990) studied the incentive problem of corporate

repayment ability. He thought that if banks terminate loans this will encourage enterprises to repay the loans. Elizalde (2003) studied three credit models. He used only a simplified enterprise model to study corporate default intensity and default probability and developed a comprehensive structural model of one or more corporates credit risk.

2.1.4 Pre-loan Assessment and Post-loan Credit Risk Measurement.

A large number of academics and institutions have focus research on pre-loan assessment and post-loan credit risk measurement. Altman (1977) first used statistical analysis method to establish the five variables Z-Score Model and then the improved Zeta discriminant model.

Martin (1977) proposed a Logit analysis model, using the company's relatively financial data to predict the probability of bankruptcy or default. Green and Smith (1987) applied genetic algorithm to study credit risk assessment problem. Based on this Koza (1993) applied the genetic programming algorithm for credit risk assessment.

Coats and Pant (1993) using neural network analysis method to predict the financial crisis of U.S. companies and banks and received success. West (2000) established five different neural network models: multi-level sensor, expert-hybrid system, radial basis function, learning vector quantization and fuzzy adaptive resonance to research the accuracy of the commercial bank credit rating. Malhotra and Malhotr (2002) used the neuro-fuzzy systems to distinguish "good" and "bad" for

the credit of lending corporates.

2.1.5 Five Credit Risk Measurement Models

Some institutions and academics put forward five models for credit risk measurement. In 1993, KMV Company used the Black-Scholes-Merton Model (BSM Model) raised the famous Credit Monitor Model. 1997 JP Morgan Bank, associated with leading banks at that time and the KMV Corporation, develop the Credit Metrics. In 1997, Altman and Kishore developed Mortality Model based on the marginal and cumulative mortality of bonds development. Suisse Financial Assets Department developed a credit risk measurement model in 1997, which is based on the Credit Risk + Model. Saunders and Wilson of McKinsey & Company established the Credit Portfolio View Model in 1998. They used the basic dynamics principles and analyze borrower's credit migration from the perspective of macroeconomic environment.

2.2 Research in China

In China, the research on commercial bank credit risk has mainly focused on the introduction of foreign methods, testing and comparison as well as the adaptability in our empirical study.

Wang and Zhang (1999, 2000) discussed the application of artificial intelligence technology, such as neural networks, genetic programming and classification trees. Wen and Ma (2001) put forward standard measures for different risk situations and

Li (2005) provided a systematic introduction and comparison for modern credit risk measurement models while Chen and Wu (2002) studied the measurement and management for credit risk. Fan (2002) introduced the Credit Metrics model and pointed out that the model is currently impossible to apply in China. Zhu and Zhang (2004) compared and analyzed the current well-known credit risk measurement model from different aspects. Pang used the probabilistic neural network (2005) and BP algorithm (2005) to construct a credit risk assessment and early warning model.

2.3 Summary

In general, foreign research on commercial bank credit risk was developed from the perspective that they analyze the main reasons of credit risk and the appropriate measurements and methods to control it. This method of analysis focused on the countries with mature market economies and in the foreign application they achieved certain success.

For the research in China, academics mostly applied foreign research on China's credit risk problem. But there was a lack of understanding of the credit risk evolution. And they didn’t take the different situations between China's market economy status and the western developed countries into account.

Chapter 3: Data and Methodology

3.1 Identification of Credit Risk

The first step in the credit risk management is the identification of credit risk. There are three significant credit risk identification methods: Scenarios analysis, Delphi method and Fault tree analysis method.

3.1.1 Scenarios Analysis

Scenarios analysis is a common method to perform risk identification by foreign risk managers. This method uses scenarios to describe the key reasons of the credit risk and its impact. The main process of this method is to use the relevant data, curves and charts to describe the future state of the manufacture, operation and management of a certain product such as a loan. Through this description process, researchers can determine the key factors to cause the risk and the degree of impact. This method establishes an identification model which is used to analyze the consequences of losses when certain factors changes.

A scenario is a depiction of a company's future. The description can be show on a computer, calculated and displayed. Also it can be show as curves and charts. So it is an understandable way for bank managers to use as a reference.

3.1.2 Delphi method

The Delphi method for commercial bank credit risk identification generally use

the following procedure: (a) develop a survey program and determine the survey content by commercial bank credit risk managers; (b) employ a number of experts and provide them the relevant information about the demand side of credit funds. Send the survey to the experts and ask them to answer the questions and then send the survey back; (c) managers collect the expert opinions and send the most consistent idea back to those experts. After this, they are asked for their opinions about the feedback; (d) repeat the process till their opinions meet with each other.

The Delphi method has great significance for complex credit risk identification, especially for those risks which not suitable to use quantitative analysis methods. But the shortcoming is that the Delphi method is very cumbersome.

3.1.3 Fault Tree Analysis

Fault tree analysis is a widely used method to analyze problems. It is a form of graphic solution to divide the large fault into small ones or to analyze the cause of the fault. A Fault tree is a risk tree when used to identify the credit risk. This analysis can break down the credit risk that commercial banks face into small risks. Also it could determine the reason for the credit risk step by step.

The advantages of this Fault tree analysis are simple, clear and fast.

3.2 Measurement of Credit Risk

The traditional way of credit risk measurement, such as the expert judgment method and the credit rating method, is simple, clear and easy to understand. The

requirements of the traditional method for the operating environment are not very high, they mainly relied on the qualitative analysis. However, the traditional measurement process does not meet its credit challenges bank face today.

Since the 1990s, a revolution commenced in the credit risk measurement method after the global market experienced several international financial crises. Many large banks and financial institutions started to develop various highly technical internal models to perform credit risk measurement.

3.2.1 Mortality Analysis Model

Mortality Analysis Model is a distribution model developed by two American academics, Altman and Suggitt (2000). They applied the actuarial idea of life insurance into credit risk management. He introduced the actuarial idea to establish the loans mortality (can be seen as the loan default rate) table. Moreover, Altman combined the mortality with Loss given default (LGD) to estimate the loans expected loss and to conduct the distribution of loans expected loss.

The Mortality analysis model uses historical loan default data to calculate the marginal mortality rate (MMR) for each period and multi-period cumulative mortality rate (CMR) within life cycle of the loan. The model combines mortality and LGD to get an estimated value of the expected loss.

3.2.1.1 Specific Steps

First calculate the MMR of a certain level of loans in its lifetime.

$$MMR_i = \frac{V_{aCertainLevelofLoansDefaultinPeriod\#i}}{V_{aCertainLevelofLoansUnpayedinPeriod\#i}} \quad 3.1$$

i=1, 2 …n

After calculating the MMRi, the average MMR ($\overline{MMR}$) can be found by the weighted average. ωi is the proportion of loan amount and loan total size in different periods.

$$\overline{MMR_1} = \sum_{i=1}^{n} MMR_{1i} \times \omega_i \quad 3.2$$

$$\sum_{i=1}^{n} \omega_i = 1$$

Then calculate the CMR. CMR is the probability a loan will default in a given period. With the relationship between MMR and Survival rate (SR) as follows (Equation 3.3)

$$MMR_i = 1 - SR_i \quad 3.3$$

The CMR can be determined (Equation 3.4)

$$CMR_n = 1 - \prod_{i=1}^{n} SR_i \quad 3.4$$

With the one-period mortality and cumulative mortality based on historical data one can obtain the loan mortality table. With this and the recovery rate one can then calculate the expected default loss:

Expected default losses= CMR × LGD

LGD = 1 - Average Recovery Rate 3.5

3.2.1.2 Source of Data

Because of the confidentiality of information for commercial banks, this paper cannot obtain detailed credit information. State-owned commercial banks only listed a few years ago and their data are limited in the database. This limits the empirical analysis. However, this paper selected the one-year short-term loans from November 2009 to December 2010 by the city's commercial bank as a sample.

3.3 Early Warning of Credit Risk

The building of a commercial bank's credit risk early warning system provides an opportunity to have comprehensive management of risk. It can help to increase the level of credit risk management, do scientific predictions of credit risk and warn for emerging problem loans. The early warning system can provide early predictions of problems so action can be take to reduce or avoid losses in time.

As the financial risks are increasing through the economic development, competition is also increasing from the entry of foreign banks and an early warning system for credit risk has become necessary.

3.3.1 Early Warning Mechanism of Credit Risk

The Early warning system for Credit risk of commercial banks is a systematic and long-term task. This requires the establishment of a comprehensive and stable

early warning systems mechanisms to ensure the smoothly progress.

3.3.2 Organization and Management Mechanism for Early Warning of Credit Risk

3.3.2.1 Non-performing Loans (NPL) Warning Mechanism

First, we need to clearly define the content of the early warning mechanism in terms of the content of monitoring, monitoring indicators, monitoring methods, the monitoring department, the relevant obligations and penalties and the execution processes. Then, determine operational procedures and clear the responsibilities of main control department and subordinate departments.

Finally, a clear standard of NPL and accurate classification of loans is necessary to reduce risk.

3.3.2.2 Strengthen Leadership and Supervision

The China Banking Regulatory Commission (CBRC) should strengthen the leadership and supervision for commercial bank to develop early warning system for credit risk by establishing guidelines and require commercial banks to develop rules according to their actual situation. The CBRC needs to make full use of its data resources and information so that the supervision department can effectively take action.

3.3.3 Risk Information Collection and Transmission Mechanism for Early Warning of Credit Risk

The risk information collection and transmission mechanism requires the

building of a complete and continuous risk warning database. The database should consist of two main aspects of information: macroeconomic and micro-economic information.

Macroeconomic information includes economic development planning and laws and regulations related to national financial. Micro-economic information is about the stock of credit assets, credit types, guarantees and the distribution of the loan period.

3.3.4 Risk Analysis and Processing Mechanism for Early Warning of Credit Risk

An efficient risk analysis and processing mechanism is required by the Credit risk early warning system. Through risk analysis, managers could concentrate on the significant risk factors and ignore other unimportant factors. At the same time analyze the causes of risk and value the potential losses. Risk warning should be based on the quantitative analysis and use international econometric analysis tools to ensure the objectivity of the warning system. Then develop appropriate measures to minimize the losses.

3.3.5 Risk Control Mechanism for Credit Risk Early Warning

The credit risk control mechanism is the precondition for the successful running of Credit risk early warning.

First, the responsibility system should be set up. Secondly, credit management

and credit decision-making departments should balance each other. Next the audit department should combine the actual situation to judge the audit range, the audit frequency and the audit strength.

Chapter 4: Results

4.1 Main Risks of Commercial Banks

Credit risk for Commercial bank including internal and external risks. Internal risk plays a dominant role and decides the external risk.

4.1.1 Internal Risks

4.1.1.1 Quality Risk

Quality risk arises because the loan officer may lack personal qualities of professional and moral quality. A loan officer with low quality can hardly make the right judgments for the loan business and loan offices with low moral quality can easily lead to the abuse of power and moral hazard.

4.1.1.2 Program Risk.

The complexity of the credit approval process makes the credit risk become difficult to control and sometimes leads the risk becomes more serious.

4.1.1.3 Manage Risk

Aftermarket management is an important part of credit management. For the current situation, the aftermarket management still has a lack of rules and regulations and the process is inefficient and ineffective. These make it more difficult for the

recovery of loans.

4.1.1.4 Policy Risk

The start-up and development of credit business are all based on the corresponding credit policies. But in reality, the credit business is sometimes difficult to adapt to the changes in the credit policy.

4.1.2 External Risks

4.1.2.1 Operational Risks

For the borrowers, once they have received the bank loans, the use and return of loans are mainly controlled by the borrower and the lending bank can neither participate nor interrupt the borrower's decisions. Operational risk of borrowers will directly affect the safety of bank loans and thus result in the credit risk of bank.

4.1.2.2 Intermediary Risk

Some accounting firms, rating companies and other agencies provide fake reports for their customers in order to obtain some immediate benefits. This behavior will mislead commercial banks to give loans to high risk borrowers and result in greater potential risk.

4.1.2.3 Administrative Risk

As state-owned commercial banks, although they are not managed by the local government, sometimes they are still largely influenced by local governments.

4.2 Result of Mortality Analysis Model

The tables below (Table 4.1 and 4.2) present the results of the analysis using a Mortality Analysis Model.

Table 4.1: One year short-term loan mortality table of a commercial bank (November 2009 to December 2010)

Credit rating	Prob. Of Default	1st month (%)	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
AAA	CMR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	MMR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AA	CMR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	MMR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A	CMR	0.00	0.00	0.00	0.00	0.00	1.38	0.00	0.00	0.00	0.00	0.00	0.00
	MMR	0.00	0.00	0.00	0.00	0.00	1.38	1.38	1.38	1.38	1.38	1.38	1.38
BBB	CMR	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.36	0.00	0.00	0.00	1.98
	MMR	0.00	0.00	0.00	0.00	0.17	0.17	0.17	0.54	0.54	0.54	0.54	2.51
BB	CMR	0.00	0.00	0.00	3.23	3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	MMR	0.00	0.00	0.00	3.23	6.45	6.45	6.45	6.45	6.45	6.45	6.45	6.45
B	CMR	0.00	0.00	0.00	0.00	0.00	7.69	0.00	0.00	0.00	0.00	0.00	0.00
	MMR	0.00	0.00	0.00	0.00	0.00	7.69	7.69	7.69	7.69	7.69	7.69	7.69
CCC	CMR	0.00	0.00	0.00	7.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.56
	MMR	0.00	0.00	0.00	7.69	7.69	7.69	7.69	7.69	7.69	7.69	7.69	12.8

Table 4.2: Expected Default Losses for Each Rating Level (￥100,000)

Rating	Number of Loans	Average recovery rate	Expected default losses
AAA	47	0.9734	1.2494
AA	229	0.9719	12.8676
A	508	0.9706	59.6804
BBB	205	0.9701	36.666
BB	282	0.9697	68.2544
B	263	0.9679	92.818
CCC	207	0.9686	229.263

4.3 Measures

4.3.1 Strengthen Internal Control Mechanisms

To achieve the standardized intensive management style, the bank needs to establish an accountability system and strengthen the risk awareness of managers and employees.

4.3.2 Improving Credit System

For commercial banks, if borrower's credit awareness is increasing, the probability of occurrence of moral hazard will be reduced. Moreover, it can help to decrease the probability of default and thereby reduce the credit risk of commercial

banks. Improving the credit system could benefit the control of credit risk of commercial banks.

4.3.3 Standardize Credit Operational Processes

Standardizing operating systems generally includes three parts: pre-loan investigation, loan approval and post-loan management. These can be achieves by upgrading the credit operations system. By using a customer's cash flow analysis and repayment capacity as standards to judge and forecast the credit risk.

4.3.4 Establish a Scientific Rapid Warning Mechanism

By establishing a scientific rapid credit risk early warning system could benefit the traditional management model to be more effective and efficient. This will strengthen the systematic and accuracy of credit risk management and improve credit risk analysis techniques.

4.3.5 Carry out Scientific Management of Loan Portfolio

By investment diversification it can minimize risks. That means banks should try to avoid large loans and increase small loans to expand their reach across a larger loan segment.

4.3.6 Strengthen Financial Supervision

For regulations as which is determine bank management the policies and

regulations of supervision need to be broadened into risk supervision that concentrates more on the bank's capital adequacy, asset quality and liquidity and pay close attention to risk indicators and develop supervision measures according to the changes of indicators.

Chapter 5: Conclusion

Credit risk is the greatest and essential risk of a commercial bank, but also it is one of the core elements that the commercial bank should control in its operation.

This paper places the present study of China's credit risk management in the context of foreign and domestic research. It analyzed on a systematic basis the following aspects: identification, measurement and the early warning of commercial banking credit risk.

In this paper, the main innovative aspects are as follows: at first, the construction of a risk management system that identifies, measures and warns of the credit risk of commercial banks. Next, it applies the measurement model and provides solutions for the identification, measurement and early warning of credit risk.

Research on this topic for banks aims to develop models and processes that will minimize loan losses by taking preventive measures. At the same time, credit risk management can also prompt commercial banks to raise funds and arrange funds more scientifically and rationally, as well as efficiently to minimize the occurrence of credit risk, so as to promote the commercial banking system's normal operations, maintain financial order and stability and promote the healthy development of the national economy.

Chapter 6: Recommendation

It is a huge and complex task to control and prevent credit risk. Due to the rapid development of the market economy, operation management cannot match with the institutional construct. Commercial banks in China still lack risk management knowledge and practice. Strengthening credit risk management has become the key factor to improve banks' competitiveness.

The next step of this research is to continue to collect credit data of commercial banks and to keep learning from foreign experience and establishing a suitable credit risk measurement model for China commercial banks.

References

Altman, E. (1997). ZETA analysis: A New Model to Identify Bankruptcy Risk of Corporation, *Journal of Banking and Finance*, 1, 29- 54.

Altman, E., and Kishore, V. (1997). Defaults and returns on high yield bonds: Analysis through 1996 Special Annual Report, *Stern School of Business*.

Altman, E. (1998). Credit risk measurement: development over the last 20 years. *Journal of Banking and Finance*, 21, 1721- 1742.

Altman, E., and Suggitt, H. J.(2000). Default rates in the syndicated bank loan market: A mortality analysis. *Journal of Banking and Finance*, 229- 253.

Arrow. (1964). The role of securities in optional allocation of risk bearing. *Review of Economics Studies*, 31, 91- 96.

Bester, H. (1985). Screening Vs Rationing in Credit Markets with Imperfect Information, *American Economic Review*, 75, 850- 855.

Chen, J.D. (2005). *Mortality Analysis and Reliability*. BJ: Peking University Press.

Dong, X. J. (2004). Research of Financial Risk Early Warning Mechanism. Economic Management Press.

Duan, M. (2006). Commercial banks non-performing assets and Countermeasures. *Financial Forum*, 8.

Elizalde, A. (2003). *Credit Risk Model I: Default Correlation in Intensity Models*.

Fan, N. (2002). Credit metric model and credit risk management in China.

Financial Forum, 5.

Freimer, M., and Gordon, M. J. (1965), Why Bankers Ration Credit. *The Quarterly Journal of Economics*, 79, 397- 416.

Green, D. P., and Smith, S. F. (1987). A genetic system for learning models of consumer choice. 2nd Inter Conf on GA, 217- 223.

Jaffee, D. M., and Russell, T. (1976), Imperfect Information, Uncertainty, and Credit Rationing, The Quarterly Journal of Economics, 90, 651- 666.

Koza, J. R. (1993). *Proceedings of the Fifth International Conference on Genetic Algorithms.* San Mateo, CA: Morgan Kaufmann Publishers Inc. 295- 302.

Li, Z. H. (2005). Commercial Bank Risk Identification Model and its Empirical Research. *Nankai Economic Studies*, 2.

Ling, J.H. (2006). *Introduction to Finance*. Higher Education Press.

Malhotra, R. and Malhotr, D. K. (2002). Differentiating between Good Credits and Bad Credits Using Neuro-Fuzzy Systems. *European Journal of Opreational Research*, 123, 190- 211.

Mao, X.W., and Ba, S.S. (2001). The impact of New Basel on China's financial supervision. *Economic Information Daily*, 4.

Martin, D. (1977). Early Warning of Bank Failure. *Journal of Banking and Finance*, 1, 249- 276.

Pang, S. L. (2003). Multilayer Perceptron credit evaluation model. *Mathematics in Practice and Theory*, 9.

Peng, F., and Wang, W. (2004). *Mortality Analysis.* BJ: Renmin University

Press.

Ran, S. G., and Feng, X. G. (2004). Legal Control of the Commercial Bank Credit Risk. *Financial Research*.

Scharfstein, D., and Stein, J. (1990). Herd Behavior and Investment, *American Economic Review*, 80, 465-479.

Shi, B. C., and Yang, W. Z. (2002). *Financial Risk Management*. Shanghai Finance University Press.

Stiglitz, J.E., and Weiss, A. (1981). Credit Rationing in Markets with Imperfect Information, *American Economic Review*, 71, 393- 410.

Wang, C.F., and Zhang, W. (1999). Commercial Bank Credit Risk Assessment Based on Neural Network Technology, *Engineering Theory and Practice*, 9.

Wen, F. H., and Ma, C. Q. (2001). New Trend of Risk Measurement. *Hunan University Journal*,12.

West, R. C. (2000). Factor- Analytic Approach to Bank Condition. Journal of Banking and Finance, 3, 253- 266.

Yan, T. H., and Zhan, Y. (2007). *An Analysis of Commercial Bank Credit Risk*. Economic Management Press.

Yu, X. M. (2007). *Research on Commercial Bank Risks*. China Economic Times Press.

Zhan, Y.R. (2004). *Modern Credit Risk Measurement and Management*. Economic Science Press.

Zhang, W. (2000). Recursion tree in Credit Risk Analysis. *Engineering Theory*

and Practice, 11.

Zhang, M.(2004). *Rebuilding of Modern Commercial Bank Management*. China Financial Publishing House.

Zeng, X. Y. (2006). Commercial Bank Credit Risk Management. *Hainan Finance,* 1.

Zhu, X. Z., and Zhang, Z. Y. (2004). Commercial banking credit risk identification. *Finance and Economics*, 9.

Appendix A:

Table 1: Table of no default probability of AAA rating loans

Table 2: Table of no default probability of AA rating loans

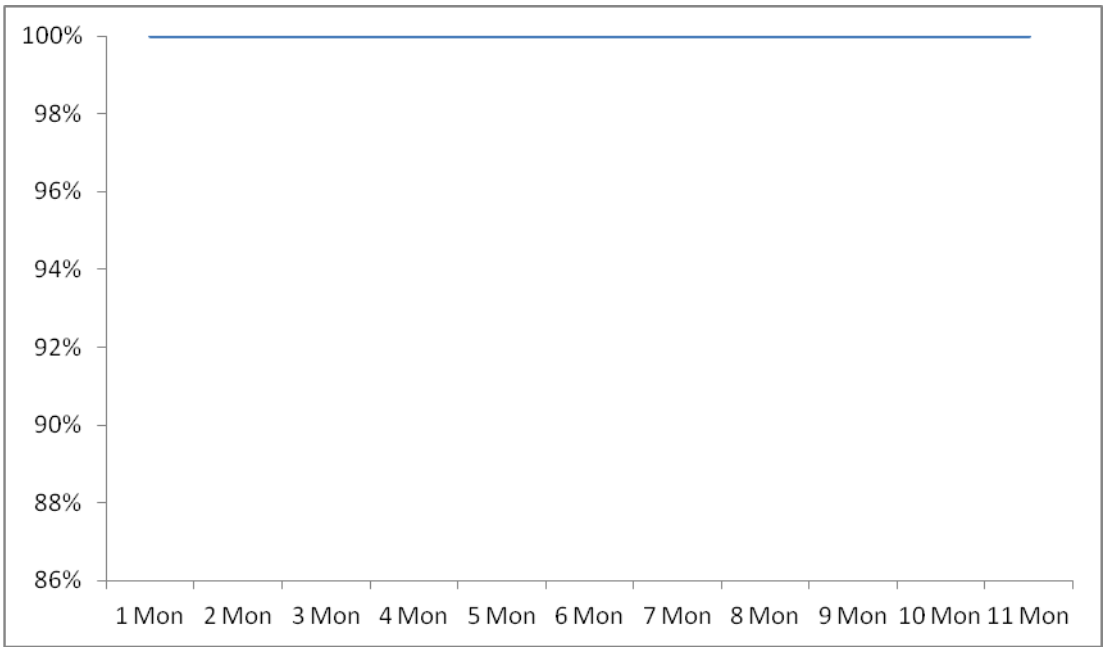

Table 3: Table of no default probability of A rating loans

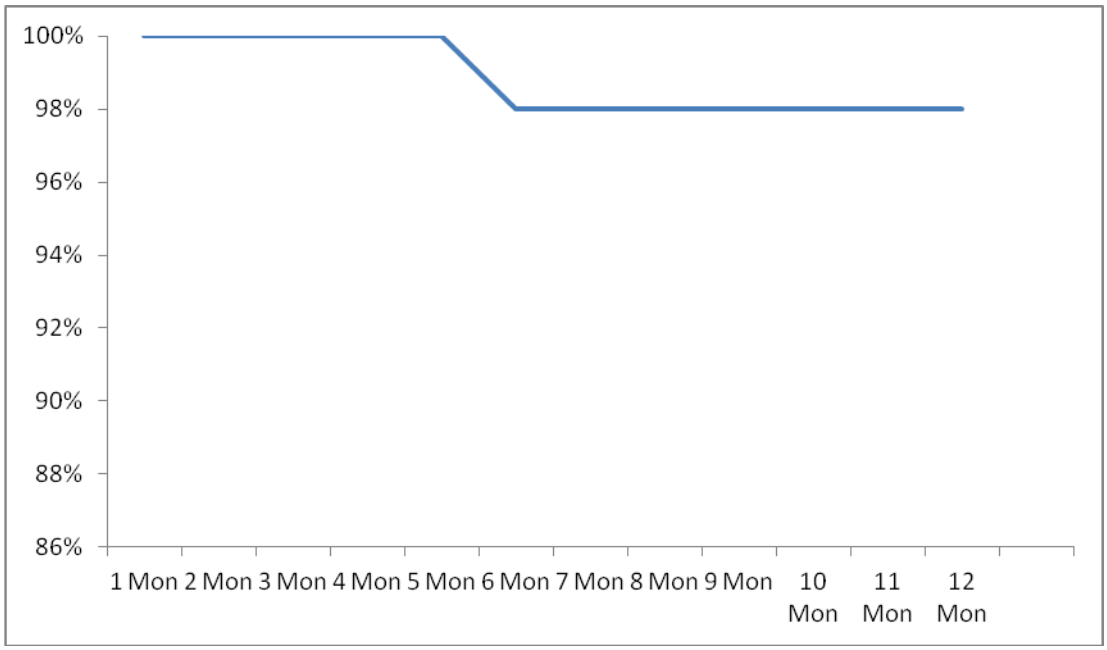

Table 4: Table of no default probability of BBB rating loans

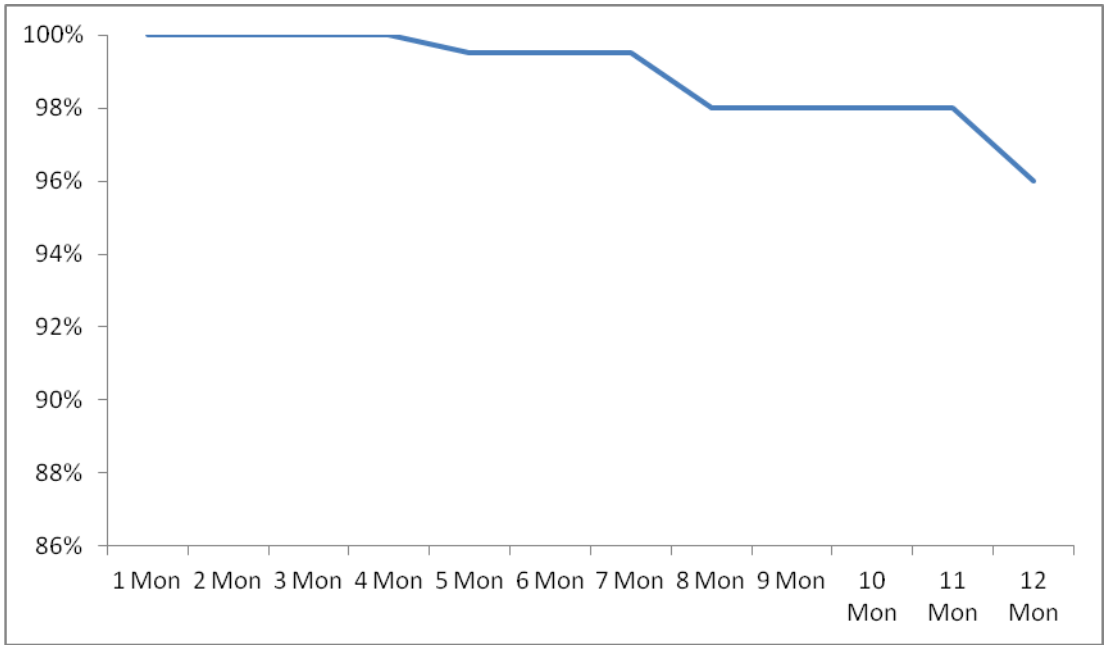

Table 5: Table of no default probability of BB rating loans

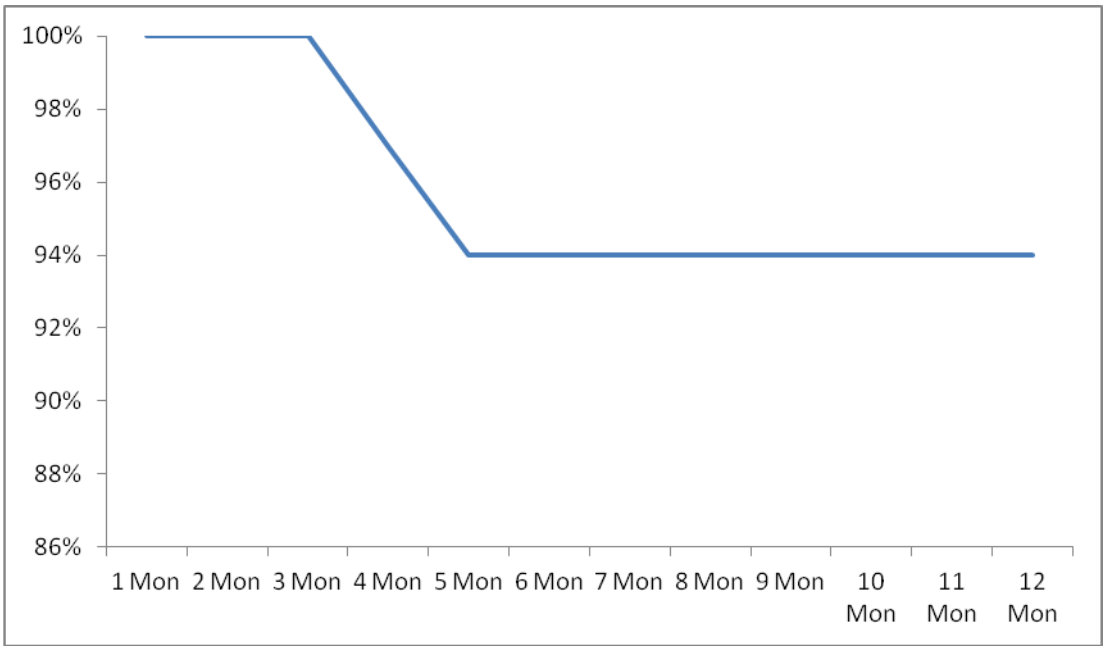

Table 6: Table of no default probability of B rating loans

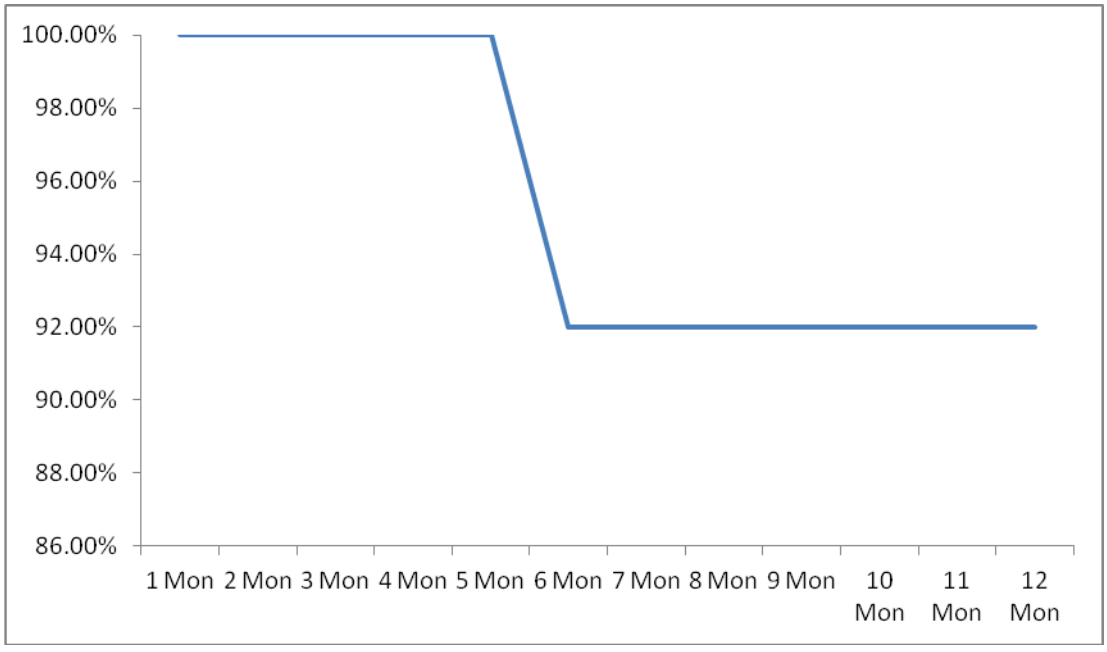

Table 7: Table of no default probability of CCC rating loans