INSTITUTO
UNIVERSITÁRIO
DE LISBOA

An Empirical Analysis on the Credit Scoring and the Intermediary Role of Financing Guarantee Institutions of China's Car Loans

YU Zhonghai

Doctor of Management

Supervisors:
PhD Rogério Serrasqueiro, Assistant Professor,
ISCTE University Institute of Lisbon

PhD LI Qiang, Associate Professor,
University of Electronic Science and Technology of China

July, 2020

BUSINESS
SCHOOL

Marketing, Operations and General Management Department

An Empirical Analysis on the Credit Scoring and the Intermediary Role of Financing Guarantee Institutions of China's Car Loans

YU Zhonghai

Doctor of Management

Supervisors:
PhD Rogério Serrasqueiro, Assistant Professor,
ISCTE University Institute of Lisbon

PhD LI Qiang, Associate Professor,
University of Electronic Science and Technology of China

July, 2020

BUSINESS
SCHOOL

Marketing, Operations and General Management Department

An Empirical Analysis on the Credit Scoring and the Intermediary Role of Financing Guarantee Institutions of China's Car Loans

YU Zhonghai

Doctor of Management

Jury:

PhD Nelson Antonio, Professor,
ISCTE University Institute of Lisbon
PhD Rogério Serrasqueiro, Assistant Professor,
ISCTE University Institute of Lisbon
PhD Nuno Miguel Simões Venes, Assistant Professor,
Lusíada University of Lisbon
PhD LI Ping, Professor
University of Electronic Science and Technology of China
PhD CHAI Junwu, Professor
University of Electronic Science and Technology of China

July, 2020

Statement of honor
Submission of doctoral thesis

I the undersigned state on my honor that:

- The work submitted herewith is original and of my exclusive authorship and that I have indicated all the sources used.
- I give my permission for my work to be put through Safe Assign plagiarism detection tool.
- I am familiar with the ISCTE-IUL Student Disciplinary Regulations and the ISCTE-IUL Code of Academic Conduct.
- I am aware that plagiarism, self-plagiarism or copying constitutes an academic violation.

Full name 于中海 Yu Zhonghai

Course Doctor of Management
Student number 70812

Email address 3619885@QQ.com

Personal email address Alaxyu@QQ.com

Telephone number +86 13228216770

ISCTE-IUL, 07/07/2020

Signed

_____

Abstract

By the end of 2018, China's car ownership has reached 240 million, an increase of 10.51% over 2017, which leads to the increase of automobile financial services and hence the associated automobile credit risks. In order to transfer risks, financial institutions increasingly are choosing to issue auto loans through financing guarantee companies. Therefore, the industry pays more attention to the credit scoring, as it acts as the main risk control measure of auto financing guarantee companies. This leads to the study of the role the financing guarantee company plays and how effective the credit rating is as a risk control mechanism.

The purpose is to investigate whether the auto financing guarantee company plays a mediating role by providing credit score. The empirical approach is as follows: a two-stage regression method is used to control or eliminate the influence of personal characteristics and other third-party credit ratings. Through which, we firstly test whether the credit score of an auto financing guarantee company contains additional information besides personal characteristics and third-party credit scores. Second, we test whether additional information of auto financing guarantee company can significantly explain the post-loan performance of whether default or non-default.

The conclusions show that even after controlling the third-party credit score and personal characteristics, the credit scoring system of auto financing guarantee companies still has a significant explanation on the performance of post-loan default. In other words, it plays an intermediary role by providing credit evaluation services, which has a direct decision reference for the financial institutions that ultimately provide credit.

Based on this, this study puts forward corresponding management enhancement and loan risk management suggestions.

Keywords: Automobile finance; Consumer credit; Credit score; Default probability; Risk management

JEL： G21; G30

Resumo

No final de 2018, a propriedade automóvel na China atingiu 240 milhões, um aumento de 10.51% sobre 2017, o que leva ao aumento dos serviços financeiros automóvel e, portanto, dos riscos de crédito automóvel associados. Para mitigar riscos, as instituições financeiras optam, cada vez mais, por conceder empréstimos automóvel através de empresas de garantia. Por conseguinte, a indústria presta mais atenção à pontuação do crédito, uma vez que esta atua como a principal medida de controlo do risco das empresas de garantia de financiamento-automóvel. Isto conduz ao estudo do papel desempenhado pela empresa de garantia de financiamento e da eficácia da sua notação de crédito como mecanismo de controlo dos riscos.

Com base no sistema de notação de crédito da T's e num total de 119.798 registos de empréstimos, este estudo examina o poder explicativo da notação de crédito das empresas de garantia de financiamento automóvel no incumprimento dos mutuários e as funções mediadoras destas empresas.

Utiliza-se um método de regressão em dois estágios para controlar ou eliminar a influência de características pessoais e outros ratings, testando primeiro se a notação de crédito de uma empresa de garantia contém informações adicionais e testando, depois, se as informações adicionais da empresa de garantia podem explicar significativamente o desempenho do mutuário pós-empréstimo,

As conclusões mostram que, mesmo após controlar a notação de crédito de terceiros e as características pessoais, o sistema de notação de crédito das empresas de garantia tem uma explicação significativa no desempenho do mutuário pós-empréstimo. Ou seja, ele desempenha um papel mediador, fornecendo serviços de avaliação de crédito que têm influência direta na decisão das instituições financeiras que, finalmente, fornecem crédito.

Correspondentemente, esta investigação apresenta sugestões de melhoramento da gestão do risco de crédito.

Palavras-chave: Financiamento Automóvel; Crédito ao Consumo; Notação de Crédito; Probabilidade de Incumprimento; Gestão de Risco

JEL： G21; G30

摘 要

截止 2018 年底中国汽车保有量已达 2.4 亿辆，比 2017 年增长 10.51%。而汽车金融信贷作为汽车产业发展的重要组成部分，也随着汽车保有量和销售量的增长而迅猛增长，其对于扩大内需，推动我国经济增长具有重要的意义。在汽车金融信贷业务快速膨胀的同时，汽车信贷风险频发。为转移风险，越来越多的银行类金融主体选择通过融资担保公司发放汽车贷款。而信用评分在融资担保公司的贷前、贷中和贷后环节也越来越受到重视。在整个汽车贷款过程中，融资担保公司扮演了什么样的作用，作为融资担保公司主要风险控制手段的信用评分的效果如何，成为了我们关注和希望研究的问题。

本文旨在考察汽车融资担保公司是否通过提供信用评分而发挥中介作用。实证思路是：运用两步回归法（Two-step regression)，控制或剔除个人特征和其余第三方信用评价的影响，通过“第一，检验汽车公司信用评分中是否包含了个人特征和第三方信用分之外的额外信息；第二，额外信息能够显著解释是否违约的贷后表现”。

研究结论表明：即便控制第三方信用评分和个人特征，汽车融资担保公司提供的信用评价对贷后违约表现依然具有显著的解释，即通过提供信用评价服务发挥了中介作用，这对于最终提供授信的金融机构具有直接的决策参考。

据此本研究提出了相应的管理启示和贷款风险控制建议。

关键词：汽车金融；消费信贷；信用评分；违约概率；风险管理

JEL: G21; G30

Acknowledgements

First of all, I sincerely thank my supervisor, Professor Rogério Serrasqueiro, for his guidance of the thesis. The help and support he gave during my thesis writing encouraged me to walk out of the trough of my career and life. Spending time with him and following his professional advice, I have both learned knowledge and gained a cherished friend.

Secondly, I sincerely thank my Chinese supervisor, Professor Li Qiang. He has given me full guidance and help during my research. Even during his visit to Portugal, Mr. Li Qiang did not forget to give advice on my thesis, giving me his pertinent opinions. Without his academic rigor and meticulous care, my thesis can never be successfully completed.

Thirdly, I would like to thank the professors and teachers in the ISCTE and UESTC that I worked with. Without the encouragement and support of Professor Xiao Wen in the DBA project department, there would be no such paper. As well as Dr. Sun Ping, Mr. Chen Yang, Professor Nelson António, Professor Virginia Trigo, Professor Ma Shaozhuang, Professor José Dias of the project team, and all the teachers who taught me during the Doctorial study. This research also got great help from Mr. Xiao Bofei and Ms. Wang Yi. Because of their support and dedication, I was able to complete all my learning and researching of this thesis.

Finally, during my Doctorial study, my family also gave me great encouragement. Their unconditional love and support are what holds me to finish my studies.

致 谢

首先，我由衷地感谢我的葡方导师 Rogério Serrasqueiro 教授对论文的指导。在我论文写作期间给予的帮助和支持，鼓励我走出事业和人生的低谷，完成本文的写作。他渊博的学术知识、专业的学术见解、友善的为人处世，让我既学到了知识，也收获了一份师徒情谊。

其次，我诚挚地感谢我的中方导师李强教授。他总是在百忙之中抽出宝贵的时间对我的学术研究给予充分的指导和辛勤的帮助，李强老师在葡萄牙访学期间，也不忘对我的论文进行指导，对本文提出中肯的意见，让我感受到他严谨的学术作风、渊博的学术知识和无微不至的关怀，在他的帮助下我的论文得以顺利完成。

第三，我非常感谢葡萄牙里斯本大学学院和电子科技大学经济与管理学院众多教授和老师们，如果没有 IDMgt 项目部肖文教授的鼓励和支持，也就没有这篇论文；以及项目组孙平博士、陈阳老师、Nelson António 教授，Virginia Trigo 教授、马绍壮教授，Jose Dias 教授以及在博士学习期间所有授课和服务的老师们；本文的也得到了肖勃飞先生和王熠女士的大力帮助及辛勤付出。因为他们的支持，我才得以完成所有的课程学习和论文的研究及撰写。

最后，在我博士学习期间，我的父母、太太和两个儿子都给予我莫大的鼓励和支持。他们为我提供了充分的后勤保障，鼓励我完成学业。

Contents

List of Tables

List of Figures

Chapter 1: Introduction

1.1 Research background and significance

1.1.1 Research background

According to statistics from the Ministry of Public Security, by the end of 2018, China's car ownership had reached 240 million, an increase of 22.85 million vehicles or equivalently an increase of 10.51% from previous year. Among them, the number of new energy vehicles has reached 2.61 million, an increase of 1.07 million compared with 2017, meaning an increase of 70%. In 2018, China handled a total of 2.58 million car ownership transfer registrations, accounting for 96.72% of the total automobile transfer registrations, an increase of 1.77 million compared with 2017, meaning an increase of 9.44%. On the one hand, after decades of rapid development to 2018, China is the world's largest automobile market. On the other hand, when the intensification of the Sino-US trade war has led to unknown effects of foreign trade on China's economic growth, the automobile industry as a pillar industry to promote national economic growth becomes more important each day.

From across the world, the number of road motor vehicles per 1,000 inhabitants is an important indicator to measure the prevalence of national automobiles. As shown in Figure 1-1, in 2018, China's car ownership per 1,000 people was 173, far lower than the 765 in the United States and the 587 in Japan. Assuming that in the next few years, the population of China remains unchanged, if China wants to reach the standard of Japan, there will be a shortage of nearly 600 million cars in China's automobile ownership. At present, Japan's automobile sales remain between 5 million and 6 million vehicles per year, and the market of automobiles is relatively saturated. According to the relationship between car ownership and sales, and based on the current situation of Japan, it is expected that there will still be a huge growth in China's automobile production and sales in the next 20 to 30 years.

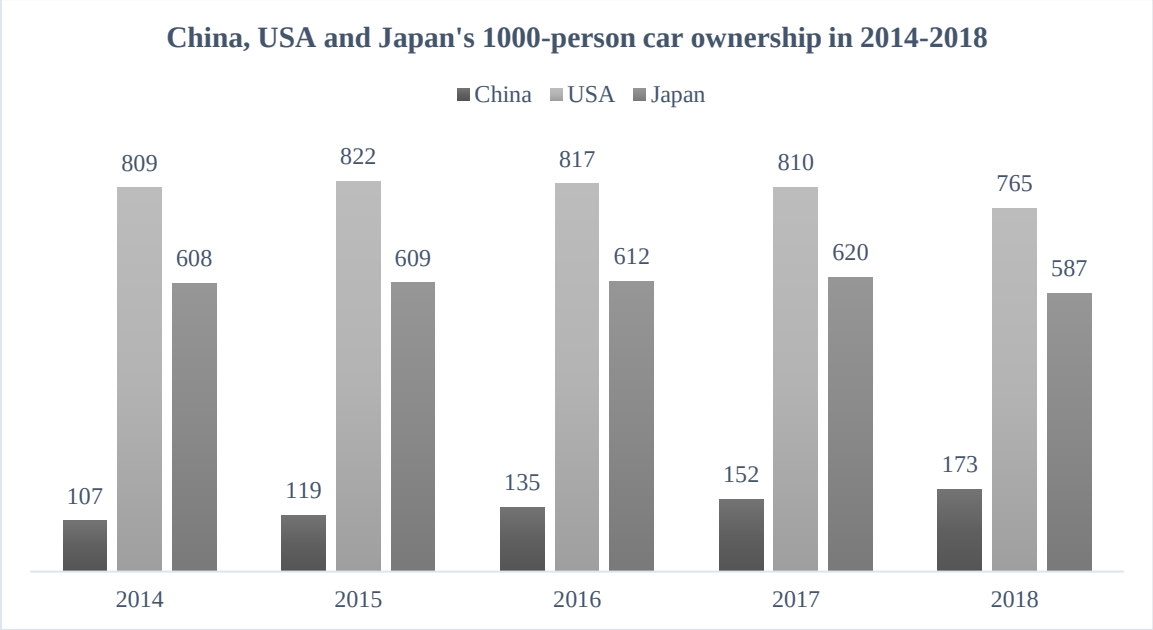


Figure 1-1 China, USA and Japan's 1000-person car ownership in 2014-2018

Data source: World Automobile Organization (OICA)

As a booster of the development of automobile industry, automobile financial services are also growing rapidly with the growth of car ownership and sales, and its important role cannot be ignored. However, even though the People's Bank of China has issued the Guiding Opinions on Developing Personal Consumption Credit in 1999, which marks the formal development of consumer credit business, the development of consumer credit business in China has not been sufficient. As an important part of China's consumer credit business, the automobile financing industry has many weaknesses, such as the incomplete laws and regulations, large fluctuations in policy supervision, imperfect social credit system, irregular competition in financial loan market, excessive fluctuation in automobile price, and malicious fraud by borrowers. As a result, risks become prominent in the auto financing industry, which largely restricts the development of China's automobile finance and credit industry. How to tackle the existing problems and put forward solutions in China's automobile financial credit from a practical point of view, how to effectively control financial risks, how to make the automobile financial credit market healthier and regulated, are becoming the focuses of the government, industry experts and scholars and automobile financial institutions.

Many Chinese experts and scholars have done a lot of research in the related fields of automobile finance and loans and put forward many constructive suggestions. To a large extent, they have contributed to the healthy and standardized development of China's

automobile finance and credit market. However, limited studies have been exploring the topics of lending risks from the point of lenders, based on the utilization of credit scoring technology, drawing lessons from the international automobile financial credit market and combining with the specific situation of our country. This thesis synthetically uses credit scoring technology, microeconomics, finance, game theory, management economics, information economics, financial innovation theory, consumer economics and other multi-disciplinary theoretical knowledge and related technologies to analyze the factors that influence China's automobile financial credit services. After that, in line with China's specialized automobile financial credit market, some practical suggestions and recommendations are put forward,

1.1.1.1 Current situation of car finance loan in China

In many western countries, car loan is a financial product with a long history in the development of financial credit services. As early as 1910, the United States completed the first automobile sales loan, which has a history of more than 100 years. In China, in 1998, the People's Bank of China promulgated "Measures for the Management of Automobile Consumption Loans" (Pilot Measures), marking the formal start of automobile financial loan business in China. On October 3, 2003, China Banking Regulatory Commission (CBRC) promulgated the Regulations on the Management of Automobile Finance Companies, which no longer restricts the automotive consumption credit business of non-bank financial institutions. This year, three auto finance companies, namely SAIC General Finance, Volkswagen Finance and Toyota Finance, which are related to the giants of the international automobile industry, passed the examination and approval, indicating that the auto finance companies to take root in China. After that, many automotive financial businesses have been established in China, and Chinese domestic automotive financial industry has entered a new period of development.

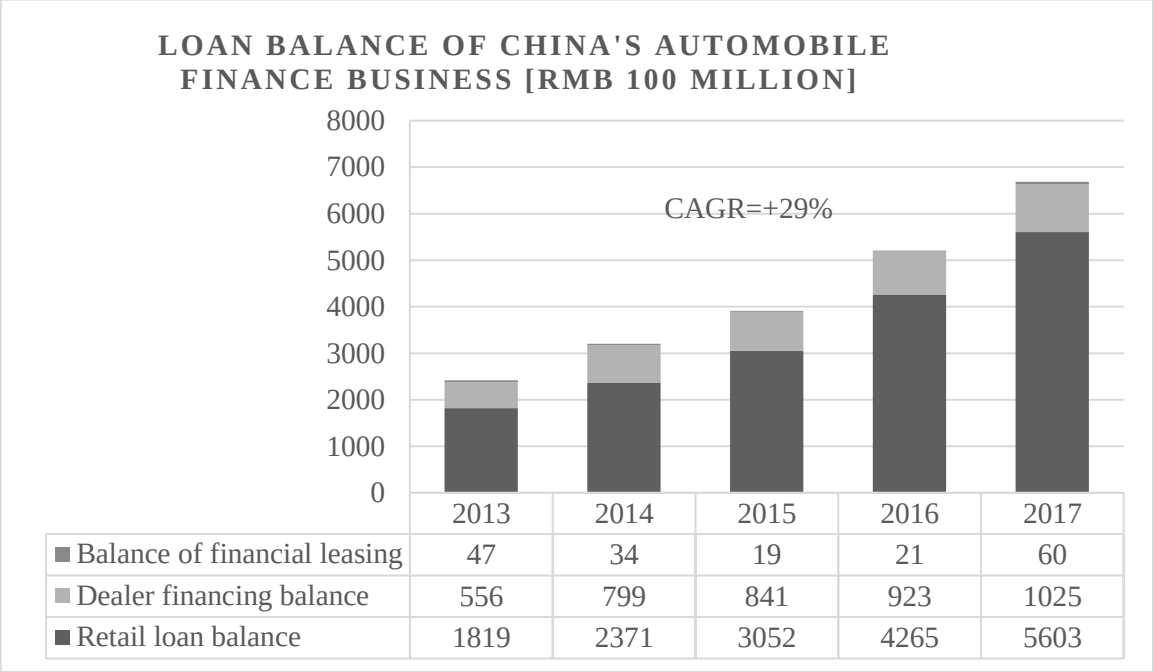
In developed countries with mature financial service system and automotive industry, automotive finance is a broad concept, mainly referring to the financial services related to automobiles. The American Consumer Bankers Association defines automobile finance as taking individuals, companies, governments and other consumer groups as objects, based on their ability to obtain future earnings and historical credit, through providing various financial products of interest rate marketization, the purchase and use of vehicles can be realized. In China's "Measures for the Management of Automobile Finance Companies", the CBRC defines an automobile financial enterprise as "a non-bank financial institution that

provides loans to car buyers in China and engages in related financial business, including Chinese-funded, Sino-foreign joint ventures and wholly foreign-funded automobile financial institutions". Wang (2003), as the first expert to systematically study automobile finance in China, defines automobile finance as "the way and path of financing involved in every link of automobile production, circulation and consumption, or a basic framework of how capital flows in the automobile field". Generally speaking, automobile finance includes several key elements involved in financing, namely the profit model, financing structure, product development and credit management of automobile finance. At the same time, it involves automobile financial institutions (capital suppliers), automobile financial instruments (financing media), automobile financial markets (financing sites) and automobile demanders.

In the narrow sense, automobile finance refers to the financing or other financial services provided by financial institutions to dealers and consumers in the process of automobile sales. Based on the above definitions of automobile finance, this thesis focuses on the narrow definition of automobile finance, that is, automobile finance is mainly automobile consumption finance, which mainly involves commercial banks, financing guarantee institutions, and other non-bank financial institutions. Automobile financing provides automobile dealers and automobile consumers with various financial services, such as mortgage-guaranteed installment loans and automobile financing leases.

Over the past decades, with the continuous improvement of Chinese people’s income levels and the maturity of the automobile market, as well as the improvement of auto consumption environment, auto sales are rising and at the same time, automobile finance is developing rapidly under the guidance of national policies. In the late 1990s, the balance of automobile loans in China was about 400 million RMB. After several years of rapid expansion of business, by 2003, China’s automobile finance loan balance reached 180 billion. In August 2004, the People’s Bank of China and CBRC jointly promulgated the new edition of the Measures for the Management of Automobile Loans. In the same year, due to the high bad debt ratio, automobile loan insurance was stopped, and the automobile financial credit crisis was on the horizon, whereby the automobile financial credit industry entered a downturn for several years, and not until 2007 did it grow again. According to the data of the Federation of Banks, as shown in Figure 1-2, after ten years of development, by the end of 2017, the scale of automobile financial assets in terms of loan balance (including financial lease) has reached 668.8 billion RMB. In 2017, the People’s Bank of China and the China Banking Regulatory Commission decided to revise the Measures for the Management of

Automobile Loans in order to further promote the automobile consumption and standardize the management of automobile loan business, effective January 1, 2018.



	2013	2014	2015	2016	2017
Balance of financial leasing	47	34	19	21	60
Dealer financing balance	556	799	841	923	1025
Retail loan balance	1819	2371	3052	4265	5603

Figure 1-2 Loan balance of China’s automobile finance business.

Data source: China Banking Regulatory Commission (2018)

According to the China automobile distribution industry report (2018-2019),With the rapid development of new automobile finance in China, the penetration rate of automobile finance (the proportion of sales of automobile financial products in total sales) has increased from 13% five years ago to nearly 40% at present, and is expected to exceed 50% by 2020. However, compared with the mature market in western countries, the financial penetration rate of new cars in 2017 in China is still far behind France (70%) and the United States (86%). As for the direct financial lease, China’s penetration rate (4%) in 2017 is far lower than France (16%) and the United States (30%). On the one hand, this is due to the immature development and short history of China’s automobile financial market. On the other hand, the low acceptance of credit by consumers and the imperfect credit system make consumers reluctant to use the product. Therefore, with the gradual enrichment and orderliness of market supply and the change of consumer group’s concept, China’s automobile financial market is gradually maturing, and there is still room for industry development and penetration improvement in the next 10 years. Second-hand automobile finance is driven by the Internet automobile finance platforms, and its penetration rate has increased rapidly in recent years to reach 28% in 2017.

According to the used car report (China Automobile Dealers Association, 2019), in 2017, policy of restrictions on the relocation of second-hand cars was passed, which means that some cities take measures to restrict the inflow of second-hand motor vehicles from other provinces or cities. According to the statistics of China Automobile Dealers Association (2019), at present, about 300 prefecture-level cities in the country have issued the policy of restricting the relocation of used cars, among which 261 cities have adopted the fourth national emission standards, and 12 places such as Hangzhou, Tianjin, Chengdu, Zhuhai and Qingdao have already adopted the fifth national emission standards. In addition, in Jiangsu, Shandong, Jilin and other areas, the age of vehicles has been limited, only vehicles with an age less than 6 years are accepted, which means that used cars with an age of more than five years will not be allowed to relocate in these areas. With the introduction of relocation restriction policy, the return of new car financial leasing after its expiration and the acceptance of consumers, the volume of used car transactions will be promoted, which is expected to reach 37% by 2020. It can be seen that the automobile financial credit industry not only develops rapidly, but also has tremendous room of improvement.

Since the end of the last century, China's automobile consumption market has gradually opened to the outside world. Many foreign enterprises with strong financial strength and advanced management experience have entered the Chinese market, which has had a strong impact on China's automobile industry, especially in the field of automobile finance and credit. At the same time, there are many problems in the macro and microenvironment of China's automobile financial loan market, which makes the automobile loan risk prominent. Especially in the micro economic environment of the development of automobile financial consumption loan in China, the frequent occurrence of automobile financial credit risk in recent years has seriously impacted the operation and management mode of automobile financial credit in China.

Therefore, in order to avoid the default risk and orderly promote the steady development of auto financial credit business, more and more bank financial institutions use financing guarantee companies as intermediary to handle automobile loans for car buyers. Can financing guarantee institutions effectively carry out risk assessment? How to control the risk of its own credit scoring system? Can financing guarantee institutions effectively play an intermediary role? In which aspects can mediation be reflected? This will be an important research direction of this research.

Combined with the development process and current situation of auto finance industry,

as well as the operation process of financing guarantee institutions before, during and after the loan, we believe that its credit risk evaluation mechanism and its intermediary role between the fund provider and the lender are of great significance for its own survival and development. Therefore, we take T company, a well-developed financing guarantee institution founded in 2008 as an example to study the composition of its credit scoring mechanism, evaluate the credit risk evaluation ability of financing guarantee institutions under the mechanism, explore its intermediary role in the auto loan industry, and provide a reference example for the healthy development of China's auto finance industry in the future.

However, in China, because of the short history of development, the laws and regulations are not perfect, the main body of the market is still banks. Other auto finance companies, financing guarantee companies, financial leasing companies and other traditional auto finance business subjects are auxiliary. Although used car e-commerce began to enter the field of auto finance in 2017, its position and market share are still at a very low level compared with the traditional auto finance entities represented by banks. Therefore, the domestic theoretical research focuses on the analysis of macro significance and the game of different interest subjects of automobile financial credit.

Although China's auto finance credit has been greatly developed since it was restarted in 2007, after all, the time to develop auto finance is still short. Until now, this credit mode is still in the initial stage of development in China. How to develop the auto finance service credit business in China, whether the risk management and control methods of auto finance credit in developed countries are applicable in China, how to cooperate with banks, auto finance credit institutions and dealers, how to control the risks in the process of auto finance credit, and how to carry out supervision at the macro level are all worthy of in-depth discussion. To sum up, at present, the research on automobile financial credit in China's academic circles mainly focuses on the following aspects:

First, it analyzes the macro-economic significance of automobile financial credit, focusing on the important role of financial credit in expanding domestic demand and promoting the development of national economy.

The second is to analyze the current situation of the development of automobile financial credit business in China, point out the problems in the development process, and put forward the corresponding countermeasures.

Third, from the perspective of the production and historical development of consumer credit, this research studies and analyzes the economic basis of the production and

development of consumer credit, the operation mechanism of consumer credit, and the evaluation of the macroeconomic effect of consumer credit.

Based on the above analysis, up to now, there is no special research on the intermediary role of auto financing guarantee institutions in China, especially from the credit business process and credit score, that is, to analyze the causes of risk from the aspects of pre loan, middle loan and post loan, and to consider the intermediary role of financing guarantee institutions in each aspect.

Automobile financial credit is not only an automobile consumer product, but also a booster for the development of the industry, in which financing guarantee institutions play a very important role. This research not only uses the related theories of finance to analyze and solve this problem, but also uses the external environment analysis methods of macroeconomics, consumption economics, management economics, marketing and strategic management to analyze and research. From the micro perspective, credit scoring, econometric analysis, combined with risk theory and information asymmetry theory.

From the perspective of an automobile financial credit institution and a financing guarantee company, this research makes a theoretical study on the credit rating of automobile financial credit and the intermediary role of financing guarantee institution. This is an innovation in itself.

1.1.1.2 Research background and current situation

The automobile financial credit business in developed countries in Europe and America has experienced nearly a hundred years of development, from the initial bank loans to the automobile financial service companies. Also, developed countries' research on automobile financial credit market is quite mature from theory to practice. At the same time, developed countries have more perfect legal system to protect consumer credit purchase behavior. Therefore, more theoretical researches in developed countries focus on the risk control of automobile financial credit. In this filed, developed countries have realized scientific management, quantitative analysis and scientific decision-making in main aspects, including the investigation and evaluation system of personal credit level before the loan, the monitoring system of personal credit status during the loan, the risk disposal system of non-performing assets after the loan, as well as the risk management prevention mechanism and internal risk control. At present, the research in western countries mainly focuses on the profit model, financing structure and development of financial products of automobile

financial service. Specifically, the automobile financial credit business, no matter in the external market environment or in the internal risk management and business operation of institutions, is more mature than that in China. Therefore, the focus of research in developed countries has been shifted from the micro business operations to the research on the macro market an environment.

1.1.2 Research Significance

Automobile financial credit institutions manage capital and credit, and risks. The core competitiveness of enterprises engaged in financial credit business is essentially reflected in the ability to manage and control credit risk, especially the ability to manage relevant legal risks. The basic function of automobile financial credit institutions is to predict, bear, manage and control risks. As an important part of auto financing credit institutions, auto financing guarantee institutions play an important role. However, there is still a lack of research on how the financing guarantee institutions themselves fulfill its intermediary role and responsibilities. Therefore, the empirical research on the intermediary role of China's automobile financing guarantee institutions, whether in theory or in practice, is of great significance to help promote the development of China's automobile financial credit industry.

1.1.2.1 Theoretical significance

Firstly, this study enriches and develops China’s automobile financial credit risk theory and credit scoring system.

Based on the theory of auto finance credit and transaction characteristics, this research studies the definition, characteristics and influencing factors of auto finance credit risk. Compared with other credit methods, automobile financial credit risk mainly presents the characteristics of credit risk, and presents different risk characteristics in different stages before, during and after the loan. On this basis, research is conducted using the real data of auto loans of T company in 2018, and regression analysis on credit score by using econometric method, so as to analyze and point out which factors have a higher explanatory effect on the default of auto loans.

Secondly, through the research of this thesis, the application of credit risk management in the field of automobile finance credit in China is expanded.

At present, there are few researches on the credit scoring model of automobile finance in China, most of which focus on the macro problems, the profitability of credit institutions

and the borrowers' credit scoring system, while the quantitative research on the credit risk of automobile finance is less. Through the comparative analysis of modern credit scoring models, this thesis extracts the modeling ideas and evaluation framework suitable for automobile financial credit and expands the application scope of modern credit risk evaluation theory.

Thirdly, through the research of this thesis, it is put forward that the financing guarantee institution plays an important intermediary role in the automobile financial credit.

Based on the analysis of the intermediary role of auto financing guarantee institutions and the characteristics of auto financing credit market in China. On the one hand, a dynamic evaluation model of auto financing credit risk is proposed. The model estimates the rational default rate of the borrowers based on the automobile credit cycle and realizes the dynamic measurement of the expected loss of the guarantee institution by combining the risk exposure, disposal and other information of the automobile transaction. On the other hand, the analysis and research on the internal evaluation model of financing guarantee can comprehensively reflect the intermediary role of financing guarantee institutions in automobile financial loans.

1.1.2.2 Practical significance

First, this research is helpful to enhance the risk management ability of China's automobile financial credit institutions, promote the healthy development of the financial credit industry, and to a certain extent, reflect the role of financial innovation.

Based on the business process of automobile financial credit, this thesis puts forward a series of evaluation models of automobile financial credit risk from the process of pre-loan, loan-in and post-loan, which will help to improve the ability of automobile financial institutions to manage credit risk. During the loan period, the automobile financial institutions can adopt active risk management mode according to the quantitative results of the model. When the borrowers' solvency or willingness to pay is low, they can adopt such risk management and control methods as active collection or disposal of non-performing assets to strengthen the self-rescue ability of the automobile financial institutions. In order to promote the healthy development of automobile finance and credit industry, the evaluation model is helpful to change the existing management and control mode of the industry. The model proposed in this thesis is the premise of asset management and information construction of automobile financial institutions. It provides a theoretical basis for China's automobile financial credit industry to take the road of specialization and informatization,

and reflects the competitiveness of automobile financial credit which is different from other financial products, thus contributing to the healthy development of automobile financial credit industry and even the whole financial credit field.

At the same time, the construction process of this model is also a process of mutual promotion and integration of finance, science and technology. It is a process of financial innovation represented by credit score landing in the field of automobile financial credit. It provides new ideas and directions for the development of China’s automobile industry and financial innovation.

Second, this research helps to enhance the core competitiveness of financing guarantee institutions in the automobile financial credit market.

The analysis of credit risk scoring system of financing guarantee institutions and the proposal of intermediary role of financing guarantee institutions are helpful to reduce the degree of information asymmetry of automobile financial credit and thus reduce the uncertainty of loan default risk. Before the loan, the financing guarantee institution collects the information of the borrowers and evaluates the value of the loan vehicle, which reflects the role of the financing guarantee institution as an information intermediary between the borrowers and the vehicle dealer. During the loan, it uses the internal credit scoring system to determine whether to provide the financing guarantee for the borrowers, which reflects the role of the financing guarantee institution as a finance guarantee intermediary between the borrower and the funding party. After the loan, through the supervision and default disposal of the borrowers’ repayment, it reflects the role of the financing guarantee institution as an information intermediary between the asset owner and the non-performing asset disposal institution, which can effectively help the fund to reduce the degree of loss. Therefore, the intermediary role of financing guarantee institutions in different stages of loans improves the efficiency of China's auto loans and reduces the risk of default, which helps to enhance the competitiveness of China's financing guarantee institutions relative to other auto financial instruments, and has an important driving significance for improving the development level of China's auto financial loans.

Third, this research helps to improve the ability of automobile financial institutions to serve consumers.

Furthermore, the improvement of credit risk management ability also improves the ability of China's automobile financial credit to serve consumers to a certain extent. In the traditional credit mode, two main factors restrict the development of China's auto finance

credit industry, namely the difficulty to get a loan and the low speed of issuing the loan. With the help of auto finance credit, such as financing guarantee, customers benefit from the efficiency and convenience of getting a loan, because the success rate of consumers obtaining auto finance credit support increases, and it solves the problem of consumers choosing auto financing services a certain extent. Therefore, improving the risk management and control ability of auto finance credit and enhance the intermediary role of financing guarantee institutions will help to improve the ability of auto finance institutions to serve consumers.

1.2 Research ideas

This research mainly adopts the empirical research method, according to the idea of finding problems - researching problems - solving problems, aiming at the current development situation and the latest theory of China's auto finance credit industry. Firstly, based on the theoretical basis of financial innovation and credit scoring, we hope to find out the problems of auto financing guarantee companies occurred during the process of auto loan, and then leads to the importance of the intermediary role and credit evaluation of auto finance credit. Then, the research conducts empirical analysis and research on the important body of China's auto credit, namely the borrower. Matching the credit scoring technology with the current situation of the intermediary role of auto financing institutions, combining the credit process before, during and after the loan, we put forward the key problem of this thesis -- the evaluation model of auto financing credit risk. According to the application and analysis results of the model, this thesis attempts to study the intermediary role of financing guarantee institutions in the risk management of auto financing credit in China to provide countermeasures and suggestions for the prevention and solution of automobile loan risks. Auto financial guarantee companies use credit scoring systems of their own, combining determinant factors of personal information, publicly available information and third-party scores. The study approach uses a two-stage regression method to control or eliminate the effect of personal information, public available information and third-party credit scores. The first stage tests aim to see whether there is any additional information provided by auto financing guarantee companies in their credit scoring system. The second stage tests find out whether the additional information has a significant explanatory power on post-loan performance of borrowers.

1.3 Research Contents

Chapter arrangement and main contents of this thesis are as follows:

Chapter 1: Introduction, mainly introduces the research background and significance, research ideas and methods, the main content of the study, research innovation and shortcomings and framework structure.

Chapter 2: Related theories and literature review, discusses the theoretical context and starting point of the research on financial innovation, consumer credit, auto finance, financing guarantee concept and risk management in detail, and points out that the core of the intermediary role of auto finance credit score and financing guarantee institution is to overcome information asymmetry. With the help of big data information technology, it is necessary to reduce the probability of default by means of credit score and other technical means. The task of auto loan financing guarantee institutions is to give full play to the intermediary role, manage and control risks in all aspects of auto financial credit.

Chapter 3: Industry status and operation process analysis, first of all, from the macro point of view, introduces the development process and current situation of the auto loan financing guarantee industry, analyzes and introduces the existing Chinese auto financing credit subjects, and analyzes the advantages and disadvantages of each subject. Secondly, from the middle economics point of view, combined with the intermediary role of financing guarantee institutions, studies all aspects of auto loan, starting with various risk factors before, during and after the loan, and introduces and analyzes various aspects of the operation process, such as customer due diligence, business scoring, loan review and approval, loan issuance, post loan management and non-performing asset disposal. Finally, from the micro level, combining with the actual operation process of T company in terms of loan approval, credit scoring and risk management, focuses on the role of credit intermediary, service intermediary and information intermediary of financing guarantee institutions.

Chapter 4: Research methods, based on 119,798 auto loans data of T company, we classify and define the data, and select Ordinary Least Square (OLS) regression and Logit regression method to analyze the loan data.

Chapter 5: Research results and discussion, makes an empirical study on the effect and intermediary role of credit rating of financing guarantee institutions. This chapter is the core chapter of the research. Firstly, the variables that affect the default probability are empirically analyzed through Logit regression. Secondly, the interpretation and stability test of the

regression results are carried out. Finally, based on the economic analysis of credit score in financing guarantee institutions, the intermediary role of T company is tested.

Chapter 6: Conclusion and prospect, first of all, summarizes the contents and conclusions of this study, then summarizes the shortcomings of this study, and finally prospects for further improvement of the research in the future.

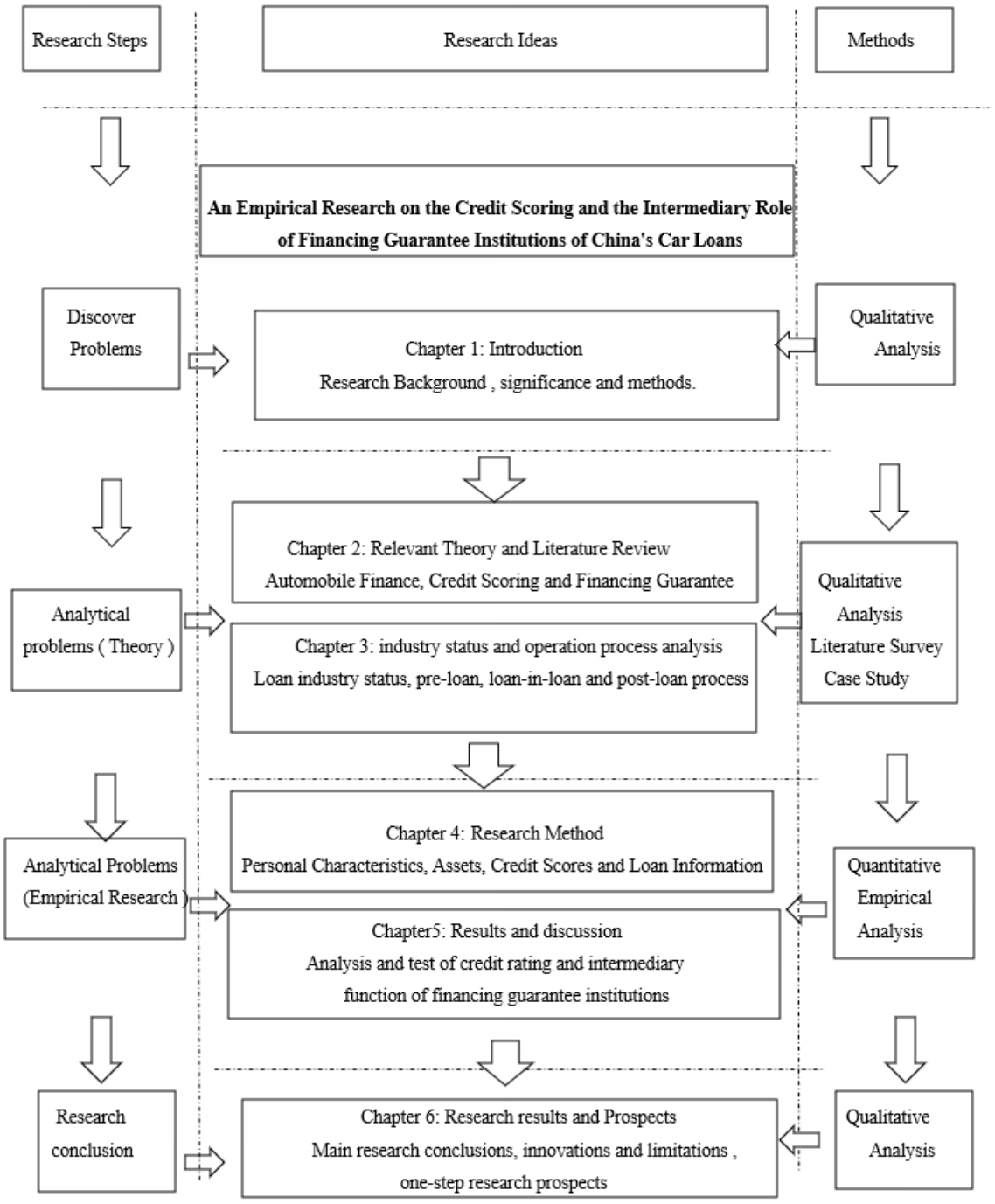


Figure 1-3 Frame Structure

The frame structure of this thesis is shown in Figure 1-3.

1.4 Innovation of research

This thesis focuses on the intermediary role of financing guarantee institutions and the credit rating of auto loans, which are mainly shown in the following aspects:

First, in the topic selection, auto finance credit is in the development stage in China, and the risk of auto finance credit is gradually exposed with the rapid development of business. There are relatively few academic researches on the topic of credit rating of automobile finance and the intermediary role of financing guarantee institutions, especially the Doctorial Thesis. At present, there is no Doctorial Thesis on the subject of credit rating of automobile loan in China. In addition, the research on the intermediary role of financing guarantee institutions is also blank. Therefore, under the background of the rapid development of automobile industry and the frequent occurrence of automobile loan risks, this thesis studies many problems of automobile loan management and financing guarantee institutions, and puts forward suggestions and opinions, hoping to enrich the research in related fields.

Secondly, in the application of credit scoring, through the empirical study of T company's internal credit scoring, the credit scoring techniques such as Logit regression and two-stage regression are applied to the analysis of automobile borrowers in financing guarantee companies. It expands the applicability of credit scoring and tests the internal credit scoring system of financing guarantee institutions with the comparison of third-party credit scoring. This thesis puts forward an evaluation model of the default rate of auto loan, which integrates risk management and control. It reflects the role of information technology in credit risk management and expands the application of financial innovation in the field of auto financial credit. In addition, the model has played a certain exemplary role in encouraging auto financial credit institutions such as financing guarantee companies to pay attention to the key indicators of borrowers, when they carry out auto loan business, which is different from the traditional credit risk management, and helps to enhance the core competitiveness of auto financial credit institutions.

Thirdly, based on the intermediary role of financing guarantee institutions, the management system and internal control process before, during and after the loan are systematically put forward. The system realizes the integration of automobile financial credit institutions and borrowers credit scores. It is suitable for risk assessment and management

before, during and after the loan.

Chapter 2: Related Theories and Literature Review

2.1 Bibliometric research

The research background of this thesis lies in the maturity of China's financial innovation and big data technology, as well as the improved loan risk control, personal credit assessment technology and credit risk management and control technology. The research focuses on the analysis of the credit rating of the borrowers and the intermediary role of the financing guarantee institution. In order to fully understand the current situation of theoretical research in these areas in China, the author chooses the China National Knowledge Infrastructure (CNKI) as the literature base. From the database, academic journals and Doctorial theses that are officially published in China are the main sources used in the study. Nine search items are used to generate search results, which can be seen in Table 2-1 below:

Table 2-1 Subject words Statistics of CNKI literature database

	As a theme			**As a keyword**		
	Total number	Journal articles	Doctorial Thesis	Total number	Journal articles	Doctorial Thesis
Financial innovation	33,309	30,996	2,313	8,155	8,077	78
Consumer credit	10,193	9,833	360	5,360	5,340	20
Credit risk	12,879	12,691	188	10,193	10,136	57
Car finance	2,024	1,997	27	287	284	3
Credit score	1,056	998	58	627	618	9
Financing guarantee	4,178	4,019	159	206	203	1
Car loan	860	836	24	123	123	0
Credit risk control	4,178	4,019	159	206	203	3
Intermediary role	43,002	41,405	1,597	14,862	14,799	63

In summary, the research direction mainly involves the credit evaluation of automobile loans and the intermediary role of financing guarantee institutions. This thesis solves problems of default probability using quantitative analysis and credit scoring, thus it involves data modeling and credit scoring based on borrowers. For credit score and intermediary role of financing guarantee institutions, this chapter divides the relevant theories and literature into financial innovation and automobile loan, consumer credit and credit score based on

credit risk, financing guarantee and intermediary role. In the relevant literature of borrower's credit evaluation, this chapter will also introduce the corresponding credit scoring methods. In view of these aspects the theoretical research status and related work will be summarized in the following chapters.

2.2 Financial innovation and car loan

2.2.1 Financial innovation

Ding (2014) thinks that finance is an economic category formed after the emergence of credit currency. It is an economic activity of optimal allocation of assets in an uncertain environment. Credit currency refers to the payment, loan, financing and exchange of currency, and a series of economic behaviors such as securities trading, bill circulation and settlement and derivatives exchange formed on this basis. Finance is the general sum of credit currency and its economic activities. Finance is dynamic, developing and closely related to human economic activities, and serves for it. Finance does not create real value but can transfer and allocate value. Shiller (2012) pointed out that finance is a functional science, which exists to help more people achieve their goals, such as expanding production of loan funds and paying for consumption costs. Participants need to use a variety of financial tools to achieve these goals. One of the main tasks of financial practitioners is to match transactions and provide a variety of financial programs, such as lending methods, methods of payment, mortgage financing, issuance of shares and bonds, and establishment of contracts, with the purpose of help participants in economic activities understand their goals and take corresponding risks (Chang, 2018).

Schumpeter (1911) thinks that the so-called "innovation" means the establishment of a new production function, that is, entrepreneurs implement a new combination of production factors and production conditions. By quoting the concept of innovation, the meaning of financial innovation is to establish a new production function in the financial field, combine various new financial elements, and form a market reform for the pursuit of profit opportunities. Generally speaking, it refers to a series of new things in the financial field, including new financial instruments, new financing methods, new financial markets, new payment and clearing methods, and new financial organization forms and management methods (Chen, 1991).

Ross (1997) believes that because the institutional relationship of financial market is

different from that of traditional enterprise and institution management, and different financial institutions have different preferences, they will have different needs for financial system and instruments. Therefore, financial innovation helps to solve the problems of adverse selection and moral hazard.

In the study of security design in incomplete financial markets, Duffie and Rahi (1995) analyzed the role of financial innovation in information sharing and risk sharing based on a CARA model. They find out that in incomplete financial market, financial innovation brings new market equilibrium. White (1997) pointed out that the rapid development of financial innovation in the United States is mainly due to two important technological advances, namely the development of data processing technology and telecommunications business.

According to Duca (2000), the main factors of financial innovation are technological progress, deregulation and economic globalization. When Grinblatt and Longstaff (2000) studied the impact of different forms of financial innovation on incomplete information market, they found that when the market has different degrees of restrictions, enriching the types of financial products to meet the needs of customers with different preferences can reduce the risk of financial market. Frame and White (2004) defines financial innovation from the perspective of function, which can be divided into several function, including new things that disperse financial risks, reduce transaction costs, provide new products, new tools and new services.

According to Chemmanur and Wilhelm (2002), it is the progress of computer and transaction technology that promotes the development of financial markets and promotes financial institutions to develop new financial products and transaction tools.

Sheng and Zhai (2015) defined financial innovation as forming a new financial operation mechanism, through which, the financial institutions break the traditional business scope and methods, use new financial technology, develop new financial business and financial tools, and open up new financial markets. Different scholars have different definitions of financial innovation, but their core contents are similar, and they all emphasize the development of new financial products or businesses.

When Hong (2018) studied the impact of financial innovation on monetary demand, he found that although the inhibition effect of direct financing proportion on money demand is statistically significant, its influence coefficient is relatively low, and the improvement of financial innovation level will effectively reduce monetary demand, while financial innovation is an effective variable to inhibit money demand in China.

Li (2019) proposed in his research on the innovation of private enterprises in China that no matter large, medium or small enterprises, they need to have new ideas in terms of structural adjustment. Only those enterprises that focus on technology, equipment and marketing innovation will not be eliminated by the market.

2.2.2 Consumer loans

Hawtreg (1947), a British financial scientist, pointed out in his research on the internal volatility of the credit of the central bank that with the increase of the bank's credit, the aggregate demand will increase correspondingly, which will bring about the upsurge and prosperity of the economy. German financial scientist Zweig (1936) pointed out in the study of consumer credit that the increase of consumer credit in the short term, on the one hand, increased consumer demand, on the other hand, increased investment demand, so it will expand domestic demand. Antzoulatos (1996) thinks that consumer credit can be used as an explanatory variable to predict consumption more accurately. On this basis, he puts forward the hypothesis of "consumption boom". He thinks that without considering the model of consumer credit, the consumption growth of a country cannot be predicted accurately.

Stiglitz and Weiss (1981) pointed out that the risk of automobile credit is closely related to its information asymmetry. The information asymmetry happens in the process of automobile financial credit between the borrowers and the lenders result in the adverse selection of interest rate. Due to the fact that lenders are trying to maximize the expected return, there is no equilibrium in the supply and demand of credit loans. In view of the imbalance between supply and demand, credit demand will be greater than supply, and the lender will allocate the loan amount, making it more difficult for the borrower to borrow.

Carroll (1992) believes that the greater the income uncertainty consumers face, the less they consume. By calculating the "buffer stock" consumption model, the precautionary motivation greatly reduces the willingness of prudent consumers to consume out of uncertain future income. High loan interest rate, high tendency of saving and low willingness of consumption make residents reluctant to buy cars with loans, because they are worried about bearing heavy economic pressure for this. At the same time, they are worried about the loss caused by the decline of car price. The current consumption of residents depends on the expected lifetime income. In addition, it is found that consumption is closely related to the expected current income but has nothing to do with the predictable changes in income. Residents will reserve savings to prevent risks such as the possible sharp reduction of income,

which limit the demand for auto loan consumption.

Hellmann, Murdock, and Stiglitz (1997) pointed out in their study of financial institutions in East Asia that due to the widespread credit risks in credit business, such as auto loans, a perfect personal credit system is the prerequisite for developing auto credit business. In the process of developing auto credit business, financial institutions need to pay special attention to collecting and analyzing the personal credit records of borrowers, including the past credit status, whether there is financial fraud risk, as the precondition of whether to issue loans, so as to ensure the safety of loan funds and reduce the probability of default.

Liu (2017) studied the credit structure from the perspective of government intervention and analyzed the structural optimization of credit resources from seven dimensions of credit scale, holder, term, ownership attribute, industry, concentration and currency. The thesis puts forward the top-level design of credit structure, which is to make overall consideration, and to strengthen the guidance and regulation of credit behavior of commercial banks and other financial institutions. Improve the policy and strengthen the supervision; optimize the credit structure according to the characteristics of different dimensions; regulate the behavior of local government to avoid blind intervention; combine the government and market to jointly promote the optimization of credit structure.

In the research on the China's consumer credit and effective dissemination of consumer credit policy, Li (2018) found out that, from the perspective of spatial subject dissemination mode, the dissemination mechanism of consumer credit policy can be divided into two main stages, which are from the central bank to financial institutions, and from financial institutions to lenders. In the first stage of transmission process, In the first stage of transmission, the transmission paths in the central, eastern and western regions of China is smooth, while there is obstruction in the northeast areas. In the second stage of transmission, the transmission paths of the whole country and the four major economic regions are unimpeded. From the perspective of time variable transmission mode, consumer credit policy transmission mechanism has its own mechanism effect in economic stability, economic security, structural optimization and other different dimensions of economic growth. In the test of intermediary effect, it is found that there is a significant intermediary effect in the credit services of financial institutions, which shows that the credit services of financial institutions play a transmission role in the spatial transmission of consumer credit policy. Among them, the whole country and the other three economic regions are

complementary intermediary roles, while the credit services of financial institutions in Northeast China have significant intermediary roles.

2.2.3 Car finance loan

Zhao (2003), an academic research of the Institute of Finance and Securities in Renmin University of China, has conducted research on China' credit situation from several aspects, including the 15% non-performing loans in 2003, the transferring of bad loans from insurance companies to commercial banks and the large exit of insurance companies from the car insurance market. The author found out that the automobile credit risk mainly comes from three aspects: 1) lack of credit, and incomplete evaluation and management system of auto loan ratio; 2) low-level of competition among banks thus loan risks accumulate; 3) the price of cars is decreasing annually, and some consumers stop paying their loans and turn to buying new cars. Wang (2002) analyzed and predicted the prospect of China's automobile consumption credit market according to the functional relationship between per capita GDP and automobile penetration rate.

From the perspective of the game between different stakeholders, Ba (2005) analyzed the game between the lender and the financial borrowing institution from two aspects, namely complete information and incomplete information. The author pointed out that in the condition of incomplete information, the means used by the auto financial institution to effectively control credit risk aim both at borrower and lenders. Auto financing institutions can require that borrowers provide collateral and legal proceedings, they can also lower the interest rates for high-income borrowers to attract their money, to reduce the situation that only low-income borrowers apply for consumer loans to increase credit risk. Guo (2006) analyzed the game relationship between banks and lenders under the condition of asymmetric information, and concluded that methods to reduce risk relying on improving the qualification of loan applicants would only inhibit the enthusiasm of banks and consumers, and could not really solve the risk problem of consumer credit. Only by establishing and improving personal credit system and using legal and institutional means can we reduce the risk of automobile financial credit. Liu, Zhang and Tong (2007) analyzed the multi-games of consumers, dealers, insurance and banks from the perspective of macroeconomics and strategies and pointed out that the main source of credit risk is intentional default and forced default. For example, in collusion between dealers and lenders, the controllable risk of falsely raising the car price to obtain a high loan can be reduced

through equilibrium game or innovation of automobile financial business.

Wang (2003) believed that with the development of automobile financial market, automobile finance has gradually developed from a single financial instrument such as automobile consumer credit to a business that comprehensively uses various financial technology means to provide various financial services for automobile consumers. With the maturity of automobile financial credit, there are a series of relatively standard laws and regulations in countries other than China, such as the Consumer Credit Act of the United Kingdom, the Fair Credit Reporting Act of the United States, the installment sales act of Japan and the capital industry rules law (Niu, 2008). The loan interest rate of automobile financial credit has also developed from fixed products and interest rates to flexible financial products and loan interest rates, that is, to provide different financial products according to different needs of customers, as well as the loan interest rate and loan term consistent with their credit situation (Li, 2018).

Fisher (1936) proposed for the first-time consumers' consumption spending behavior arranged by stages, and analyzed and elaborated how consumers could achieve a balance between current consumption and future consumption. Hirshleifer (1958) conducted an in-depth study of consumer behavior on this basis and believed that when consumers purchase durable consumer goods such as automobiles and choose the best installment consumption mode, they have a demand for financial support.

Banner (1958) conducted a case study on General Motors finance company and concluded that financial holding institutions increase the product sales of the parent company by providing financing to customers, which has a positive impact on the real economy of the parent company and makes the parent company more competitive in the market. At the same time, because the holding financial institutions' main goals is to promote the sales performance of the parent company, they ignore the risks to the financial institutions themselves. As a result, the risk of financial market increases.

Robert (1963) analyzed many factors influencing the change of automobile credit interest rate in automobile financial credit. The development of auto finance is divided into four stages, and the factors that affect the interest rate in each stage are analyzed. Finally, the author concluded that the supply factor has a larger influence on the decision of interest rate than the demand factor. Aizcorbe (1997) found that auto finance credit has become one of the most common sources of household debt. Hassler (2001) believes that compared with other uncertain factors, financial credit is an important part of the determinants of household

consumption of vehicles. Dasgupta, Siddarth, and Silva (2007), through the comparative analysis of the average income of residents and the average price of automobiles, found that the majority of automobile consumption is realized by means of automobile financial credit, and household automobile consumption is mainly purchased by means of financial credit.

Harris (2010) analyzed the causes of the contemporary automobile financial credit, and found that the main factor causing the credit risk is the information asymmetry between the automobile financial institution and the borrowers. When using the method of game theory to analyze the game between the automobile financial institution and the borrowers, he found that due to the information asymmetry, the automobile financial institution will overestimate the credit of the borrowers and hence raise interest rates. For the borrowers, it is easy for them to overestimate their repayment ability, which increases the credit risk of auto finance.

Li and Li (2010) thought that the perfect legal system and personal credit system could guarantee the rapid development of auto finance in developed countries. In the study, the credit system of western developed countries is divided into three modes. The first one is the American mode, or the market operation mode. After more than 160 years of development, the American credit system has formed a sound and perfect credit mechanism with credit rating as the core, credit transaction as the means, laws and regulations as the guarantee, and credit intermediary as the link. The second is the European model, which is dominated by the government and the central bank. As a department of the central bank, credit agencies, dominated by the central bank and the government, mostly appear in the background of the bank or the government and serve the public interest or policy objectives. The degree of marketization is low and limited to the scope of peer credit. The third is the membership model represented by Japan. This kind of model only aims at member units to share credit information, which is both obligation and power, but the power to use credit information needs the consent of information owners. On this basis, advanced management experience, strict risk control and stable financial channels have created a developed automobile financial market. At one time, the proportion of foreign full payment, credit and financial leasing modes reached a ratio of 20:34:46. To fill the huge gap, China needs to start from the national conditions, learn from the experience of mature automobile financial markets, from laws and regulations, credit system, financial institutions and risk control and other aspects to help the growth of auto finance industry.

According to Stiglitz (2012), the main reason for the occurrence of non-performing credit is information loopholes. When the probability of default of the borrower is high, the

automobile financial institutions tend to reduce the risk by reducing the loan proportion or contracting the scale, which will cause a vicious circle, restrict the development of automobile finance credit, and cause the imbalance of supply and demand Situation.

Einav, Jenkins, and Levin (2013) studied the application of automated credit scoring in a large auto financing institution and its changes in loan practice. They found out that the credit score increased the profit of a single loan by about 1000 dollars. At the same time, the study found through the screening of high-risk borrowers, and the increase of the credit loan amount to low-risk borrowers, auto financing institutions can effectively reduce the operational risk. At the same time, the study also records that credit score reduces the profitability of the dealers, and provides evidence that credit score may be a replacement of the geographical advantage of local dealers.

Liu (2016) started from the current situation of automobile financial loan risk in China, and divided the factors causing automobile financial loan risk into external and internal factors, including national macroeconomic policies, economic cyclical fluctuations, social environment and market competition factors. Internal factors include internal employees' ability to identify credit risk, the operational risk of the financial company itself and the risk of the borrowers' repayment ability. In order to improve the credit risk management of China's automobile finance, some strategies are put forward, such as improving the credit system, building the second-hand car market, enhancing the transparency of macro policies, reducing the operational and operational risks, and promoting the innovation of automobile financial products.

Based on the analysis of the development trend of auto finance in China and the auto finance business model of commercial banks in other countries, Liu (2017) discussed the main reasons why Chinese commercial banks could not make big breakthrough in the scale of auto loan. Commercial banks have defects in the areas of marketing strategic planning, risk control, customer management, cross selling and automobile consumption, which restrict the development of automobile financial credit. Nowadays, the development mode of commercial banks and the behavior preference of financial customers have changed greatly. It is necessary to speed up the application of digitalization in Customer Relationship Management (CRM), risk control, cross selling and business process. At the same time, we all need to learn from the successful experience in how to realize the high integration of consumption and financial business. Starting with the construction of the core platform, integrate the customer needs of all aspects of automobile consumption is necessary.

2.3 Credit risk and credit score

2.3.1 Related concepts and research status of credit risk

2.3.1.1 Credit

As early as thousands of years ago, Confucius put "Faithfulness" into the "Five constant". In Confucianism, the Five Constants are the five virtues of humans and the guiding principles of Chinese people. They are the five basic virtues and characters that a person should possess as an independent individual in the society for his own growth and development and social progress. The five virtues include Rén (benevolence), Yì (righteousness), Lǐ (courtesy), Zhì (wisdom) and Xìn (faithfulness). Confucius first proposed "benevolence, righteousness and propriety", then Mencius expanded to "benevolence, righteousness, courtesy and wisdom", and then Dong Zhongshu expanded it to "benevolence, righteousness, courtesy, wisdom and faithfulness", which are then later called "Wuchang" or literally five constants. This "five constant" runs through the development of Chinese ethics and becomes the most core factor in Chinese value system. In "the Analects of Confucius. Learning", Confucius said, “I examine myself three times a day. Am I faithful for the sake of other people when acting on their interests? Am I a loyal friend? Have I done what I was taught? ... Faith is close to righteousness, and words can be repeated." Faithfulness means to be honest, trustworthy and not hypocritical.

In the west, the word "credit" originated from the Latin word "credo", which has the meaning of trust and reputation (Xiang, 2011). The original meaning of English "credit" refers to people's trust in others. To be trustworthy is to pay attention to maintaining others' trust in themselves. It first belongs to the category of social ethics, embodied in religious doctrines and cultural traditions and other fields. Religious doctrine is one of the most important moral classics in the west, the Bible repeatedly emphasizes the importance of credit to a person. In the Bible, if a person loses his credit, he will lose the capital to gain others' trust and will not be able to engage in interactive behavior. The concepts of honesty and justice have a direct impact on the principle of "honesty and credit" in western countries' laws.

It can be seen from this that credit is the earliest equivalent to trust, which is a word at the level of ethics and morality, specifically referring to the production and social relations of mutual trust formed between people, units and units, as well as commodity transactions.

Ouyang (2000) divides credit into ethical credit and economic credit. Credit is equal to honesty and credit is understood as moral category. Li (2004) thought that credit is a kind of moral standard and behavior standard of keeping promises, which also belongs to the concept of moral level. Wang (2005) and Sun (2008) also interprets and analyzes credit from the aspect of morality.

With the development of society and economy, commercial credit and financial credit are gradually rising, and the connotation of credit is also expanding. Nowadays, credit has not only the meaning of morality, but also the meaning of law and economy. From the perspective of legal contract, the General Principles of Civil Law of China stipulates that “civil activities shall abide by the principles of voluntariness, fairness, compensation for equal value, honesty and trustworthiness". The Contract Law requires that “the parties shall be honest to others, be creditable and keep their promises, and interpret and abide the contract according to the principle of honesty and trustworthiness when disputes arise in the content.”

In the west, Hart (1996) believes that "any transaction needs some forms of contract as a medium, whether explicit or implicit. The transaction itself can be understood through the contract, and the determination of the transaction should also be determined through the contract, while the conclusion or failure of the transaction reflects the performance, suspension or violation of the contract.” Song (2001) thought that credit is a kind of contractual relationship. Because human nature is profit-oriented, the formation of credit must be based on the relevant laws and regulations. Liu (2008) also elaborated and analyzed the relationship between credit and contract as well as the effect of contract on credit.

Economically speaking, credit refers to the value movement in which the credit giver lends money to the recipient on the basis of full trust that the recipients will realize their commitment, and hence guarantees that lenders’ principal can flow back and increase in value. Commons (1961), the founder of institutional economics, once proposed a credit theory that "debt and ownership are not wealth, but institution". Wei (2002) thinks that the operation of modern credit economy is based on the credit relationship, and the core content of which is to perform the contract. Credit is the basis of a contract and contract is the manifestation of credit relationship and the means to maintain credit relationship. Ma and Mao (2007) used the method of mathematical modeling to analyze the problem of contractual credit, revealed the mechanism of credit in the process of transaction, and designed an effective credit mechanism from the perspective of economic activities.

2.2.1.2 Credit risk

The definition of credit risk can be divided into broad sense and narrow sense (Ba, 2003; Yan, 2010). The broad sense refers to the risk of loss caused to the counterparty due to credit default (Luo, 2005; Chen, Liu, & Liu, 2006). The risk caused by various credit transactions can be included in the scope of credit risk (Aunders & Anthony, 2000). The narrow sense generally refers to the risk of loss caused to the creditor due to the debtor's default. From the perspective of commercial banks and financial institutions, credit risk, also known as default risk, is the commitment made before, during and after the loan, including the risks faced by various links such as fund use, loan repayment and the combination with market-related risks (Jiang, 2006; Zhang, 2012). In our research, by credit risk we mainly refer to the narrow sense of credit risk, that is, personal credit risk.

Personal credit is the sum of personal credit information in the market economy. It is the basic economic relationship between social members and the foundation of the whole social credit. With the help of good credit in economic life, it is much easier for individuals to obtain the support of funds, materials and quick transactions. The continuous accumulation of personal credit forms a kind of personal capital, namely credit capital. Therefore, personal credit is not only a simple act of borrowing and lending in the credit relationship, but also a comprehensive reflection of the individual's social concept, consciousness, personal ability, economy, morality and law (Shi & Jin, 2003). From the perspective of the whole society, personal credit information includes information recorded by relevant institutions and departments such as financial institutions, municipal administration and public security system. Among them, the industrial and commercial department can easily obtain personal business activity information through the industrial and commercial registration data. The tax department can easily obtain personal income and tax information through the tax registration data. Medical institutions can easily obtain personal medical information data through the health data. It is natural that each functional department has its own data collection method and database. Financial institutions can help assess credit risk through personal credit information.

Jiang (2003) thinks that credit risk refers to the possibility of causing loss to financial institutions in the process of operation and management due to the influence of various uncertain factors that lead to the actual return of loan funds lower than the expected return. The causes of credit risk are various, from the changes of domestic and foreign political and economic environment to natural disasters, and the repayment ability and willingness of the

borrower will affect the repayment of the loan. Western commercial banks and other financial institutions define credit risk as:

$$R = f(I, E) \tag{2.1}$$

Where R represents credit risk, I represent internal factors, E represents external factors, that is, credit risk is a function of internal factors and external factors. External factors are factors that cannot be controlled by financial institutions, such as macro political and economic environment and natural disasters. Internal factors mainly refer to the attitude of financial institutions' managers towards credit risk, which has a direct impact on the size of credit risk. This kind of influence will permeate into the loan policy, risk management, credit evaluation and staff management before, during and after the loan of financial institutions. At present, credit risk evaluation methods include complex quantitative methods that uses mathematical models and relatively simple qualitative methods. Evaluation methods can be either based on public evaluation of open information of financial market, or internal evaluation of non-public information. Generally speaking, the methods of credit risk evaluation show a scope from qualitative to quantitative and from simple to complex. The main scope of credit risk in our research is on quantitative model analysis and internal non-public information evaluation method.

2.2.1.3 Personal credit risk

Personal credit risk or personal default risk refers to the possibility of default owing to the borrowers' personal reasons. Subjectively or objectively, the borrowers are unable to fulfill the loan commitments, and cause the bank and other financial institutions to suffer losses (Wang & Wang, 2003). Personal credit risk assessment refers to the risk assessment conducted by financial institutions or personal credit rating agencies to predict borrowers' solvency and willingness to pay, based on the historical records of borrowers' personal credit, as well as the probability of default presented by various credit transactions (Wei & Zhou, 2014). For banks and other financial institutions, the object of personal credit risk assessment is the borrowers. The assessment content is mainly based on the borrowers' credit information held by financial institutions, including data information that can reflect the individual's solvency, such as basic personal information, personal income and assets, and historical information that can reflect the borrowers' willingness to pay and moral hazard, such as personal loan and repayment records, ethics and other credit information. Personal credit risk assessment usually evaluates the factors affecting personal credit risk, including the economic strength and repayment ability of the borrowers, as well as the historical record

of credit behavior on behalf of the borrower's willingness to repay the loan.

Fair Isaac Corporation (FICO) personal credit assessment factors are divided into four categories, which are personal information, economic information, financial institution relationship information and credit records. Among them, personal information includes housing situation, current residence, occupation, working years and many other personal information. Economic information includes credit card situation, debt ratio and assets. Relationship information of financial credit institutions includes bank account, credit line utilization rate and number of revolving credit overdraft accounts. Credit record information includes number of queries within one year, credit file years and default records.

Shi and Jin (2003) classified the factors affecting credit risk into three categories, including natural information, social credit information and professional information. Natural information includes the basic information of the borrowers, such as borrowers' age, education level, marital status, real estate, residence, family income and number of people to support. Social credit information includes credit record, credit history, number of credit accounts, credit utilization degree and judicial information. Professional status includes occupation, working time, position and job stability.

According to Cui (2005), there are three main factors affecting personal credit risk, namely personal basic information, credit system information and value system information. Personal basic information includes age, education level, marriage status and health status. Credit system information includes credit card malicious overdraft records, overdue records, malicious arrears of water and electricity charges records, tax evasion and tax evasion records. Value system information includes type of organization, income level, family asset value, monthly average repayment amount and disposable income ratio and financial leverage ratio.

According to Hu (2007), the factors affecting personal credit risk can be divided into four categories, which are qualification evaluation information, asset evaluation information, expenditure situation and historical credit. Qualification evaluation information includes age, gender, marriage, education background, industry, occupation, position and working years. Asset evaluation information includes housing, credit card, transportation, bank deposit, marketable securities and insurance. Expenditure includes number of family members, household demographics, employment, medical insurance and retirement plans. Historical credit including the number and total amount of business with the bank, the number of times of dishonesty and default records.

Based on the method of qualitative analysis, Xie (2007) divides the factors affecting personal credit risk into four categories, which are personal natural information, personal economic information, personal career information and credit history. Among them, personal natural information includes age, gender, marital status, place of birth, education level, house, residence and number of people to support. Personal economic information includes personal income, annual family income, assets and liabilities. Personal career information includes industry situation, type of organization, position, working time Personal history information including credit record, business relationship with the bank, deposit account in the bank, whether it is an employee of the bank, and whether it has other loans. Through these four kinds of information, the bank can indirectly understand the borrowers' repayment ability and willingness.

2.2.1.4 Causes of credit risk

Shuai (2015) thinks that the main causes of personal credit risk in China are from mainly three aspects, which are personal credit risk, credit system and information inaccuracy of the borrowers.

The personal credit risk of credit customers includes the willingness and moral hazard of the borrowers to repay the loan, and the ability of the borrowers to repay the loan. The borrowers' willingness to repay refers to whether the credit customer has the tendency of conducting subjective default. The moral hazard of the borrower is manifested in various subjective dishonest behaviors driven by economic interests to achieve personal goals. In personal credit, moral hazard is usually manifested as changing the purpose of loan without following the promise of loan, concealing and transferring personal property to avoid debt, and deliberately defaulting on the repayment of loan. The main reason for moral hazard is that the borrower does not follow the loan commitment and invests the loan funds into the project with high risk, hoping to gain a high return. Once the investment fails, the risk of loss is transferred to the financial institutions, and the borrowers only bears limited loss. On the contrary, if the investment is successful, the lender can obtain high income. Therefore, the borrowers' willingness to repay and moral hazard are the risks that financial institutions need to prevent before and after the loan. Personal repayment ability refers to whether the borrower have sufficient repayment sources and loan guarantee, which is the guarantee of loan repayment ability. If the borrowers have no disposable income available for repayment, even if the borrowers' willingness to repay and moral standards are high, repayment will become a mirror image. This is the main source of personal credit risk, and also a risk that

financial institutions need to focus on before lending.

For the credit system, China's social system is not perfect, and there is still a big gap compared with developed countries (Zhou & Chen, 2005). This is reflected in the incomplete credit law. A sound personal credit system needs to be supported by appropriate laws and regulations. The Outline of Social Credit System Construction Plan (2014-2020) issued by the State Council points out that the imperfection of credit system is reflected in several aspects. Firstly, the credit system that covers the whole society has not been formed. Secondly, the credit records of social members are seriously missing. Thirdly, the enforcement (incentive and punishment) mechanism for dishonesty are not perfect. Fourthly, the incentive for dishonesty is insufficient, and finally the cost for conducting dishonest behaviors is low (Lai, 2017). The current laws and regulations on personal credit in China are relatively behindhand, which leads to the lack of legal support for the protection of personal privacy, the disciplinary mechanism for dishonesty, and the operation of credit intermediary agencies. The credit supporting system is not perfect, and the relevant supporting systems of personal credit, such as personal credit files, personal property declaration system, personal bankruptcy system, are missing. The imperfection of credit supporting system leads to the imperfection of personal credit information in China. Credit information technology is underdeveloped. Compared with the developed countries, the development and utilization of information technology in China is still relatively behindhand, and the relevant information is scattered in different departments, which fails to realize interconnection and information sharing. There is a serious phenomenon of information island, which to some extent causes the imperfection of personal credit information. There is no effective mechanism to cultivate credit service market and to use credit products.

Information asymmetry refers to the possible lack of information about the counterparty when the information is incomplete or there is information cost (George, 1970). From the perspective of the borrowers, the individual credit customers with information advantage may have opportunistic tendency, which will increase the credit risk of the lender. From the perspective of the financial institution, because the credit risk of borrowers is quite different in quality and quantity, it needs to invest a lot of manpower and material resources to collect the real information of the borrowers, which will undoubtedly increase the credit cost. At present, in the case of imperfect social credit system in China, the credit risk of the borrowers is difficult to be identified quickly and effectively, which leads to the adverse selection and moral hazard problems. Zheng, Liang and Ma (2005) believed that information asymmetry

was the main reason for the credit risk of the borrowers. The existence of information asymmetry makes it difficult for financial institutions to make an objective and effective assessment of the credit information, repayment ability and risk types of the borrowers, and to make differential pricing for the borrowers with different credit risks. In order to compensate for the cost of information acquisition and risk control and reduce the loss caused by default risk, financial institutions will choose to set a higher interest rate and try to increase the income to compensate for the risk cost. This causes the problem of adverse selection. Because of the high loan interest rate, the borrowers with good credit chooses other financing methods and exits the loan market.

2.3.2 Related concepts and research status of credit scoring

Credit scoring is a successful application of statistics and other disciplines in the financial field, and it is also one of the earliest financial risk management tools developed. Although many experts and scholars have different formulations about credit rating, the overall concept is the same. Credit scoring is to score the credit risk of the borrowers scientifically by establishing a suitable mathematical model according to the credit information of the borrower.

From a statistical point of view, this is essentially a method of classified statistics. Fisher (1936) first proposed the idea of dividing the whole into different groups according to certain criteria. He distinguishes skulls by measuring their volumes, and plants of the same genus by measuring their sizes. Durand (1941) proposed to use statistical model to help distinguish the quality of loans and use statistical methods to deal with the personal credit information of consumers. In the 1930s-1950s, mail order companies and retailers in the United States began to use the quantitative credit scoring system to overcome the inconsistency of credit decision-making standards of credit analysts. At that time, the method used was not based on the modern mathematical model to analyze consumer behavior data.

In the late 1960s, with the gradual increase of the number of credit card applicants, banks found that it was unable to meet the needs of business development to rely entirely on manual credit card application and approval. Through research, Orgler (1970) found that when the credit card issuer established personal credit risk scoring system and automatic operation process based on data model, because of its better prediction ability, the probability of default was reduced by more than 50% compared with relying on manual subjective judgment. Because the personal credit risk scoring system can effectively accelerate the

process of credit decision-making, improve the efficiency of approval, and can more accurately assess credit risk, so that commercial banks and financial institutions can more accurately define the acceptable system credit risk, thus expanding the scope of personal credit. Since then, credit scoring has played a key role in the significant growth of global consumer credit and other credit products. It has affected almost everyone in the United States and Europe, and its application has gradually expanded to various fields such as government supervision, commercial marketing, credit trading and recruitment and job hunting.

Guo (2017) claims that after a long time of practice in developed countries, personal credit risk assessment has developed mature models and application experience, forming the American model, the European model represented by Britain and Germany, and the Japan model. At present, the 3 most influential personal credit rating agencies, also known as the 3 main bureaus in the world, which are Experian, Equifax and Trans Union, have hundreds of millions of credit records. The most commonly used and well-known personal credit scoring system is FICO scoring system, independently developed by Fair Isaac and Company. The system stores the personal credit information records of the past 7-10 years, including the personal credit information related to bank credit and commercial credit, as well as the information of industry and commerce, tax, court, insurance and other social public sectors, and the data is calculated in real time, whereby it can measure individual's credit condition more comprehensively.

Zhang (2016) believes that, at present, FICO scoring system is widely used in financial institutions and other business fields. The three rating agencies have cooperated with Fair Isaac and Company successively and established their own credit scoring systems based on FICO scoring method. If the credit score is between 300 and 850 and above 680, the borrower's credit can be considered outstanding. If it is lower than 620, the lender either requires the borrower to increase the guarantee or refuse the loan. If it is between 620 and 680, the lender needs to make further investigation and verification. Because the automatic evaluation system of personal credit risk accelerates the whole decision-making process of personal credit, the standard credit report can be made in a few minutes, so it greatly improves the efficiency of credit decision-making (Chang, 2018).

Combined with the current situation of our country, although the phenomenon of personal credit risk and poor credit evaluation quality has been improved to some extent, the construction of credit system is still deficient, which has seriously affected the healthy

development of personal credit and automobile financial market. In China, due to the difficulty in collecting personal credit information, personal credit information mainly comes from loan, credit card information of financial institutions such as commercial banks, and basic credit information related to personal age, work, education background, income (Wei, 2001). Because different financial institutions have different measurement standards for credit score, they can only share credit score simply, and it is difficult to realize the calculation, classification and evaluation of credit risk of personal credit information. Therefore, how to build a scientific and complete personal credit rating system has become an important issue to be solved in China (Wang & Nie, 2012). At present, the traditional personal credit evaluation methods can be divided into three categories, which are expert judgment, statistics and artificial intelligence (Du, 2014).

2.2.2.1 Expert judgment

In other countries, the first way to score personal credit is to use expert judgment, using a method known as the 3Cs of credit (Capacity, Character, Collateral) and the 5Cs of credit (adding Capital and Condition to 3C judgment).

According to Wang (2004), there are three main methods used by financial institutions in China for credit rating of borrowers, which are subjective judgment method, Guarantee Law and simple quantitative evaluation method. Subjective judgment method mainly judges the repayment ability and willingness of the borrowers based on the experience of the risk control personnel, for example, the traditional 3C and 5C analysis methods. Under Guarantee Law, the borrower provides guarantee or collateral as the guarantee for individual performance repayment. At the same time, the fund provider gives the corresponding credit score and credit according to the specific situation of the borrowers. Simple quantitative evaluation method summarizes the experience and simply quantifies the credit risk through the statistical analysis of historical data, so as to achieve personal credit score.

The above-mentioned methods are mainly qualitative analysis, because they rely too much on the experience of financial subjects. These methods are subjective and do not form a credit scoring system while it takes a lot of time and human resources to perform. Therefore, scholars began to seek quantitative analysis methods that could support automated credit scoring without subjective human factors. However, financial credit subjects such as banks have also changed from traditional credit scoring based on experience and subjective analysis, to modern credit scoring based on statistical model and artificial intelligence learning model.

2.2.2.2 Quantitative statistics

1) Discriminant analysis

Durand (1941) first introduced the idea of statistics into this field and divided the borrowers into several groups according to different characteristics, then evaluated the credit risk of the loan and judged the quality of the loan. The typical method of quantitative analysis is credit scoring method, which aims to predict whether the borrower defaults. At present, the representative of credit score is FICO, which is still the main basis for credit institutions to decide whether to provide loans to borrowers (Fisher, 1936).

Linear discriminant analysis (LDA), or Fisher Linear Discriminant (FLD), is a classical algorithm for credit score recognition (Belhumeur, Kriegman, & Yuille, 1999). By judging the geometric centers of "performing" and "defaulting" personal loan customers, the corresponding linear discriminant function is constructed, so as to realize the classification of personal loan customers (Jiang, 2006). The method is described as follows:

Suppose that the overall sample (A) is composed of "performing customer" (P) and "defaulting customer" (D). The overall sample is divided into "performing customer" A_P and "defaulting customer" A_D, with as few misconceptions as possible. C_P and C_D are used to represent the proportion of "performing customer" and "defaulting customer" in the overall sample respectively. L is the average loss of profit caused by mistaking "performing customer" as "defaulting customer". B is the average bad debt loss caused by mistaking "defaulting customer" as "performing customer". When the characteristic variable is x, the probability density of "performing customer" and "defaulting customer" is expressed as c(x / P) and c (x / D). q (P / x) and q (D / x) represent the probability of "performing customer" and "defaulting customer", where q (P / x) is positively correlated to p (x / P) C_P, and q (D / x) is positively correlated to P (x / D) C_D. In order to reduce the possibility of misidentification, the expected formula of loss minimization is as follows:

$$\min Loss = L \int_{x \in A_p} \mathbf{p}\left(\frac{\mathbf{x}}{\mathbf{P}}\right) \mathbf{C_P dx} + D \int_{x \in A_D} \mathbf{p}\left(\frac{\mathbf{x}}{\mathbf{D}}\right) \mathbf{C_D dx}$$

$$= L \int_{x \in A_p} \mathbf{q}\left(\frac{\mathbf{x}}{\mathbf{P}}\right) \mathbf{dx} + D \int_{x \in A_D} \mathbf{q}\left(\frac{\mathbf{x}}{\mathbf{D}}\right) \mathbf{dx} \quad (2.2)$$

Because

$$p(x/P)\ C_P/p(x/D)\ C_D = q(P/x)/q(D/x)$$

Then the optimal solution of (2.2) can be obtained. In sample A, "default customer" AD

is

$$\mathbf{A_D} = \left\{ \frac{\frac{x}{q\left(\frac{P}{x}\right)}}{q\left(\frac{D}{x}\right)} < \frac{B}{L} \right\} \tag{2.3}$$

2)Linear regression

In 1963, Myers and Forgy (1963) used the linear regression method to study the credit score, the purpose of which is to find the best combination of personal credit characteristics. After that, Fitzpatrick (1976), Lucas (1992) and Henley (1995) also carried out relevant research.

When linear regression is used to evaluate personal credit risk, it can be described as: Suppose that there is the following relationship between the default probability p of the individual loan customer and the personal characteristic variable X_1, X_2, …… X_i of the loan customers:

$$\boldsymbol{p = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_i X_i + \varepsilon} \tag{2.4}$$

Where ε is a random variable, then the sample data can be used to estimate the parameter β_i, and then calculate the default probability p of the borrowers.

There is a defect in the linear regression method in the construction of credit scoring model. The value range on the right side of formula (2.4) is (- ∞, + ∞). The P on the left side of formula is probability value, and the value range can only be in the range of [0,1]. If we change the left side of the formula into a function of P, so that it can take any value, the model construction will be more reasonable.

3) Logistic regression

According to the defects of linear regression, we transform the (2.4) left category to make p become the logarithm of probability ratio, which is the logistic regression model. Logistic regression model is often used to deal with the random variables with two dependent variables, such as default as 0/1 dummy variable, which is one of the most widely used models in the field of credit scoring (Wiginton, 1980). In general, logistic regression model has high stability, good regression performance and strong explanatory power, which is suitable for explaining various variables as qualitative indicators (Govaerts, 1989). Leonard (1995) applied logistic regression model to credit rating of commercial loans. Hand and Henley (1997) compared the applicability of Logistic regression model and classification tree and found that the Logistic regression model is more stable and accurate in predicting

the binary qualitative variables.

When the regression model is used for personal credit rating, the basic ideas are as follows (Xu, 2017):

d = 1 is defined as "default", d = 0 as "performance", and the probability of default (i.e. d = 1) of the borrower is p; p and n characteristic variables of the borrower (X1, X2,...,Xn) has non-linear relationship, β_i （n=1,2, …,n）the coefficient β and the corresponding explanatory variable X_i (i=1,2, …,n). $\log\left(\frac{p_i}{1-p_i}\right)$ is the ratio logarithm of two possible prediction results. Establish logistic regression model for sample data, that is, express the logarithm of probability occurrence ratio as the linear combination of characteristic variables, and the formula is as follows:

$$\log\left(\frac{p_i}{1-p_i}\right) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_n X_n \tag{2.5}$$

Because the value range of $\log\left(\frac{p_i}{1-p_i}\right)$ is in (- ∞, + ∞), while the value range of $\left(\frac{p_i}{1-p_i}\right)$ is in (0, + ∞), we can get the index based on e on both sides of formula (2.5):

$$p_i = \frac{e^{\beta \cdot x}}{1+e^{\beta \cdot x}} \tag{2.6}$$

This is the hypothesis of Logistic regression model. Through the application of this model, the probability of default P of the borrower is predicted, and the corresponding relationship between the probability of default and the credit score is established, thus the personal credit risk can be evaluated.

Logistic regression model is a kind of partial distribution sample analysis, which only makes a few distribution assumptions. Because the variables are not required to meet the assumption conditions of equal variance and normal distribution, the limitation of Model-Driven Architecture (MDA) model strict assumption is avoided. Logistic regression model is more suitable for discrete, continuous or mixed variables. Less distribution hypothesis makes the model easy to compound, upgrade, second-order discrimination and test. Compared with other credit scoring methods, only a few parameters are needed, which improves the robustness and applicability. Therefore, it is considered to be one of the effective credit scoring technologies, and the disadvantage is that its prediction accuracy is lower than that of artificial neural network (Liu, 2010). Logistic regression model has been widely used in the field of credit scoring practice, and this model has been used for many times in the quantitative analysis of this thesis.

4) overall planning method

The method of overall planning can be divided into linear programming method and multi-objective programming method. Freed and Glover (1986) used linear programming to classify personal credit risk and used minimum absolute error sum (MASE) or minimum maximum error (MME) to distinguish loan customers.

On the basis of data mining technology, Shi et al. (2002) extended the linear programming model to multiple criteria linear programming (MCLP). The advantage of MCLP model lies in its high classification accuracy and flexible modification of parameters.

5) classification tree method

Classification tree model, also known as recursive segmentation (RPA) was proposed by Makowski (1965). This method is based on the non-parameter identification technology of statistical theory applied to personal credit evaluation. The basic method is that based on the recursive segmentation algorithm, we create a classification tree for the best segmentation of samples, recursively segment the samples into disjoint subsets sthrough the non-return tracking segmentation method and expect to minimize the miscalculation loss. The purpose of classification tree method is to establish the classification and prediction model of each input variable for the target variable after training the sample set. By grouping the target variable and input variable under different values, the new sample data can be effectively classified and predicted. Common classification tree algorithms include ID3, C4.5, Quest and Cart.

The classification tree model is widely used in the field of credit scoring, which has a good explanation for the evaluation results. Its disadvantage lies in the low classification accuracy and lack of stability. In the Equal Credit Opportunity Act, the Federal Reserve proposed that the classification tree method is an empirical test in the credit system and a perfect method in the statistical sense (Xiang, 2011).

2.2.2.3 Artificial intelligence method

At the end of the 20th century, with the rapid development of the global computer technology and network technology, the field of credit scoring also ushered in the application of neural network, Support Vector Machine (SVM) and other artificial intelligence credit evaluation theories and methods (Xia, 2018). Next, it will introduce the related concepts and research status of artificial intelligence method in credit scoring.

Artificial neural networks (ANNs) is the result of the interdisciplinary research of

computer technology and statistical methods. It has the advantages of automatic learning, associative memory and strong robustness. Its powerful nonlinear data processing ability is a method suitable for personal credit scoring (Cheng & Titterington, 1994). Nowadays, there are dozens of artificial neural networks models. The representative ones include Hopfield neural networks, BP (Back-Propagation) neural networks, counter propagation networks, adaptive resonance networks and self-organizing mapping networks.

Li (2003) studied the application of neural network in the field of consumer credit scoring and summarized the advantages of neural network in this field. Wang, Zheng, and Hao (2005) trained neural networks through BP algorithm, and proved the effectiveness of neural networks in credit scoring. Cao (2008) studied the application of personal credit scoring model of artificial neural networks in commercial bank.

Rosenberg and Gleit (1994), Desai, Crook, and Overstreet (1996) found that there was a strong nonlinear relationship due to the mutual correlation and influence of risk factors in the field of credit scoring. West (2000) and Malhotra (2003) found that neural networks usually have high accuracy when applied to credit scoring. Morton (2011) thinks that the application of artificial neural network in the field of credit scoring is limited due to its poor stability, lack of interpretation, difficult to determine the structure and other defects. Pang, Li and Xu (2005) thought that as the most commonly used neural network, BP is a kind of multi-layer forward neural network with one-way propagation, which can effectively deal with the learning of implicit units in the multi-layer neural network. Huang, Zhou and Fu (2010) optimized Levenberg-Maruardt Back Propagation (LMBP) algorithm to improve the defect of BP neural network in personal credit scoring.

In recent years, experts and scholars have proposed many improved algorithms for the application of artificial intelligence in the field of credit scoring. Fogarty (1993) first applied genetic algorithm (GA) to credit scoring, and then Michalewicz (1996) carried out an extended research based on it. Davis and Albright (2004) and others applied genetic algorithm to the development of credit scoring card. Li, Song and Chen (2006) studied genetic neural network algorithm (GA-NN). Zhou, Duan and Deng (2004) proposed particle swarm optimization (PSO).

Holland (1992) proposed particle swarm optimization algorithm, which is a model of "adaptive learning rate method" and "additional momentum method" based on BP algorithm. Because of its wide applicability and higher robustness, it has been used in pattern recognition, function optimization and other fields, and become an effective way to train

neural network.

Baesens, Gestel, and Viaene (2003) applied support vector machine (SVM) to the field of credit scoring, because compared with other artificial intelligence methods, SVM method has no strict requirements on samples, and many experts and scholars have conducted corresponding research on it. Luo (2004) found that SVM has achieved good risk assessment effect in the application of student loan. Schebesch and Stecking (2005), Bellotti (2008) studied the extension of SVM model and summarized its advantages and applicability. Shen (2004) applied SVM model to the credit rating of consumer credit and found the adaptability of its optimal parameters. Zhong (2005), Xiao and Fei (2006) compared SVM with regression analysis, LDA, nearest neighbor discrimination and neural network credit scoring methods, and concluded that SVM has the advantages of easy modeling, stable performance and short running time.

2.4 Research on risk management of financing guarantee

2.4.1 Research on financing guarantee

The development of China's financing guarantee industry is greatly affected by official policies (Han & Li, 2016). The guarantee law of the People's Republic of China implemented in 1995 is the legal basis of the guarantee industry. The Interim Measures for the management of financing guarantee companies issued in 2010, as a milestone for China's financing guarantee industry to start a comprehensive regulatory environment, formally regulates the establishment conditions, business scope, guarantee proportion and investment proportion of financing guarantee companies. In 2015, the opinions of the State Council on accelerating the development of financing guarantee industry was issued, which played a supporting and leading role in the financing guarantee industry by the government. The three parties comprised “government, bank and guarantee" participated in the construction of a sustainable business cooperation model between commercial banks and guarantee institutions. The core content of the model is to implement the trinity of financial risk compensation mechanism, proportional liability re-guarantee and bank risk sharing mechanism. The effective performance of regulatory responsibilities, keeping the bottom line of risk, and strengthening the cooperation between government and enterprises have jointly supported the development of China's financing guarantee industry (Liu, 2015).

Huang, Ni and Sun (2005) pointed out that credit guarantee institutions are an important

part of the development of the financial industry, which are conducive to break the loan concession and help small and medium-sized enterprises (SMEs) to finance through formal financial institutions. Jiang (2011) argues that commercial banks and financing guarantee institutions face "prisoner's dilemma" in their cooperation, because of the compensatory obligations of financing guarantee institutions. When there is risk in the credit business, commercial banks will rationally choose to receive loans first, suppress loans and cut off loans. Gu (2012) believed that the introduction of guarantee mechanism in the financing of SMEs can effectively alleviate the problem of information asymmetry, thus changing credit rationing. Luo and Song (2015) believes that financing guarantee companies mainly have three main functions, which are risk sharing, information processing and outsourced loan marketing service of commercial banks. Because of the profit pressure and system defects, financing guarantee companies often involve shadow banking business such as illegal operation, off account operation, private financing and private usury. The fundamental way to solve this problem is to establish the risk sharing system of commercial banks and financing guarantee institutions, guide financing guarantee institutions to access the credit system, and strengthen the local government to financing guarantee institutions.

2.4.2 research on risk management

At present, the research on the risk of auto loan is relatively weak in China, and the research on the prediction of default probability of auto loan is very scarce. Shu and Yang (2017) used counting model (Poisson model, negative binomial model) and binary selection model (Logistic model, Probit model) to measure and predict the two variables (default and default period) of auto loans by studying and analyzing the customer data of domestic auto financing companies. The research shows that the current default evaluation system is not effective, and the basic information of customers, loans, credit status, loan period and real estate will have an impact on the default situation. In addition, it is concluded that the Logistic model is suitable to predict customer defaults probability, and the negative binomial model is more effective to predict the default duration.

In June 2004, the New Basel Capital Accord was formally implemented around the world and was generally accepted and implemented. The agreement focuses on risk identification and strictly standardizes the accuracy of risk measurement. It emphasizes the core role of internal ratings-based approvals (IRB), applies Loss Given Default (LGD) and other key indicators in many links of credit management, and provides technical support for the formulation of credit policies and other issues (Zhang, 2004). In 2007, the New Basel

Capital Accord proposed and required commercial banks to implement three pillars as soon as possible, namely minimum capital requirements, information disclosure, and regulatory authorities' supervision and inspection of capital adequacy ratio (Ba, Xing, & Zhu, 2010). In 2011, the Seoul summit further improved Basel Capital Accord III, strengthened the leverage ratio of commercial banks, the correction of capital supervision deficiency and liquidity management.

Song and Ding (2007) found that the relationship between risk management and internal control is not only related but also different. The relationship is reflected in the absorption and development of risk management for internal control. The difference is reflected in the different connotation and boundary, the different framework and content, and the different technology and methods. In terms of connotation and boundary, from the perspective of audit, internal control is the condition and basis of audit work, which requires to verify the authenticity and fairness of financial reports based on internal control. From the perspective of management, internal control belongs to the category of management and has all the characteristics in management. In terms of framework and content, risk management has one main objective more than internal control, namely strategic objective. Risk management put forward a new concept of risk portfolio management, and two innovative concepts of risk preference and risk tolerance. At the same time, risk assessment elements are extended to goal setting, event identification, risk assessment and response. In terms of technology and methods, the risk management framework introduces the concepts of risk preference, stress testing, risk tolerance, scenario simulation, and uses a large number of quantitative assessment methods, portfolio management technology and financial derivatives. Based on the practical level of COSO, Wang (2010) studied risk management and internal control and found out that the difference between the two lies in the decision-making level. COSO is the abbreviation of the Committee of Sponsoring Organizations of the Treadway Commission. In 1985, the American Institute of certified public accountants, the Association of Financial Managers, the American Accounting Association, the Association of Management Accountants and the Association of Internal Auditors jointly established the anti-false financial reporting Committee, whose purpose is to explore the causes of fraud in financial reporting and find solutions. In 1987, the COSO committee was established by the sponsor based on the recommendation of the committee, and the internal risk control was studied. According to Wang (2010), risk management can improve strategic decisions, emphasizes more on risk identification and response, while the goal of internal

control is more standardized management, which focuses on the design and evaluation of internal control. The two are complementary, and to carry out the two tasks requires strong support of the management, the recognition and active input of the business department, as well as high requirements of human resources.

Wang (2014) points out that the research on credit risk management of banks and other financial institutions in China mainly focuses on the learning and adapting of foreign advanced models. China lacks initiative and innovation in the aspects of credit risk management and model construction of financial institutions. Wang (2019) concluded that risk management is a necessary management activity for the survival of an enterprise, and the focus of internal control is to regulate and coordinate. The long-term development of an enterprise cannot be separated from the control and restriction of the system.

Based on COSO-ERM (2017), Zhou (2019) analyzed the risk management problems of commercial banks in China and found that there are three main problems of financial institutions in risk management, including low risk awareness, incomplete risk management and lack of effective management structure, and outdated technology. In September 1992, COSO committee issued the report of internal control integration framework, which was called COSO report for short, and supplemented it in 1994. Since then, COSO launched the revision of risk management framework for the first time in 2014 and issued the latest revised version of enterprise risk management framework on September 8, 2017, which is referred as COSO-ERM (2017). Zhou (2019) concluded that the corresponding countermeasures are based on the mission, vision and core values of the enterprise. From the perspective of corporate governance, we should establish an effective risk management mechanism, strengthen professional learning, make up for the lack of risk management tools, and enrich our own risk management experience.

Based on COSO (2017), Gao and Li (2019) emphasized the absence of risk management positions and the lack of risk management talent reserves in China's financial institutions. It is suggested to upgrade information system, establish scientific data processing system, decision support system and management information system, so that financial institutions can effectively use and process information in big data environment. It is suggested that technical support through risk quantification model such as VaR (value at risk) model should be provided for risk management in order to attract and retain excellent talents, so as to improve the professional quality of the whole risk management team.

Chapter 3: Industry Status and Operation Process Analysis

3.1 Industry status

3.1.1 Industrial history

In 1993, Beijing Ordnance Industry Automobile Trade Co., Ltd. first proposed the installment purchase in China, which opened the prelude of China's automobile consumption credit. In 1995, various financial institutions began to enter the automobile consumption credit industry, and China's automobile finance has since entered the embryonic stage. China's auto finance industry has developed rapidly for the past 20 years, passing several stages of germination, blind expansion, adjustment of storage capacity and development revitalization, and has entered the stage of multiple competition since 2008. The initial stage of germination was from 1993 to 1998. During this period, in 1993, Beijing Ordnance Industry Automobile Trade Co., Ltd. first proposed the concept of buying cars using installment. In 1995, financial institutions began to participate in automobile consumption credit business, which then was stopped by the central bank. In 1998, the central bank issued the measures for the Administration of Automobile Consumption Loans (Pilot Measures), which requires that the lenders of automobile consumption loans are only commercial banks approved by People's Bank of China and without the approval, no other unit or individual is allowed to start auto consumption loan business. At this stage, the auto consumption credit market was emerging, but the development of auto consumption loan was slow due to the restrictions of loan subjects and market reasons.

The blind expansion stage was from 1999 to 2003. In 2000, with the rapid growth of the sales of private cars in China, automobile consumption loans also raised. The central bank promulgated the measures for financial companies of enterprise groups to allow auto finance companies to carry out auto consumption credit business, which laid a foundation for the formation of auto consumption finance. Due to the maturity of various conditions, the automobile credit business achieved unprecedented rapid development, which lasted for nearly three years. During this period, the banks focused on the marketing of auto credit

business, carried out various promotions of auto loans, and reduced the interest rate for customers who applied for auto loans during this period. Some banks directly reduced the interest rate for all customers obtaining car purchase loans. In addition to the price war in the marketing of auto loan business, the time war between banks began again. Through radio, television, newspapers, magazines and other media, banks announced the time for auto loan business. At the beginning, it took five days to handle auto loan business, then the time reduced to three days and lastly the times reduced to only one day to complete auto loan business. Seizing time made the auto loan business enter a strange circle. It seems that the faster the time, the more auto loan business and the shorter the time, the higher the profit of auto loan business.

At this stage, the auto credit market not only faced the competition among banks, but also attracted insurance companies. With the increasing number of car buyers, insurance companies entered the auto loan market. Through the introduction of car purchase loans to guarantee insurance business, while providing guarantee for bank auto loans, it also opened up new ways for insurance companies to make profits. At the same time, another protagonist in the auto loan market, auto dealers, with the help of the rise of auto loan business of banks and insurance companies, rapidly expanded the market and obtained high profits from customers' car purchases. The cooperation among banks, insurance companies, auto dealers and manufacturers has become the main mode to promote the development of auto consumer credit business. Since then, the auto consumption credit business has entered a blind expansion period, and the auto loan scale has increased rapidly, from 2.9 billion yuan in 1999 to nearly 200 billion yuan in 2003.

The adjustment and accumulation stage happened around 2003 to 2004. After the explosion of automobile credit, due to the lack of credit system, automobile credit bad debts occur frequently, and a large number of automobile bad loan debts break out. In the second half of 2003, the loss ratio of automobile loan insurance began to soar, insurance companies began to retreat, and banks began to gradually raise the lending threshold of automobile consumption credit. In 2003, CBRC issued the measures for the administration of auto financing companies, which stipulated the access conditions, business scope and risk management of auto financing companies. In 2004, the sales growth rate of the whole auto industry fell sharply, and the auto financing industry also shrank seriously. In the same year, the China Insurance Regulatory Commission stopped the auto loan insurance business. Since then, the auto financing industry has entered a slump. Loan penetration has plummeted, but

it has also played a role in promoting the birth of auto finance companies in a real sense.

From 2004 to 2008, it was the revitalizing development stage. Based on the implementation of China's commitment to opening up the automobile consumer credit market after China's accession to the WTO, CBRC issued the measures for the administration of automobile financial institutions in October 2003, and the detailed rules for the administration of automobile financial companies in November. On December 29 2003, China approved the establishment of SAIC General Motors Finance Co., Ltd., Toyota Motor Finance (China) Co., Ltd. and Volkswagen Finance (China) Co., Ltd. In 2004, SAIC General Motors Finance Co., Ltd., the first auto finance company in China, opened its business in Shanghai, and auto finance companies officially entered the auto loan market in China. In the same year, the central bank issued a new version of the auto loan management measures, the 2004 version of the auto loan management measures and the 1998 version of the auto consumption loan management measures (Pilot Measures) Compared the two, there are many differences. First, the scope of the lenders has been adjusted, thus more financial institutions are eligible to enter the market. Second, the borrower's type has been refined, and the type of loan customers has been clearly defined. Finally, the types of loan vehicles have been expanded and enriched. In addition, the measures for the administration of automobile loans clearly stipulates that the buyer can also apply for loans when purchasing second-hand automobiles. Since then, auto finance has entered a period of specialization dominated by auto finance companies.

From 2008 to present, it is the multiple competition stage. After the establishment of SAIC General Motors Finance Co., Ltd., relevant departments such as the CBRC and the people's Bank of China have continuously issued policies to support the development of auto finance, including increasing the maximum proportion of auto consumption loans, gradually relaxing the financing channels of auto finance companies and financial leasing companies in the market, allowing auto financing companies to carry out financing through various ways to stimulate the development of auto finance. In 2008, the CBRC issued a new version of the measures for the administration of auto financing companies, which increased the financial leasing business within the business scope of auto financing companies. Since 2013, due to the increase of Internet finance, financial leasing companies, Internet platforms and other emerging players have successively entered the auto financing market. With the rapid growth of market scale, auto finance has also emerged a pattern of diversified competition. In November 2016, Dasouche automobile group, an Internet automobile company, launched

the TanGeChe platform and put forward the slogan of "10% down payment, rent first and then buy", which has since opened the prologue of Internet automobile financial leasing. On November 16, 2017, Yixin group was listed in Hong Kong. Through self-operation and loan assistance, it provided consumers with financing services to purchase new and second-hand automobiles, becoming the first share of Internet automobile financial trading platform. Yi Xin (02858. HK) was listed on the main board of the Hong Kong stock exchange, with an issue price of HK $7.7 per share and a raised capital of HK $6.5 billion. On the opening day, it rose 29.87% to HK $10 / share.

The next year, in June 2018, Uxin, a second-hand automobile e-commerce platform, was officially listed on Nasdaq, with an issue price of $9 per share. In addition to convertible bonds issued at the same time, it raised a total of $400 million. Uxin group opened at $10.40/ads, up 15.56% from the issue price, and closed at $9.67, up 7.44% from the issue price. Next, on July 26, 2018, China's leading automotive financial technology service platform, cangu (CANG), was officially listed on the New York Stock Exchange. Cangu's IPO issued 4 million American Depository Stocks (ADS), with a total financing amount of US $440 million and an issue price of US $11 per share. Cangu opened at $12.50 a share, 13.64% higher than the issue price, and closed at $13.9 a share, 26.36% higher than the issue price. On October 30, 2019, Meili auto Holdings Limited, a used car financial service platform, submitted a prospectus to the Securities and Exchange Commission (SEC) of the United States, intending to land on the New York Stock Exchange, with a planned capital raising of US $100 million and a stock code of ML. This also means that it may become the first stock of used car finance in China. Such a large number of auto financial service providers accelerate the fund raising in secondary market. On the one hand, it is driven by the trend of Chinese Internet companies going overseas. On the other hand, it also reflects the urgent need for auto financial service providers to strive for competitive advantage in financing under the situation of fierce diversified competition.

Looking at the five stages of the development of China's auto finance industry, we can find that the national policy plays a very important role, directly or indirectly affecting the development of China's auto finance industry. Therefore, the next section will sort out the policies that have made a significant impact on China's auto finance industry in recent years, in order to have a clearer understanding of the current situation of the industry and provide a more comprehensive understanding of the research of this research.

3.1.2 Macro policy

Since the issuance of the measures for the administration of automobile loans by the CBRC in 1998, the relevant policies of automobile finance have been successively issued, and the order of automobile financial market in China has been gradually standardized. In 2008, the new version of the "management measures for auto financing companies" was released, and the diversification of auto financing business was emerging. In the past five years, various regulatory agencies have issued policies to encourage consumption upgrading and automobile circulation to promote the development of automobile industry and automobile finance industry. See Table 3-1 for details.

Table 3-1 policies and regulations of auto finance industry

Release time	Publishing Department	Policy name	Impact on the industry
2018 September	CPC Central Committee, State Council	Some opinions on improving the system and mechanism of promoting consumption and further stimulating the consumption potential of residents	Clearly put forward to promote the upgrading of automobile consumption, especially to encourage automobile consumption in rural areas
2018 January	CBRC	Circular of China Banking Regulatory Commission on further deepening the rectification of banking market disorder	Unified standard for business on the outside and in the outside, prohibition of illegal cross industry channel business, including the use of entrusted loans.; prohibition of banks to receive the guarantee credit service provided by the third-party institutions not qualified for financing guarantee business and other cash credit enhancement services
2017 November	People's Bank of China and CBRC	Notice on adjustment of relevant policies on auto loans	Since January 1, 2018, the maximum proportion of loans for private traditional power vehicles is 80%, the maximum proportion of loans for commercial new energy vehicles is 75%, and the maximum proportion of loans for second-hand vehicles is 70%.
2017 October	Central bank, CBRC	Revision of measures for the administration of automobile loans	External credit rating is introduced into auto loan, and auto loan institutions examine the credit rating of borrowers from multiple dimensions to enhance risk control ability
2017 April	Ministry of Commerce	Measures for the administration of automobile sales	Relaxing the single system of dealer brand authorization, reducing the burden of consumers' car purchase by improving the dealer's operating cost, which is conducive to promoting car sales
2016 October	People's Bank of China	Notice on strengthening credit investigation and compliance management	All social credit agencies are required to carry out the management of credit compliance and strengthen the protection of personal credit information

Release time	Publishing Department	Policy name	Impact on the industry
2016 August	National interbank lending center	Detailed rules for operation of national interbank lending market business	On the basis of canceling the examination and approval of entering the market at the beginning of the year, the rules of the same industry's lending market were refined, the threshold for financial institutions (including auto financing companies) to enter the interbank lending market was lowered, and the information disclosure was made clear
2016 April	People's Bank of China, CBRC	Guidance on increasing financial support for new consumption	Allow new energy vehicles and second-hand car loans to independently determine the down payment ratio within the regulatory scope, and allow auto finance to provide financing for ancillary products
2016 March	General Office of the State Council	Some opinions on promoting the convenient trade of used cars	Abolish the system of second-hand car transfer restriction, open the second-hand car circulation market, and create greater market space for new car consumption
2015 August	General Office of the State Council	Opinions on accelerating the development of financing guarantee industry	Give full play to the government's support and leading role, improve the service ability of financing guarantee institutions; the three parties of government, bank and guarantee jointly participate in building a sustainable business cooperation mode of banks and guarantee institutions, which is conducive to the development of financing guarantee institutions in the field of automobile finance
2015 April	People's Bank of China	"Registration system" is implemented in the issuance of credit asset-backed securities	Reducing the cost of asset securitization business and capital cost of auto financing companies is conducive to the development of auto financing business
2014 November	CBRC	Notice on the workflow of credit asset securitization filing and registration and notice on the work procedures of asset securitization business qualification approval and product filing and registration of auto finance companies, consumer finance companies and financial leasing companies	Asset securitization changed from "examination and approval system" to "filing system"

As a whole, on the one hand, China's relevant policies on auto finance promote the development of the industry in an orderly manner, on the other hand, they implement more strict management on the industry, and have a certain tightening trend in terms of regulatory agencies, business nature and capital sources.

In terms of positive impact, in 2017, the CBRC issued the notice on adjusting the relevant policies on auto loans, which reduced the down payment ratio requirements for loan purchase of cars. The down payment requirements for traditional cars and used cars were reduced to 30%, and the down payment ratio for new energy vehicles was reduced to 15%. This ratio is not mandatory but provided to financial institutions as a reference. The "zero down payment" type of auto financial products for auto finance leasing and other businesses are also emerging in an endless stream. Although some institutions collect down payment in the form of handling fees, management fees, intermediary service fees, they also form a certain publicity effect in the auto financial market.

In terms of capital sources, with the adjustment of Internet Finance in China, the macro policies have tightened the two ways of lending for other financial institutions. The scale of financial credit companies' lending through their own funds is greatly restricted by the leverage ratio. Before China's Asset-backed Securities (ABS) was initially established and tightened, financial and credit companies could move their claims out of the statements through the way of ABS, so as to avoid the restriction of the regulatory authorities on leverage ratio. For example, during 2015-2017, JD finance and its related entities issued financing securities worth more than 40 billion yuan through ABS. From the perspective of supervision, if they are included in the statement, the leverage ratio has been violated. In December 2017, the office of the leading group for the special rectification of Internet financial risks and P2P network loan risks officially issued the notice on regulating and rectifying the "cash loan" business, which requires that the financing through asset transfer, ABS and other means also need to be consolidated into the table. Therefore, the sources of funds that are transferred out of the balance sheet by means of creditor's rights are limited. This policy is undoubtedly a huge blow to the financial credit industry, but it also has a greater role in promoting the transformation of high-risk online small loan business into traditional financial business such as auto finance.

Another source of funds for financial credit is to provide intermediary loans to other financial institutions. The CBRC issued the notice on further deepening the rectification of banking market chaos in January 2018, which has defined 128 red lines of supervision. The

notice clearly stipulates that it is not allowed to “illegally accept the guarantee, credit enhancement service, and commitment and other disguised credit enhancement services provided by the third-party institutions that has not been able to obtain the financing guarantee business license”. This regulation has a great impact on the capital source channel and loan scale of auto financial institutions. On the one hand, it restricts many micro credit companies’ access to loans from banks, and makes clear that only the financing guarantee companies can help banks to lend, which highlights the intermediary role of financing guarantee institutions. On the other hand, it also effectively restricts the automobile financial market. On April 20 of the same year, CBRC became the corresponding management organization of the financial leasing company, which means that the multi-level management system was ended.

The above two regulations have great restrictions on the sources of funds and the scale of loans of auto financial institutions. In order to expand the scale of performance, on the one hand, auto financial institutions seek to go public to expand the scale of assets, on the other hand, they seek the investment from market industry giants, and expand the market scale by improving the capital adequacy ratio.

3.1.3 Major players of auto finance

Commercial banks, auto finance companies and financial leasing companies are the main body of traditional auto finance business, Figure 3-1 shows the proportion of each main body of China's auto finance business, while that of foreign mature markets is shown in Figure 3-2. Since 2017, Internet platforms have also begun to enter the auto finance field. As the main auto financial market participants, commercial banks and auto financial companies of manufacturers make full use of their own advantages in capital, channels and other aspects to expand their business. However, the traditional auto finance leasing companies and Internet platform companies pay more attention to the market of new car finance leasing and second-hand car consumer finance, focusing on the business development in the regions with less coverage of 4S stores in the third, fourth and fifth tier cities and rural areas. Most of the traditional auto financial institutions use SP (service provider), which stands for the solicit financial brokers in the field of auto finance, especially in the auto market for financial institutions. However, SP mode is prone to moral hazard, such as helping customers to make loan application materials, or even colluding with loan fraud institutions for financial fraud. With the help of technology empowerment and internet promotion, emerging Internet

platforms have certain advantages in acquiring customers, but there are systematic risks in operation and supervision. Therefore, all kinds of automobile financial competitors have their own advantages and disadvantages in the field of automobile finance. Table 3-2 below has compared the four main bodies of auto financial institutions in China.

Firstly, commercial banks have traditional capital advantages and a more perfect credit system, but they have disadvantages in the aspects of flexibility of auto financial products and the convenience of transaction. They are far away from where the transactions are made and have a low degree of specialization in the auto industry.

Secondly, auto financing companies are more relaxed than banks in terms of credit approval. Their auto financing products are more flexible, while limited to their relatively high cost of capital. The interest rate of consumer loans mostly depends on the discount intensity of the host manufacturer. The auto financing companies of dealer series are closer to the car purchase behaviors that actually take place than commercial banks and have natural channel advantages. They are more professional and most of them have the certification service for second-hand car and endorsement of car brand.

Thirdly, financial leasing companies include commercial banks, mainframe factories, dealers and professional leasing companies. The advantages and disadvantages of financial leasing companies with different backgrounds are different. However, generally speaking, the business models of automobile financial leasing in China are mainly direct leasing and after-sale leaseback, in which the after-sale leaseback model currently accounts for more than 75% of the automobile financial leasing market;

Fourthly, on the Internet platform, the approval process is relatively loose and the loan process is rapid, but there are disadvantages in transaction security and loan interest. There are many restrictions on the source of vehicles and capital. At present, the Internet platform mainly focuses on Internet trafficking. In time, the Internet platform can improve the operation efficiency thanks to the increasingly perfect big data system and consumer credit.

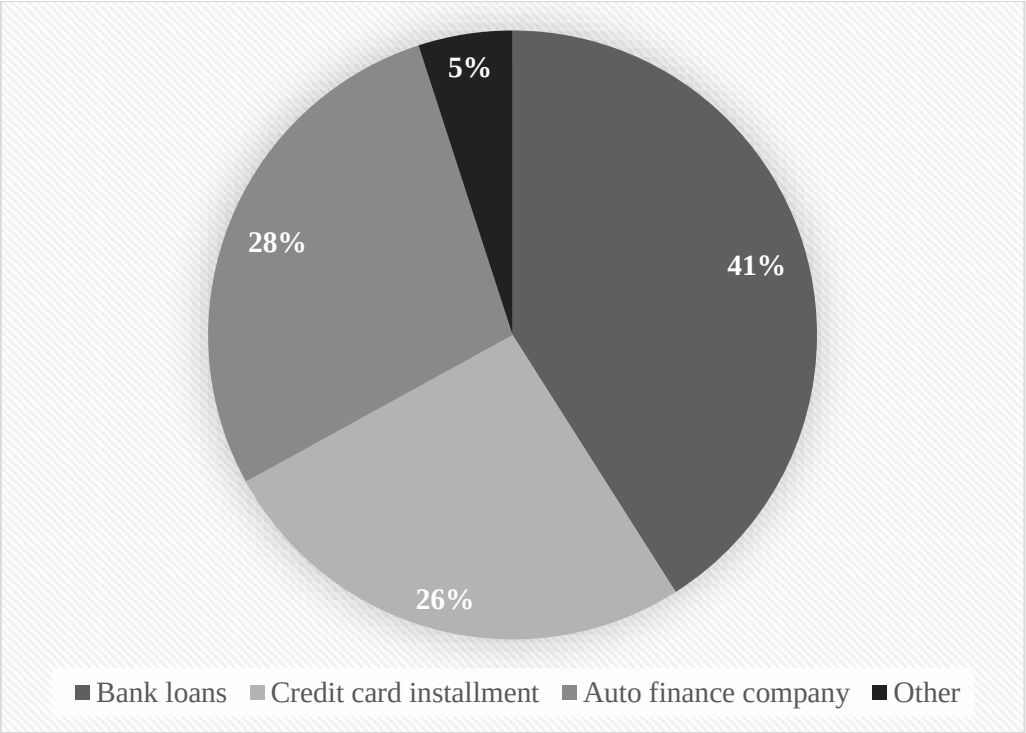


Figure 3-1 Proportion of each main body of China's auto finance business (2016)

Source: China Banking Regulatory Commission (2017)

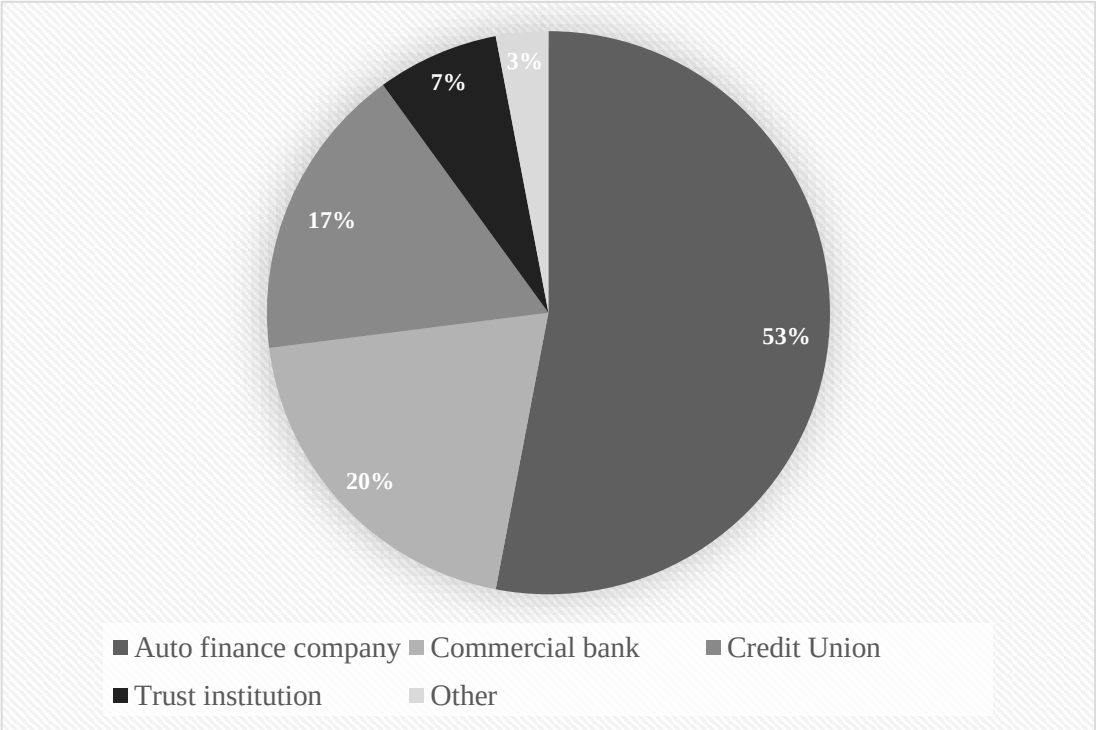


Figure 3-2 Proportion of each main body of automobile financial business in mature foreign market (2013)

Source: China automotive aftermarket Blue Book (2013)

Table 3-2 Comparison of four main bodies of auto financial institutions in China

Participants	Commercial banks	Auto financing companies	financial leasing companies	Internet platforms
Features	Mainly joint stock banks	25, 24 of which are vehicle manufacturers and 1 is dealers	Participants include commercial banking department, mainframe Factory Department, dealer department and professional leasing company Department	Including loan assistance platform, automobile trading platform and other Internet platforms for automobile financial business
Main models	new car loan and credit card installment	new car loan	leaseback and direct rent	new car and used car loan
Advantages	1. Sufficient capital and low capital cost; 2. Comprehensive coverage of outlets; 3. Consumers have strong cognition and high trust; 4. The business focuses more on traditional retail credit, with lower business risk;	1. Professional service, flexible products; 2. Close relationship with dealers, easier to obtain customers through dealer channels; 3. Relatively low rigid requirements for borrowers; 4. It can obtain the self-owned brand vehicle source of the whole vehicle factory at a low price in the first time;	1. The business model is mature, the risk control ability is strong, and the service is professional; 2. The approval process is simple, the lending time is short, the required materials are few, and the credit threshold is low; 3. Rich products, low down payment ratio and flexible repayment methods;	1. The high degree of digitalization and informatization can give full play to the technology enabling to achieve online customer acquisition, approval, risk control, improve operating efficiency, and at the same time, it can export technology to other enterprises; 2. The approval process is simple, the lending time is short, and the credit threshold is low;

Participants	Commercial banks	Auto financing companies	financial leasing companies	Internet platforms
Disadvantages	1. High proportion of down payment; 2. The approval process is tedious, the loan cycle is long, and multiple qualification certificates are required; 3. It has high requirements for borrowers, many restrictions and single repayment method; 4. General service, low specialization of automobile industry;	1. Relatively high capital cost; 2. The interest of consumer loan depends on the discount interest of vehicle manufacturer; 3. The product support models are limited. Many products may only support the vehicles owned by the vehicle manufacturer, and consumers have relatively few choices; 4. It is difficult to approve the license plate of auto financing company;	1. The cost of capital is higher than that of commercial banks and auto financing companies; 2. The borrower's credit situation is relatively poor and the business risk is relatively high; 3. The source of vehicles is greatly affected by the vehicle manufacturer, and many new models may not be covered; 4. The overall product interest rate is relatively high;	1. The capital cost is high, and the overall product interest rate is high; 2. The borrower's credit situation is relatively poor and the business risk is relatively high; 3. The source of vehicles is greatly affected by the vehicle manufacturer, and many new models may not be covered; 4. Lack of offline customer acquisition scenarios, slow speed and high cost of self built stores, and difficult to maintain the relationship between dealers and distributors;
Representative enterprise	Ping An Bank, China Merchants Bank	SAIC General Motors finance, Shanghai Dongzheng auto finance	pioneer alliance, Jianyuan capital.	dashuchi, Youxin, cangu

3.1.2.1 Commercial bank

In contrast to the absolute dominant position of auto finance companies in foreign mature auto finance market, China's commercial banks occupy the dominant position in the market. Since 1998, CBRC issued "auto loan management measures", the auto credit business of commercial banks has entered the formal development stage. Before the auto finance company entered the auto finance market in 2004, the commercial bank was the monopolist of the auto consumption finance market. In recent years, with the development of financial industry and automobile industry, automobile consumer finance has entered a stage of diversified competition in which multiple financial entities coexist. However, commercial banks still enjoy the largest share in automobile financial industry with their extremely low capital cost, first mover advantage and reputation.

At present, the main commercial banks are joint-stock banks and urban commercial banks, which focus on the layout of automobile consumer finance. Compared with the supply chain finance, the automobile consumption finance is scattered, and the single loan amount is small, which has relatively weak attraction to large commercial banks. However, with the growth of consumer demand and the growing scale of China's auto financial market, auto consumer finance has begun to attract many large commercial banks.

Compared with other auto consumer financial entities, the capital of commercial banks comes from the deposits of bank customers, with the lowest capital cost. However, the credit threshold for applying for auto loans is high, the procedures are complicated, and the approval process is long. As a comprehensive financial service institution, commercial banks lack the professional risk control evaluation ability and the advantage of being in the scene of car consumption in automobile consumption.

In terms of customer acquisition mode, auto finance loans of commercial banks can be divided into "direct customer" and "indirect customer". "Direct customer" means that the consumer applies to the bank on his own, the commercial bank evaluates the credit of the borrower, and the consumer purchases the car after obtaining the loan approval amount. "indirect customer" refers to the intermediary mode in which the financing guarantee agency or auto dealer handles loans for consumers. The financing guarantee agency or dealers bear the liability for consumers and collects interest on behalf of commercial banks.

The automobile consumer financial products provided by commercial banks can be divided into traditional automobile loans and credit card installments. According to the data

of CBRC in 2016, auto loan accounts for about 61% of the retail auto finance business of commercial banks, and credit card installment business accounts for 39%. Under the traditional auto loan of commercial banks, they cooperate with financing guarantee institutions, dealers or loan aid institutions to issue loans to the borrowers that meet the loan requirements after detailed risk management measures. With the gradual expansion of commercial banks' business layout for retail banking, some banks also began to provide installment purchase service for credit card holders or consumers with car purchase demand. Compared with the traditional automobile loan, the installment purchase of credit card has higher requirements on credit evaluation for the people who already have credit card or the new customers who provide guarantee through financing guarantee institutions, but the approval process is faster than the traditional automobile loan process. The installment of credit card requires a certain handling fee, and the total cost is slightly higher than the automobile loan.

Taking Ping An Bank of China as an example, as the leader of China's commercial banks in the automobile financial market has started the automobile loan business since 2002, and set up the automobile consumer credit business department in 2011. We can see from Figure 3-3 below, from 2012 to 2018, its auto finance business grew rapidly. In 2017, the balance of personal automobile financial loans of Ping An Bank has reached 100 billion yuan, and by the end of 2018, it was 172 billion yuan. In November 2018, Ping An Bank was authorized by the CBRC to establish an automobile consumer finance center to provide online services, through online banking official website, WeChat public account and other Internet channels. The borrowers can check the loan progress, check the bill and repayment information in real time through official website and WeChat public account, and get real-time online and robot services.

Ping An Bank's auto finance center cooperates with many middle and high-end brand auto manufacturers such as Benz, BMW, Land Rover and Porsche, to expand the market share of auto finance with the advantages of channels. At the same time, with the help of science and technology, through cloud computing, big data, artificial intelligence, blockchain and other technologies, Ping An realized to issue loans within seconds. At the end of 2018, the automated auto finance approval system of Ping An Bank accounted for 75%. From application, approval, remote face-to-face signing to real-time lending, it uses financial technology to make the automobile consumer loans issuing more intelligent and automatic.

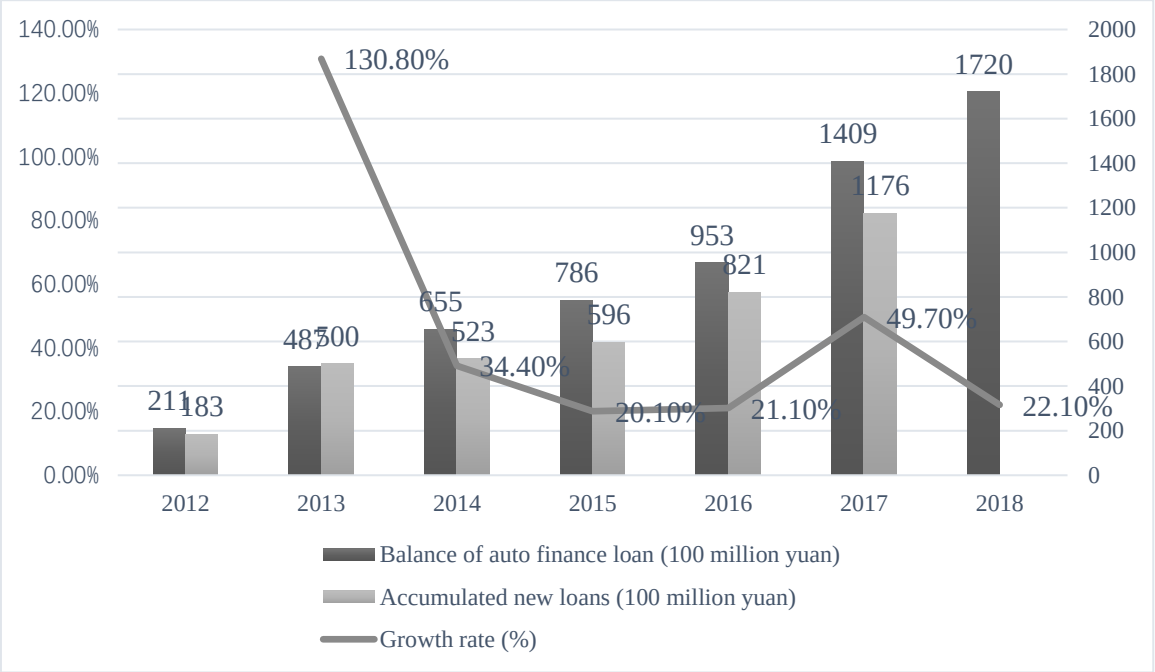


Figure 3-3 Balance and growth rate of automobile consumer finance loan of Ping An Bank from 2012 to 2018

Source: The annual financial report of Ping An Bank (2018)

To sum up, commercial banks as the largest participant in China's auto finance, have an absolute advantage in the current auto finance market with the help of strong capital advantages and extensive channel network layout under the diversified competition pattern. By means of the diversity of its auto finance model, with the help of auto finance intermediaries such as financing guarantee companies, commercial banks comprehensively cover supply chain finance, auto consumer finance and other fields.

3.1.2.2 Auto finance company

According to China's measures for the administration of auto financing companies, "the main investors of auto financing companies shall be the enterprises or non-bank financial institutions that produce or sell auto complete vehicles". After entering the mature period, in order to ensure the liquidity of capital and facilitate the coordination and control, auto brand enterprises often reduce the financial support for banks and choose to establish auto finance companies with group shareholding. As of 2019, there are 25 auto financing companies approved by CBRC (see Table 3-3 for details). Except Shanghai Dongzheng auto financing company whose main investor is dealer, the other 24 main investors are auto brand enterprises. The 24 auto finance companies provide financial services to various parts of the

shareholders' auto group. The licensed auto financing companies can use the funds of the national interbank market and also carry out interbank lending. Therefore, although the cost of funds is higher than that of commercial banks, it is still lower than other auto financing entities. Moreover, due to the discount of the main engine manufacturers, the interest rate of auto loans is generally lower. At the same time, with the help of shareholder resources, auto financing companies are closely connected with dealers and have channel advantages compared with other auto financing entities. However, because the auto financing companies generally only provide services for the shareholders' brands of the main engine manufacturers, the scope of business development has limitations.

Table 3-3 list of domestic auto financing companies (25 in total)

Auto finance company	Registered capital (billion yuan)	Establishment date	Site	Ownership structure
SAIC GM Finance	15	2004 August	Shanghai	SAIC finance 45%, GMAC UK 35%, SAIC GM 20%
Volkswagen Finance (China)	40	2004 August	Beijing	Volkswagen financial services 100%
Toyota Auto Finance	31	2005 January	Beijing	Toyota financial services 100%
Ford Motor Finance	32.6	2005 June	Shanghai	Ford credit 100%
Mercedes Benz Auto Finance	54.83	2005 September	Beijing	Daimler AG 52.2%, Daimler Greater China investment company 47.8%
Dongfeng Peugeot Citroen Auto Finance	10	2006 June	Beijing	DPCA 50%, Dongfeng Motor Group 25%, Peugeot Citroen Dutch finance company 25%
Volvo Car Finance	5	2006 July	Beijing	Volvo Group 100%
Dongfeng Nissan auto finance	15.29	2007 October	Shanghai	Dongfeng Group 35%, Japanese auto 29.75%, Nissan investment 21.25%,Dongfeng Co., Ltd. 14%
Fiat Chrysler Auto Finance	7.5	2007 December	Shanghai	Fides Limited 100%
Chery Huiyin Auto Finance	10	2009 April	Anhui	Chery Automobile holds 80% of the total shares, and Huishang bank holds 20%
GAC Huili Auto Finance	16	2010 May	Guangdong	Guangqi group 50%, Dongfang Huili personal finance 50%

Auto finance company	Registered capital (billion yuan)	Establishment date	Site	Ownership structure
BMW Auto Finance	98	2010 September	Beijing	BMW 58%, BMW Brilliance 42%
Sany Auto Finance	19.73	2010 November	Hunan	Sany group 94.43%, Hunan Trust 3.75%, Hunan Valin Steel Group1.82%
FAW Auto Finance	20	2012 January	Jilin	FAW finance 83%, Bank of Jilin 17%
Beijing Hyundai Auto Finance	40	2012 June	Beijing	Hyundai Finance Co., Ltd. 46%, BAIC motor Investment Co., Ltd. 33%, Beijing Hyundai 14%, Hyundai Auto Co., Ltd. 7%
Chang'an Auto Finance	25	2012 August	Chongqing	Ordnance Equipment Group holds 45% shares in total, Chang'an Automobile 35%, Chongqing Yufu assets 16%, Chongqing agricultural and commercial bank 4%
Rifford Auto Finance	10	2013 January	Anhui	Jac 50%, tanzand 50%
BYD Auto Finance	15	2015 February	Tianjin	BYD 80%, Bank of Xi'an 20%
Huatai Auto Finance	5	2015 February	Tianjin	Huatai Automobile 80%, Bohai bank 20%
Tianjin Great Wall binyin Auto Finance	5.5	2014 May	Shanghai	Great Wall Motor 90%, Tianjin Binhai agricultural Commercial Bank 10%
Shanghai Dongzheng Auto Finance	16	2015 March	Shanghai	China Zhengtong automobile service holding 95%, Dongfeng Motor Company 5%
Brilliance East Asia Auto Finance	8	2015 April	Shanghai	Brilliance China Automobile Holding 55%, leading finance 22.5%,FinConsume22.5%
Jizhi Auto Finance Co., Ltd	9	2015 August	Shanghai	Geely Holding 80%, BNP Paribas personal finance 20%
Shandong HOWO Auto Finance	5	2015 September	Jinan	Sinotruk (Hong Kong) 50%, sinotruk group 20%, Shandong International Trust30%

Auto finance company	Registered capital (billion yuan)	Establishment date	Site	Ownership structure
Yulong Auto Finance (China)	5	2016 February	Hangzhou	Yulong Automobile Manufacturing Co., Ltd

Source: Enterprise business information grade website (2016)

With good relationship and channel advantages with automobile manufacturers, auto financing companies have more flexible product solutions that meet consumers' choices. In addition, they also have the following advantages:

1) compared with the auto loan business of commercial banks, the procedures of auto financing companies are more convenient. There is no need for guarantee and credit investigation, the products are more flexible, and they have obvious advantages in terms of loan approval standard, repayment period and down payment ratio.

2) auto financing companies often cooperate with shareholders' automobile manufacturers to carry out promotional activities by purchasing cars at low interest rates. On the one hand, they can maintain the price of brand cars, on the other hand, they can also promote consumers to buy their own brand cars.

3) relying on the core advantages and strong capital flow of the vehicle factory, auto financing companies play a role of overall support in integrating industry resources and coordinating the advantages of industry chain.

4) in the pre-loan audit of the borrowers, the auto financing company not only uses the traditional credit system of the bank, but also the data sources include the third-party credit agencies and network information, so it has more advantages for its own brand of financial loans.

Compared with the mature auto financial market in developed countries, the market share of China's auto financial companies still has a large room for improvement. In other countries, auto financing companies account for 53% of the market, while in China, auto financing companies only account for 28% of the auto financing loan market. The main reason is that the financing channels of auto financing companies in China are relatively single, and the cost of capital is higher than that of commercial banks. Financial debt and ABS as the supplement of auto financing companies in addition to bank loans, have weaknesses in the flexibility and amounts. Another reason is that in China, auto financing companies are non-bank financial institutions, supervised by the CBRC, and subject to more

restrictions in terms of financing, and the risk control and capital and other rigid regulatory indicators are relatively strict.

3.1.2.3 Financial leasing company

China's automobile financial leasing business began to rise in the 1980s. Many enterprises use financial leasing to avoid the national restrictions on the level and quantity of automobile use. Since then, the auto finance leasing business has been banned for many times. Until 2004, the auto finance leasing business was "legitimate". In recent years, auto finance leasing business has developed rapidly to become an important credit way of auto finance in China.

Automobile finance lease is based on installment payment, which separates the right of use and ownership of automobile. After the expiration of the lease term, the lessee may choose to own the ownership or transfer its right of use to the lessor. Compared with the traditional automobile consumption credit, automobile finance leasing has lower threshold, higher transaction efficiency and more flexible product portfolio. The shareholders of automobile financial leasing are mainly commercial banks, automobile manufacturers, automobile leasing companies and dealers. The financial leasing company, which is dominated by dealers and leasing companies of the whole vehicle factory group, has advantages in both equipment and capital, and is in the leading position in the automobile financial leasing market. In general, all kinds of auto financing leasing companies have advantages and disadvantages in terms of capital source, capital cost, vehicle source and business process.

1) Commercial banks: because of the stable capital source and the lowest cost, the lease price is relatively low, but the lessee's qualification requirements are the highest and the approval time is long.

2) Complete vehicle factory: the source of vehicle is stable, the cost of vehicle purchase is the lowest, the cost of lower capital can be obtained through inter-bank borrowing and other ways. The rental price is relatively low, and there is a slight disadvantage in professionalism.

3) Car leasing department: it has rich experience in financial leasing business and convenient leasing process but lacks in channel and capital cost.

4) Dealer system: with the help of dealer background, it provides rich models and brands for the lessee. Compared with other types of financial leasing companies, it has

obvious channel advantages and the strongest ability to obtain customers, but it is weak in terms of capital and expertise;

The difference between financial leasing companies and auto financing companies lies in the difference of license plate and products. In terms of institutional license, the license of financial leasing companies was issued by the Ministry of Commerce and supervised by the Ministry of Commerce. The license of auto finance company is issued by CBRC and supervised by CBRC. The difficulty of obtaining the license of financial leasing is far lower than that of auto finance. Up to now, according to the statistics of China leasing network, there are more than 7000 financial leasing companies registered nationwide, while only 25 auto financing companies. In terms of products, compared with auto financing companies and commercial banks, financial leasing companies have lower thresholds for consumers, generally do not require asset mortgage, are more flexible in terms of loan cycle and repayment methods, and can provide differentiated financial solutions for the needs of different borrowers. Of course, compared with the first two types of financial entities, financial leasing companies have higher capital costs because of their higher capital costs, and consumers are usually required to pay higher interest.

China's financial leasing companies can be divided into three groups, which are financial leasing companies, foreign-funded financial leasing companies and domestic funded financial leasing companies. Among them, financial leasing companies belong to banking financial institutions and are supervised by the CBRC. In May 2018, the operation and regulatory responsibilities of foreign and domestic funded financial leasing companies changed from the Ministry of Commerce to the CBRC, so they are faced with more stringent access conditions and regulatory requirements. In the short term, small and medium-sized financial leasing companies with irregular management may face delisting.

3.1.2.4 Internet platform company

In China, auto finance Internet platform includes auto trading platform and other Internet platforms for auto finance business. The Internet platform of auto finance provides consumers with a wealth of financial products, including new and used car loans, direct rent, after-sale leaseback and other auto finance credit modes, among which direct rent is the most important way for Internet platform to participate in auto finance.

The Internet platform of automobile finance obtains the customers of automobile purchasing through the advantage of trafficking, and provides various services such as

automobile information inquiry, financial scheme selection and automobile transaction. At the same time, the auto finance Internet platform can involve multiple models and brands, and the financial products are more diverse. The loan requirements are relatively low, and the approval speed is relatively fast. Compared with commercial banks and auto financing companies, Internet platform has higher financing cost and lower customer loan threshold, so the probability of bad debts is higher.

In the way of direct leasing through the Internet platform, the lessors purchases cars from the dealers according to the needs of the lessee, and then leases them to the lessee. The ownership of the car belongs to the lessor during the lease period, and the lessee, as the demander, has only the right to use the car but no ownership during the lease period. The lessee obtains the right to use the car through direct lease, so it is not limited by the minimum down payment limit of the car loan. Generally, it only needs to pay 10% down payment or even 0 down payment to obtain the right to use the car. There are two modes of direct rent provided by Internet platform, which are "N + 0" and "1 + n".

The "N + 0" mode of direct rent means that consumers pay N installments and purchase cars at the cost of 0 yuan. The most common base of "N + 0" mode is 36 or 48 installments. During the lease period, the consumer pays the rent to the lessor on a monthly basis. After the lease period is over, the rented car belongs to the consumer, as the consumer is equivalent to paying the whole purchase fee.

In the "1 + n" mode of direct rent, the most common one is "1 + 2" mode. The Internet financial platform determines the down payment proportion according to the situation of the vehicles purchased by the consumers and the credit score and determines the lease term as 3-4 years. In the first year, the consumers obtain the right to use the vehicles by leasing. From the second year, the consumers can choose to pay the final payment for the purchase of vehicles, renew the lease or return the lease.

In recent years, with the rapid development of Internet Finance in China, there are a series of problems in the field of consumer finance in the Internet platform because of the nonstandard management and market. Since the central bank and the CBRC issued the notice on regulating and rectifying the "cash loan" business in November 2017, the regulatory authorities have been increasingly strict in the supervision of Internet platforms, which has brought challenges to the development of auto finance business.

3.1.4 Auto financing guarantee agency

In China, the financing guarantee company refers to the joint stock limited company and limited liability company which are established to operate the financing guarantee business according to law. Financing guarantee business refers to the behavior that the guarantor and the creditor such as banking financial institutions agree to provide financing guarantee for the guaranteed. When the guaranteed fails to perform or is unable to perform the financing debt owed to the creditor, the guarantor shall bear the agreed guarantee liability according to law.

As one of the most important business in guarantee business, financing guarantee is a kind of credit intermediary service, which is produced with the development of financial credit, commercial credit and the financing demand of the guaranteed. The financing guarantee institution intervenes between the fund lenders such as banking financial institutions and the financing borrowers through the intermediary status. They provide credit guarantee for the fund borrowers as the third-party guarantors - to guarantee that the financing parties or borrowers perform the responsibilities and obligations of the contract. In the nature of its business, financing guarantee has the dual attributes of intermediary and financing, which belongs to a special financial intermediary service.

Financing guarantee institutions provide financing guarantee services for fund lenders and fund demanders through their own third-party credit to promote the completion of loan business of both parties. In the process of carrying out financing guarantee business, guarantee institutions need to complete two aspects of work. On the one hand, they need to carry out credit evaluation on financing demanders to evaluate their repayment ability and willingness. On the other hand, they need to provide their own credit certificates to fund lenders. This aims to obtain approval from creditors such as banking financial institutions of the performance ability and qualification of their own financing guarantee.

Due to the imperfection of the credit system in China, banking financial institutions lack sufficient knowledge of the past credit standing and future repayment ability of the borrowers. At the same time, because of the high amount of auto finance credit, the interest driven fraudsters and institutions falsify the information or cheat people to apply for loans, thus the bad debts increase, which have a great impact on all aspects of auto finance credit in China. The financing guarantee institutions can effectively reduce the risk of auto financing loans through their own credit scoring system, professional risk control

management and identification of fraudulent loan institutions. Therefore, more and more auto financing institutions, especially commercial banks choose to cooperate with financing guarantee institutions to carry out auto loan business.

Loan intermediary business (also known as "loan assistance business") is an important business mode of financing guarantee institutions. In the mode of loan intermediary, financing guarantee institutions provide financial parties such as commercial banks with customers, loan evaluation, risk control and post loan management. In return, they obtain income through charging guarantee fees. Banks obtain customers through financing guarantee institutions, and pay corresponding fees to financing guarantee institutions. Automobile consumers directly repay the banks after obtaining loans from banks.

The loan intermediary mode meets the demands of banks, financing guarantee institutions and consumers at the same time (Figure 3-4). For commercial banks, especially small and medium-sized banks, the loan intermediary mode overcomes two shortcomings of banks, namely the lack of automobile financing consumption scenario and single market channel. They provide commercial banks with more technical and data support for automobile finance related credit. As for guarantee institutions, loan intermediaries not only provide stable and low-cost sources of funds for them, but also enable them to obtain consumers with the help of commercial banks' reputation, as well as banks' licenses to vigorously expand business in the field of automobile finance. For consumers, they can obtain more convenient loan process, more professional auto financial services and relatively low loan interest rate through loan intermediary services of financing guarantee institutions.

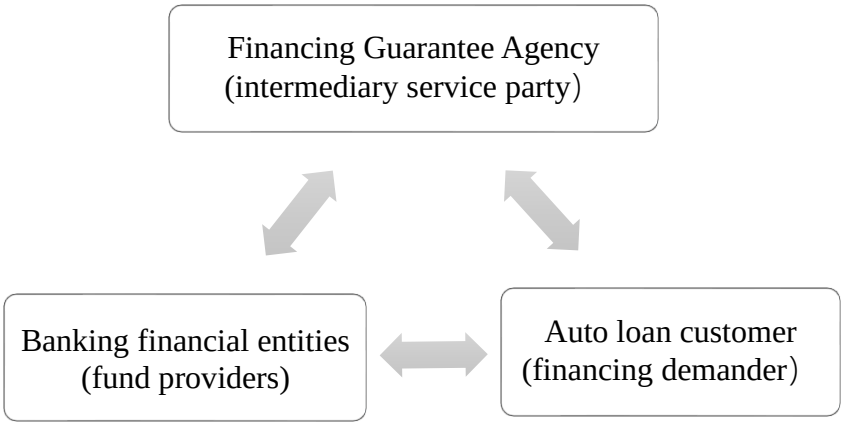


Figure 3-4 business model of financing guarantee company

3.2 Operation process of financing guarantee institutions

In China, the process of vehicle loan intermediary business of financing guarantee institutions can be divided into three parts, including pre loan investigation, loan processing and loan management. The pre loan investigation stage mainly includes the application of the loan intermediary business, the customer's due diligence investigation, the vehicle value evaluation, the field investigation and verification, the system submission report, the customer credit score and other links. The middle stage of the loan mainly includes the financial sector's main body reporting, the approval of the loan amount, the mortgage of vehicles, the payment of the advance payment, and the repayment of the main body of the banking financial entities. The management stage mainly includes post loan tracking, maturity management, post automobile service, disposal of non-performing assets and determination of guarantee liability.

3.2.1 Pre loan

Pre loan, also known as pre credit investigation, is the beginning stage of the whole auto loan business process. It is mainly about the early work between the business manager of the guarantee company, the auto buyer and the auto dealer. The business manager receives the auto consumers who need the loan for consultation, waits for the loan customers to visit the auto dealer, understands the actual needs of the auto customers, helps the loan customers to match the appropriate auto loan products with the auto dealer, and determines the model and brand. After the third-party evaluation, the company determines the value of the vehicle and evaluates the qualification, credit record, repayment ability and repayment intention of the purchaser. Through the on-site visits, it ensures the fairness and authenticity of the pre loan investigation. After the investigation, the report is written and uploaded to the system. In fact, the main purpose of the pre loan investigation is to verify the real intention of the borrower and evaluate the repayment ability and willingness of the borrower.

There are mainly 6 steps in the pre loan survey. The process framework is shown in Figure 3-5.

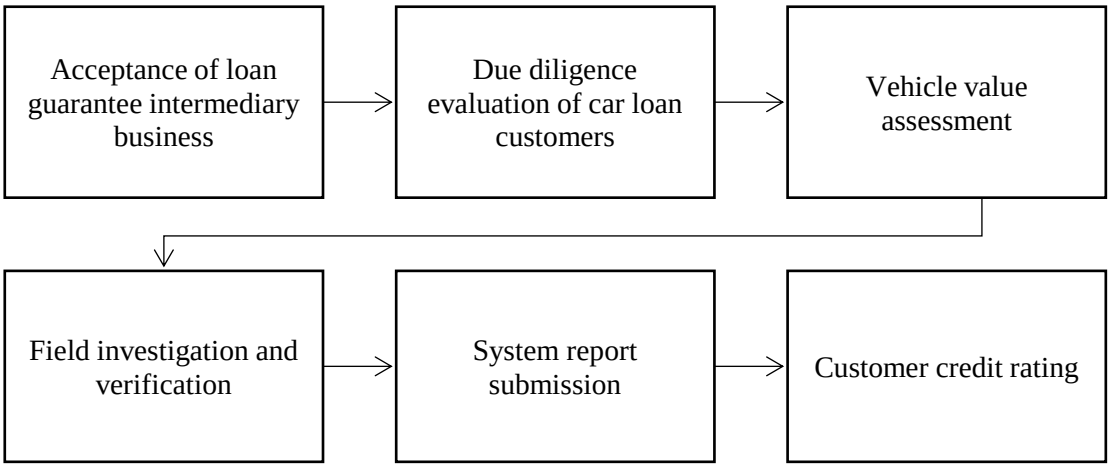


Figure 3-5 pre loan investigation process framework.

3.2.1.1 Acceptance of loan guarantee intermediary business

Business acceptance is the initial stage of business. In this stage, there are two main situations. One is that the customer who has the demand for loan to purchase a car directly contacts the business manager of the guarantee company and consults the business manager about the loan to purchase a car for guarantee. After confirming the demand and willingness, the business manager matches the appropriate car model for the customer through the cooperative car dealer. In this case, the financing guarantee company industry is not only a financial intermediary, but also an information intermediary between the buyer and the dealer. In the other situation, the buyer and the dealer have reached an initial intention to purchase and make a loan. The cooperative dealer informs the business manager of the guarantee company to assist in handling the guarantee and intermediary business of the car loan. In this case, Financing guarantee companies are more of a financial intermediary. In this link, not all car buyers can be accepted by the guarantee company. The business manager will preliminarily screen the customers according to the customer access rules of banking financial entities. Only those business applications that meet the rules of banking financial entities for car loan customers, have real willingness to purchase cars, and are willing to cooperate with the guarantee loan process can be accepted.

3.2.1.2 Due diligence of auto loan customers

After accepting the loan guarantee application of the car buyer, the business manager will require the car borrowers to prepare relevant materials according to the list of loan application materials formulated by the banking financial entity. The auto borrowers also needs to sign an application to query its credit records. The business manager will analyze the authenticity, rationality and compliance of the relevant materials provided, establish a preliminary understanding of the basic information, the purpose of purchase and the source of repayment of the auto borrower, and be responsible for the authenticity of all materials.

3.2.1.3 Vehicle value assessment

The most basic risk control method of automobile loan guarantee business is vehicle mortgage. The business manager collects the vehicle information of borrowers and submits it to the third-party evaluation company that are recognized by the banking financial subject for assessment. The evaluation company evaluates the vehicle according to the market transaction price and issues the vehicle value evaluation report. According to the evaluation report and the mortgage rate policy of the banking financial subject, the financing guarantee institution pre checks the value of the vehicle, and finally determines the loan amount of the vehicle at a certain discount. In this link, the value evaluation ability of the vehicle collateral of the financing guarantee institution and the implementation degree of the mortgage rate policy will have an important impact on the post loan management.

3.2.1.4 Field investigation and verification

The field survey is also called home visit, which is mainly a door-to-door visit by the business manager to the car borrower. This stage requires two people to pay a visit to borrowers. The first thing to be investigated and verified is whether the customer's home address is consistent with the materials provided by the customer. At the same time, on-site verification is carried out for the family information provided by the customer, including family members, residence, and property rights information. Also, they identity certificate, work situation and original verification of the borrowers. In addition to investigating relevant information, business managers also need to take photos of residential areas, doorplates, family internal structures, car borrowers and guarantors. In the end, the customer manager shall also interview the auto borrowers and the guarantor, communicate the loan details, repayment requirements and liabilities for breach of contract. They will communicate with relevant personnel, sign relevant guarantee and loan contracts, and take record, video and photos.

3.2.1.5 System report submission

The financing guarantee institution's evaluation of vehicle borrower mostly comes from the pre loan investigation report submitted by the business manager in the system. As a result, the business manager writes the pre loan investigation report strictly, and the pre loan investigation report needs to include the following 10 parts: 1) personal information such as credit records of the borrower and guarantor; 2) the borrower's balance sheet and external guarantee situation; 3) the bank's running records of the borrowers in the past six months; 4) the third party's vehicle value assessment report; 5) the relevant photos of the borrowers such as film and video; 6) loan amount and repayment period of the borrowers; 7) analysis of the repayment source of the borrowers, including the first repayment source and the second repayment source and the guarantor's repayment source; 8) analysis of the borrowers repayment ability and willingness to repay; 9) loan and guarantee contract signed by the borrowers; 10) other situations that the borrowers needs to explain. As the first line of defense for the company's risk control, the business manager needs to ensure the authenticity and reliability of the above content submitted through the internal system.

3.2.1.6 Customer credit rating

The background of risk control of financing guarantee institutions comprehensively collates and analyzes the investigation data and materials of business managers through the content submitted by the system and gives the credit score for the automobile loan customers in combination with the credit scoring system of themselves and the third party. According to the customer's credit score, the financing guarantee institution determines whether to guarantee it. If the auto borrowers refuse to provide guarantee, they can submit supplementary materials and try to improve the credit score to pass the audit. For customers passing the audit, the guarantee company will select appropriate banking financial entities and loan products based on their scores.

3.2.2 Processing in loan

Processing in loan is the second stage of the whole automobile loan guarantee business process. The business manager has completed the writing of the pre loan investigation report in the pre loan investigation section. At the same time, the loan reporting process has been submitted to the system. The next stage of the loan processing stage is divided into five steps, and the specific process framework is shown in Figure 3-6. The main task is to connect the financing guarantee company with the banking financial entities. The financing guarantee

company matches the appropriate banking financial entities and loan products according to the credit rating of the auto loan applicant. Through the evaluation materials of the buyer provided by the financing guarantee company, the fund provider determines the loan amount. The business manager assists the borrowers in vehicle transfer and mortgage, and the financing guarantee institution advances money to the auto dealer. The financing party shall collect complete transaction materials from the financing guarantee institution and collect funds from the financing guarantee institution.

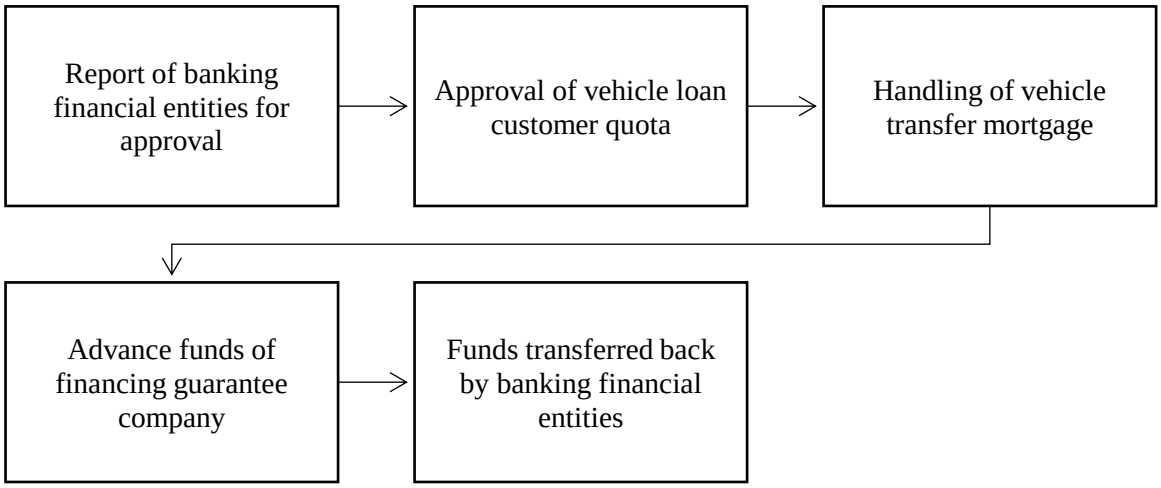


Figure 3-6 Processing flow framework in loan

3.2.2.1 Report of banking financial entities for approval

According to the credit rating of customers, financing guarantee companies report the guarantee business to cooperative banking financial entities. This link is divided into two situations. One is that financing guarantee companies submit financing guarantee business applications to cooperative banking financial entities according to their own loan purchase customers. In this case, financing guarantee companies are not only financial intermediaries It is also the information intermediary between the borrowers and the banking financial subject. Another situation is that the buyer or the automobile dealer has submitted the automobile loan application to the banking financial institution, and the fund provider needs the financing guarantee company to provide guarantee to complete the loan business, in this case, the financing guarantee company is more the identity of the financial intermediary. In this link, not all the car purchase borrowers reviewed and reported by the guarantee company can be accepted by the banking financial subject. The financing guarantee company will re-

match or supplement the loan customers according to the feedback of the banking financial subject, which is also the embodiment of the intermediary role of the financing guarantee company in service.

3.2.2.2 Approval of vehicle loan customer quota

When the financial entity accepts the loan application of the financing guarantee company's car purchase customer, according to the cooperation agreement between the banking financial entity and the financing guarantee institution, as well as its internal risk control requirements, the bank will review the car purchase loan customer and approve the available loan amount. The financing guarantee company will give feedback of the approved loan amount in the system, and the business manager will communicate with the auto lenders and dealers according to this information to assist the dealers to achieve auto sales. In this process, the service intermediary role of financing guarantee company provides guarantee for the transaction between dealers and customers.

3.2.2.3 Handling of vehicle transfer mortgage

If the car borrowers have no objection to the loan method and amount, they pay the down payment to the dealer. Based on the cooperation agreement with the financing guarantee company and its guarantee function, the guarantee company shall assist the customer to complete the vehicle transfer to the national automobile transaction management center and mortgage it to banking financial institutions. In this link, the service intermediary role of financing guarantee company is reflected again.

3.2.2.4 Advance funds of financing guarantee company

Financing guarantee institution's advance money, also known as loan, refers to that when the vehicle under the customer's name is mortgaged, financing guarantee institution shall pay the final payment to the dealer in advance to complete all aspects of automobile sales. In this link, in order to improve the timeliness of vehicle transactions, when the auto loan customer completes the matter of vehicle mortgage to banking financial institutions, the financing guarantee company generally pays the vehicle balance with its own funds on behalf of the customer. So far, the transaction between the car dealer and the buyer has been completed. At the same time, the buyer has become the user of the vehicle, only the ownership of the vehicle is mortgaged to the fund provider. When the loan buyer completes all the loan agreements within the agreed repayment period, the full ownership of the vehicle can be obtained.

3.2.2.5 Funds transferred back by banking financial entities

The financing guarantee institution shall sort out the materials of the buyer, the guarantee contract, the vehicle mortgage certificate provided by the vehicle management, and submit them to the banking financial subject. When the fund provider completes the audit according to the internal process, it shall pay the advance payment to the financing guarantee institution and notify the auto borrower to start the repayment. Since then, all the processing links in the loan have been completed, and the financing guarantee institutions and banking financial subjects have cooperated with each other to enter the post loan management link.

3.2.3 After loan

Post loan management is the embodiment of guarantee responsibility of financing guarantee company after loan granting. After the financial institutions such as banks issue the automobile loan, it does not mean the end of the intermediary business of the financing guarantee institution. As the final link of the automobile guarantee loan business, the post loan management is the management of the process from the financial institutions to the end of the guarantee period of the financing guarantee company. It plays an important role in ensuring the completion of guarantee liability of guarantee company, preventing and controlling default risk and post loan management. The post loan management process is divided into five steps, which need to be completed through the cooperation of banking financial entities and financing guarantee companies. See Figure 3-7 for specific steps.

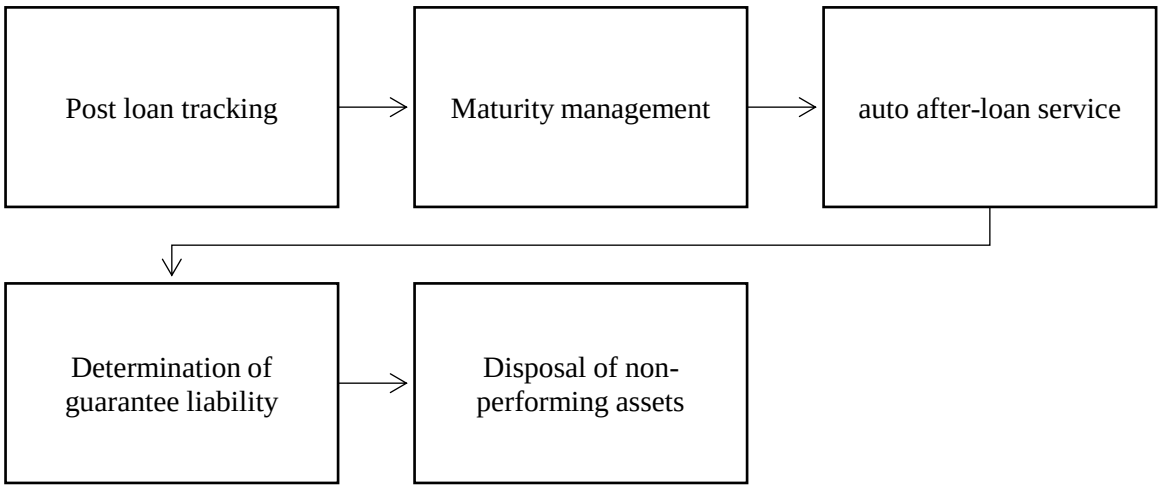


Figure 3-7 Post flow framework in loan

3.2.3.1 Post loan tracking

Financing guarantee companies provide different guarantee liabilities according to the guarantee agreements signed with different banking financial entities. This means that within the guarantee period (from three months to the whole loan period), guarantee companies provide full responsibilities for its guarantee business according to the guarantee agreement (from part of loan amount to full amount). In this link, there are two types of tracking. One is that the financing guarantee company proactively tracks the customer's car purchase after loan is issues during the guarantee period, through its internal post loan management system, to ensure that the customer pays in full on schedule. The other is that the financing guarantee company passively tracks the customer's car purchase after loan during the guarantee period, when the buyer fails to pay in full on schedule. When the fund is paid to the bank financial subject, the fund provider requires the financing guarantee company to fulfill the guarantee responsibility. In this case, the financing guarantee company will trace default through its post loan management system. In the former mode, the daily operation cost will be higher, but the default rate can be reduced to some extent. In the latter mode, the management cost of financing guarantee institutions will be reduced, but because the timeliness of overdue treatment is not high, in some cases, the guarantee cost will be increased, which will seriously affect the operation of guarantee companies.

3.2.3.2 Maturity management

The maturity management of auto loan business of financing guarantee company mainly includes the pre collection of customer repayment, the adjustment of guarantee period, the settlement of guarantee period, the adjustment of loan period, the collection of overdue loan. Maturity management is a way of active loan management, which can reduce the overdue risk to a certain extent and improve customer satisfaction.

3.2.3.3 auto after-loan service

Automobile post service refers to the comprehensive services after the loan has been provided by financing guarantee company to loan customers. These services include sending direct push messages of insurance and maintenance, providing diversified financial product recommendations according to customer credit score and repayment. They satisfy customer claims after accidents and handling violations through high-quality services. Through the automobile post service, the company is able to expand the automobile post service market,

which reflects the service intermediary role of financing guarantee company, and obtains the intermediary service income while effectively resolving the bad debt impact.

3.2.3.4 Determination of guarantee liability

The determination of guarantee liability refers to how to determine the liability of the guarantee company according to the guarantee agreement signed by the financing guarantee company and the banking financial bodies. Generally, the overdue period in the guarantee period will be recognized as the guarantee liability of the guarantee company, which needs to undertake the full or partial loan balance compensation for the defaulting auto loan customers according to the guarantee agreement. Using self-owned funds or guarantee funds deposited in bank financial entities to repay automobile loans on behalf of customers. During the period of loan compensation, the financing guarantee company will use its own channels to recover the loan or external non-performing assets, so as to reduce its own cost.

3.2.3.5 Disposal of non-performing assets

The management and disposal of non-performing credit assets refers to that the financing guarantee institution completes the whole process of entering into non-performing assets, disposal and listing after the vehicle acceptance, post loan management and disposal and other business links for the overdue automobile loans within the guarantee period. The guarantee company shall be responsible for the default loans during the guarantee period. During the guarantee period, the change of risk classification may become the write off of bad debts, or normal or concerned loans. However, most of the non-performing automobile loans are disposed by means of collection, transfer of creditor's rights or vehicle sale, so as to reduce the risk exposure, reduce the loss of the company, and finally complete the disposal of non-performing assets.

To sum up, on the one hand, due to the role of information intermediary, service intermediary and financial intermediary embodied in the whole process of pre loan, loan and post loan of financing guarantee company, automobile transaction and loan process can be completed conveniently, efficiently and safely. The customers get rid of the tedious and long loan application procedures and get the car at a lower loan interest rate. The dealers get the customers, and quickly complete the car sales business and capital collection. The banking financial institutions complete the reliable car loan business and get the support and guarantee of the post loan management. The financing guarantee companies also get the service fee, commissions and income guarantee business, which is a win-win situation for

all sides. On the other hand, in the specific operation process, financing guarantee companies also face huge operational risks, which can be divided into external risks and internal risks.

External risks include policy, market, banking financial subjects and loan applicant risks. In terms of policy, financing guarantee company, as an automobile financial intermediary service agency with Chinese characteristics, is greatly influenced by the policy, which is full of challenges for daily operation. In terms of market, many changes in the automobile industry will also affect the business of financing guarantee company, especially for automobile dealers to pursue the maximization of business volume and profit, and help packaging high-risk buyers by undertaking The industry in which the guarantee company obtains automobile loans also artificially creates operational risks for the financing guarantee company. The banking financial bodies, as the fund provider, pursue the externalization of income and risk, which makes the operation of the guarantee company difficult due to its double important requirements of business scale and risk exposure. In terms of the borrowers, organized fraud and delinquency for a variety of reasons are the biggest sources of risk for guaranteed companies.

Internal risk includes management risk, employee risk, financial risk and credit rating risk. In terms of management, because the guarantee company is mainly dealing with preventing and reducing risks, it needs rigorous and scientific management from all aspects before, during and after the loan, as any part of dereliction of duty may cause huge risks and losses. Employees risks happen when employees face pressures and temptations and have difficulties or problems to devote to duties and complete their tasks according to the company rules and moral requirement. In the financial aspect, every link faces financial risks and loopholes from advances to loans, from repayment to collection, from settlement to disposal of non-performing assets. Credit score is the core of risk management of financing guarantee companies, and the effectiveness of credit score requires high levels of technology and models. Excellent credit scoring system is the cornerstone of the successful operation of a financing guarantee institution, and imperfect credit scoring system will bring huge losses and operational risks to the company. Therefore, how to effectively develop a credit scoring system suitable for itself is also one of the focuses of this research. Next, we will take T company as an example for empirical analysis, through the study of T company credit rating and intermediary role, we hope to find the risk management methods of financing guarantee company in the field of automobile finance.

3.3 Business process of T company

T company was founded in 2008 with a registered capital of 200 million yuan. The company is co-funded by C Asset Management Co., Ltd. and D company, which is one of the top three famous credit risk management company in China. The senior management of the company is composed of industry elites who have been engaged in finance, law, investment, finance, taxation and marketing for many years. T company is an innovative consumer financial service company specializing in financing guarantee, automobile transaction, financial leasing, second-hand car brokerage and insurance agency.

Headquartered in Chengdu Hi-Tech Zone, T company has more than 4000 employees national wide. With more than 50,000 long-term partners of auto dealers and has provided auto loan services to more than 100,000 borrowers. T company has been approved by the head office of bank G of China to carry out nationwide automobile loan financing guarantee services and ranks in the top three in the ranking of the automobile loan financing guarantee service providers.

As previously stated, senior management team of T company has professional education and business background in finance, law, management and other fields. The actual controller is Mr. Gao, is chairman of the board, founder of the company and a lawyer. He obtained a master’s degree of law from Southwest University of Finance and Economics, ranked top ten outstanding young lawyers in Chengdu in 2010. He is the founding partner of D law firm, chairman of D company, chairman of C Asset Management Co., Ltd. As a senior asset management expert, he has rich experiences in automobile loan risk management control and financing guarantee institutions. At present, he is a director of Sichuan Law Association, an arbitrator of Chengdu Arbitration Commission, a member of Chengdu Youth Federation and have many other social roles.

T company's main businesses is to provide financing guarantee business for automobile consumption. It mainly provides information, service and financial business for automobile dealers, banks and borrowers. Next, we will introduce the business details of T company from three aspects, namely pre loan, in-loan and post-loan business in combination with the operation process of financing guarantee company.

3.3.1 Pre loan

T's pre credit survey is completed through hundreds of branch offices and more than

3000 business staff across the country. Because they are direct employees who have been unified and trained by the company, thus they bear the responsibility of the whole process for the submitted business. To a certain extent, this employee system avoids personal moral hazard. T company's employee system effectively eliminates the risks that would be much likely to happen with external agencies, such as helping customers package loan application materials, and even colluding with loan fraud agencies for financial fraud. The main purpose of T's pre loan investigation is to ensure the authenticity of consumption loan of each vehicle, and to confirm that every guarantee business is charged by manager. In this case, it is easy for T to trace back to the relevant staff when the risks or adverse events occur. At the same time, in view of the main steps of pre loan investigation, T company has a certain degree of internal process optimization.

First of all, in the business acceptance process of T company, some customers come from the company's network platform and branch company, thus, the business manager select local car dealer for these customers. For this group of customers, T company embodies the value and role of its information intermediary in this process. Other groups of customers are introduced by car dealer partners, then T company’s managers will be called on actual physical sites to provide consulting services. In this link, due to the professionalism and experience of T company's business manager, as well as the recommendation of long-term cooperative auto dealers, the real willingness and qualification of customers can be effectively judged. The business manager introduces the business process and charging details of T company to the customers. They remind the customers that their vehicles must be mortgaged to bank financial entities, and the customers need to cooperate with the handling of relevant loan procedures, including the necessary conditions for home visit, photo archiving and ID card or copy of account book. They also answer the questions of customers.

Secondly, in terms of vehicle value evaluation, T company will invite the third-party evaluation agency to conduct a professional evaluation on the loan vehicles. According to the on-site inspection results of the business manager, T company issues a valuation report on the loan vehicles. The report is based on the comprehensive consideration of the depreciation of vehicles during the loan period, the disposal problems after the expiration of the loan period, combined with the market situation of second-hand vehicles, and the evaluation results of professional evaluation software. In this link, T company will pre evaluate the vehicle in combination with the credit rating of customers and the mortgage rate

policy of banking financial entities. The discount rate of the loan amount is closely related to the customer's credit rating. In short, according to the internal credit rating of T company, the lower the credit rating and the higher the risk, the higher the discount rate of the loan, the lower the loan amount. On the contrary, the higher the credit rating and the lower the risk, the lower the discount rate of the loan, the higher the loan amount. This is also one of the functions of T company as an intermediary.

Finally, when the business manager completes the home visit and submits the customer materials into the system, the internal risk control management department of T company will carry out big data evaluation of customers. At present, T company uses the internal credit scoring system (T score) as the bottom-level big data. It requires that car borrowers, their spouses and guarantors need to be part of the bottom-level big data. Third party scores such as Wanxiang score and Tongdun score are used as the selective big data. Different selective big data are used according to the customer's regional and T score, and then T company decides whether to pass the loan application or not. For example, when the T score is too low, the big data may have shown that the applicants are at large, drug addicts, drug-related people, people with criminal record, have risks of multiple application, M3 overdue or above, and risk of fraud, T company will directly refuse to lend. When the T score shows that the risk level is poor, but the big data shows that there is no illegal or dishonest behaviors, then T company requires that both the husband and wife should sign and provide the guarantor. When the guarantor or the husband and wife have stable formal work (including individual business with operating entity stores, social security or provident fund payment records, other materials that can prove that there is stable formal work) or can provide financial statement, then they can apply for a loan of no more than 100,000 yuan. T requires that they need to increase the down payment percentage and reduce the car loan ratio. See Table 3-4 for the score definition and credit evaluation suggestions.

Table 3-4 T score definition and evaluation suggestions

T score range	**Risk level**	**Interval credit definition**	**Population distribution**	**Bad debt rate**	**Evaluation suggestion**
775-850	excellent	The highest credit quality and the lowest credit risk	10%	<0.2%	Apply for normal loans of less than 200000 + loans that can be upgraded loan ratio + reduced loan interest rate / loan application

					above 200000 + guarantor
715-774	preferably	High credit quality and low credit risk	20%	<1.0%	Apply for normal loans of less than 200000 + loans that can be upgraded loan ratio / loan application above 200000 + guarantor
645-714	commonly	General credit quality with low credit risk	40%	<3.0%	Apply for loan of less than 150000 yuan / apply for loan of more than 150000 yuan + (jointly signed by husband and wife / guarantor)
585-644	Poor	Poor credit quality, with certain credit risk	20%	<10%	Reject / (couple sign / guarantor) + reduce loan ratio+ Loans under 150000 yuan
300-584	difference	Poor credit quality and high credit risk	10%	>15%	Reject / couple sign + guarantor + reduce loan ratio+ loans under 100000 yuan

Through the T company's pre credit investigation and evaluation, we can effectively classify the risks of customers, thereby reducing the risk of default. This is another embodiment of its credit evaluation function.

3.3.2 Processing in loan

Compared with the traditional auto financing guarantee company, T company's loan processing has the characteristics of comprehensiveness, professionalism and systematic approach, owing to its combination of big data credit evaluation and internal review and approval. T's internal examination and approval, conducted through real-time network and system and pre-loan surveys, timely feedback, enhance the timeliness of loans and reduce the risk of loans to avoid invalid work. The approval process of T company mainly includes three stages: risk audit, compliance audit and financial audit. See Figure 3-8 for the specific process.

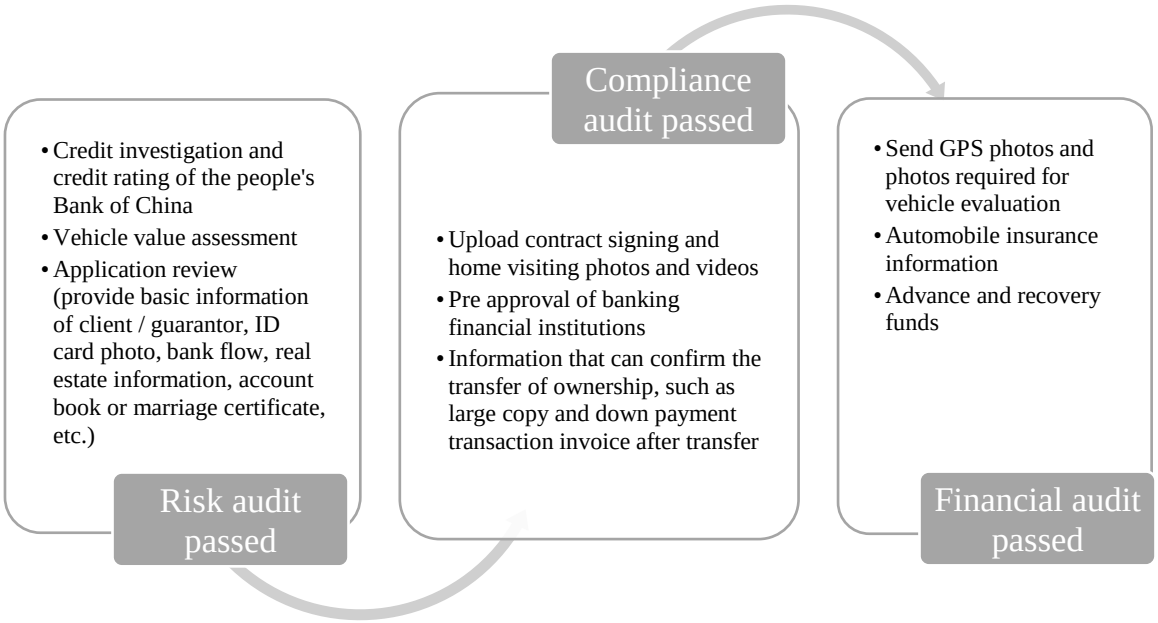


Figure 3-8 Approval process of company T

3.3.2.1 Risk audit

Risk audit stage is the stage of pre loan investigation and front-end real time communication conducted by T company's risk control department. When the business manager obtains the authorization of customer credit inquiry, he will submit the customer information and vehicle information to the pre-trial through the business end or mobile app of T company's OA system. The risk control department of the head office will query the big data of credit investigation, T-score of customers and feedback the credit evaluation suggestions, Meanwhile, the third-party evaluation company will provide the vehicle value evaluation report. Then the business manager will communicate with customers regarding the credit evaluation suggestions and the vehicle value evaluation report to determine the loan amount and requirements. When the loan customer submits relevant materials that meet the requirements, the risk audit is passed.

3.3.2.2 Compliance audit

The compliance audit stage is the stage of real time communication between T risk control departments and banking financial institutions for loan approval. After the home visit is passed, the business manager will submit the contract, photo and video information signed by the customer to the banking financial institutions through the Office Automation (OA) system. The fund provider shall determine the loan amount and term in combination with the loan customer information previously submitted. After receiving the feedback, the

business manager shall notify the auto borrowers to pay the down payment to the dealer, and assist in the transfer and mortgage of the vehicle. When the business manager uploads the down payment transaction invoice and transfer book, the compliance review phase is completed.

3.3.2.3 Financial audit

The financial audit stage includes three parts. First, the risk control department and business manager of T company cooperate to install GPS vehicle positioning system in the vehicle, purchase full commercial insurance for the vehicle with bank financial institutions as the first beneficiary, and carry out post loan management preparation. Second, the financial department of T company advances funds with its own funds, and pays the balance to the automobile dealers, and complete the sales of automobiles. Third, banking financial institutions complete their own internal lending process, collect money from T company, and pay service fees and guarantee fees.

3.3.3 **After loan**

During the guarantee period, T company will take the initiative to carry out the post loan tracking of the loan customers and conduct the real-time tracking through the company's post loan management system to ensure that the borrowers repay the loans in a time manner. Compared with the traditional financing guarantee company, T company uses credit score to manage customers through classifications, and it has different vehicle supervision, post loan inspection, post vehicle service and risk early warning measures for different customers. In case of overdue, T company firstly identifies the overdue customers, and call the customers to pay the loan gradually. When the collection is not favorable, T company will confirm the guarantee liability with the banking financial entities and enter into the treatment stage of non-performing assets.

Before overdue, T company will send the repayment reminder letter to customers through the combination of APP platform, WeChat platform and SMS to remind customers to prepare for repayment. In this stage, we mainly teach and remind customers. By educating and reminding customers, we urge them to repay their car loans in time, avoid affecting personal credit, and effectively reduce overdue. At the same time, in this stage, it will regularly and irregularly send push messages about automobile insurance, financial products and automobile service information. On the one hand, it will improve customer satisfaction, on the other hand, it will open up the post automobile market.

When the overdue occurs, T company will identify the overdue situation of customers. Generally, it can be divided into the four types based on different credit rating and overdue reasons, whereby different strategies will be adopted to deal with each situation. The first situation happens when borrowers are willing to pay and have the ability to repay, but forget or delay to do it due to specific reasons. In this case, the overdue period will not affect the guarantee liability and loan security. According to different credit scores, T company will give different grace periods for such overdue. In addition, it will contact customers within 24 hours through manual communication to remind customers of timely repayment and inform customers of the risk of overdue repayment;

The second situation is when the borrowers are willing to pay but are not able to repay. In this case, T company will contact the host business manager to confirm the customer's willingness to repay and determine whether the customer actively tries to find a way to repay. Good willingness to repay is reflected in many aspects, such as whether the customer cooperates to issue a letter of commitment, whether he is actively working to find ways to raise funds, and whether he cooperates to provide information. For such customers, the business manager will focus on the analysis of their repayment ability. If the short-term repayment ability is insufficient, it is highly possible that the T company will give these customers a recovery period till they have the ability, which ranges from 15 to 90 days based on their different credit scores. T company will provide them with other loan products or adjust the repayment plan according to the actual situation and strengthen the attention of this customer. If the loan customer has lost the repayment ability or the repayment ability is not recovered when the recovery period has passed, T company will enter the non-performing asset processing process, reducing the risk of itself and the banking financial entities.

The third situation is when customers having the ability to repay but are not willing to repay. There are many reasons for this situation, such as the lack of awareness of the consequences of overdue, insufficient post loan service and communication problems. The basic response strategy is to gradually exert intensive negotiation and communication in order to correct and improve the repayment willingness of customers. If the repayment willingness of the auto borrowers cannot be changed within the grace period corresponding to its credit score, T company enters into the non-performing asset processing process.

The fourth situation happens when customers have both weak or no repayment ability and no willingness to repay. The reason for this may be the defects of the manager's pre

credit investigation, the existence of customer fraud or the employee's moral hazard. For such customers, T company will directly reduce the credit score, carry out the guarantor recovery and non-performing assets processing process.

In the stage of non-performing assets disposal, when the guarantee liability is clear with the banking financial subject, T company mainly outsources the third-party asset disposal company, assisted by litigation and arbitration. Through a third-party professional asset company, the non-performing assets within the guarantee liability are converted into creditor's rights, which are collected and processed on behalf of it to make up for the guarantee money paid to the banking financial entities.

In the whole process of automobile loan application and handling. T company serves the roles of financial intermediary, information intermediary and credit intermediary. Through such intermediaries, the normal 5-10 working day loan process can be completed in an average of 1.5 days, which greatly improves the user experience and the cycle of payment collection by dealers. It not only promotes the automobile sales market, but also promotes the development of automobile financial market, and provides efficient and convenient services for the whole loan process.

In the post loan management stage, T company uses its own credit scoring system to manage customers by category, effectively preventing overdue and managing default risk. It can be seen that, while the core of a financing guarantee institution lies in internal risk control and management, T company's core lies in the identification and prediction of customer risk of automobile loan utilizing T score credit scoring system. In the next chapter, we will make a quantitative study of T company's T score and intermediary role, and further analyze the application of credit score in financing guarantee institutions, as well as the intermediary role of financing guarantee institutions in China's automobile loans.

Chapter 4: Research Method

4.1 Research methods

The research is mainly based on empirical research, supplemented by case discussion and qualitative analysis. The main research methods include literature review, Logit, regression, a construction of a two-stage regression and other quantitative research methods.

Literature review plays an important role in the research. Through the systematic analysis of previous research results and relevant points of view, literature review helps researcher form a new understanding of the topic and put forward the new ideas. First of all, in the process of reviewing previous literature, the author summarizes the relevant theories and research results, clarifies the existing achievements and research gaps, and forms the research ideas and innovation points of this research. Secondly, in the empirical research, combining the research results of the more common credit risk assessment model, it also helps this research better explain the rationality of the empirical results, and points out the hidden risks in each link of automobile financial credit and the embodiment of the intermediary role of financing guarantee institutions. On the one hand, this makes the research results of this research to form a certain degree of comparison with the existing literature results, and on the other hand, it also makes a meaningful expansion of the relevant research results.

Quantitative research methods: Based on the principle of financial credit and its transaction characteristics, and according to the element theory of credit risk, this research first puts forward various measurement indicators of automobile financial credit risk. On this basis, in order to verify the correctness of the theory and increase the accuracy of empirical analysis, Logit regression and two-stage regression analysis are used to assess the intermediary role and credit scoring effect of financing guarantee institutions. As the supplement to empirical research and literature research, quantitative methods provide quantitative support to the study, and provide credible basis for research conclusions.

Empirical research methods trace back to the development and policy of China's auto finance. Empirical research deeply analyzes the role of current major players in auto finance loans, the business processes of financing guarantee institutions before, during and after loans, the probability of default based on credit score, and the financing guarantee

institutions' borrowers data. This research analyzes the intermediary role of capital guarantee institutions and draws specific conclusions, all of which belong to the scope of empirical research.

Case study method: This research selects T financing guarantee company as the case study, which has a large market share in China, systematically collects the data of its auto loan borrower in 2018, and conducts in-depth research to explore the current situation of credit scoring and financing guarantee institutions in China's auto financial industry. Through the research and analysis of the similarities and differences between the borrowers who defaulted and the borrowers who do not default, this research explores the general law of credit scoring and intermediary role of financing guarantee institutions.

Qualitative analysis method: using qualitative analysis method, this research systematically analyzes the characteristics of concepts, financing guarantee mechanism and relevant risk control measures of China's automobile finance. From the perspective of intermediary role, this research supplements the connotation and extension of financing guarantee institutions, aiming to make qualitative judgment and analyze its essence.

The comprehensive application of various research methods makes the research of this research more theoretical, scientific and practical.

4.2 Sample and Data

The samples used in this study are collected from T company internal sources, which include the public information of the auto borrowers and the internal data of the loan application. Therefore, based on the confidentiality of T company's business and customer data, confidentiality principles are applied to certain information. During the whole analysis process, the name and details of the company will not be described, and pseudonyms will be used to denote certain types of information and factor, so the collected sample data is only used for data analysis and research, and cannot be traced back to the company or used for other purposes. This research uses 119,798 records of loans of borrowers, who successfully obtained auto loans from T company from 2018-01 to 2018-12 and ended the financing guarantee period six months later as samples to empirically investigate the credit scoring mechanism of financing guarantee institutions and its prediction effect on post loan default performance. One thing to notice is that it is not 119,798 borrowers, but a record of 119,798 loans. The sample of loans were collected based on the loans of cars not on the number of

customers because it is highly possible that one customer could buy more than one car and has more than one loan records.

The total sample is divided into default loans and non-default loans. When buyers buy a car with a loan, they will negotiate a repayment plan with T company, including the repayment time and terms. T company's auto loan is paid by both principal and interest, and the financing guarantee period is 6 months. According to Liao, Li and Wang (2014), if during the six-month guarantee period, the borrowers has incurred one or more overdue payments of 30 days or more during the repayment process, and the borrowers miss these payments in terms that they are late for deadlines or the repayment is less than the required amount, then we say the loan is defaulted, otherwise it is not- defaulted. According to the internal scoring system, T company gives each borrower a corresponding T score based on internal and external determinants such as payment history, debt burden, length of credit history, credit type used and recent credit search. We divide the T score into 10 grades, where 1 is the lowest grade and 10 is the highest grade. See Table 4-1 for the detailed distribution of the total loan samples of each credit rating. In the sample, there are 115.064 non defaulted loans and 4.734 defaulted loans.

Table 4-1 Samples of defaulted and non-defaulted loans, monthly 2018

2018	Credit Grade	1	2	3	4	5	6	7	8	9	10	Total
	Score Range	<=573	(573, 586]	(586, 597]	(597, 606]	(606, 614]	(614, 621]	(621, 629]	(629, 637]	(637, 648]	>648	
01	Non-Defaulted	2792	1994	1085	404	176	71	27	20	6	3	6578
	Defaulted	442	189	87	25	7	2	0	1	0	1	754
	Ratio	13.67%	8.66%	7.42%	5.83%	3.83%	2.74%	0.00%	4.76%	0.00%	25.00%	10.28%
02	Non-Defaulted	1757	1658	1025	419	196	63	43	13	9	10	5193
	Defaulted	237	140	64	27	6	3	0	1	0	0	478
	Ratio	11.89%	7.79%	5.88%	6.05%	2.97%	4.55%	0.00%	7.14%	0.00%	0.00%	8.43%
03	Non-Defaulted	1336	1333	886	306	199	72	34	19	7	2	4194
	Defaulted	159	87	34	25	7	1	0	0	0	0	313
	Ratio	10.64%	6.13%	3.70%	7.55%	3.40%	1.37%	0.00%	0.00%	0.00%	0.00%	6.94%
04	Non-Defaulted	1028	1111	1054	705	519	312	286	208	124	76	5423
	Defaulted	146	85	63	39	19	7	3	9	3	1	375
	Ratio	12.44%	7.11%	5.64%	5.24%	3.53%	2.19%	1.04%	4.15%	2.36%	1.30%	6.47%
05	Non-Defaulted	820	832	1055	994	979	840	898	766	837	742	8763
	Defaulted	176	87	87	59	47	29	28	6	16	8	543
	Ratio	17.67%	9.47%	7.62%	5.60%	4.58%	3.34%	3.02%	0.78%	1.88%	1.07%	5.83%
06	Non-Defaulted	582	675	891	990	1069	1003	1086	1009	1067	1086	9458
	Defaulted	137	79	96	52	44	32	32	17	21	9	519
	Ratio	19.05%	10.48%	9.73%	4.99%	3.95%	3.09%	2.86%	1.66%	1.93%	0.82%	5.20%
07	Non-Defaulted	593	699	1098	1129	1250	1267	1405	1264	1327	1417	11449
	Defaulted	124	100	72	79	53	34	29	26	20	13	550
	Ratio	17.29%	12.52%	6.15%	6.54%	4.07%	2.61%	2.02%	2.02%	1.48%	0.91%	4.58%
08	Non-Defaulted	276	547	986	1230	1422	1452	1743	1613	1737	1793	12799
	Defaulted	55	54	86	66	48	40	53	23	13	13	451

2018	Credit Grade	1	2	3	4	5	6	7	8	9	10	Total
	Ratio	16.62%	8.99%	8.02%	5.09%	3.27%	2.68%	2.95%	1.41%	0.74%	0.72%	3.40%
09	Non-Defaulted	304	569	1057	1293	1562	1576	1753	1638	1844	1800	13396
	Defaulted	56	51	59	57	55	47	33	25	15	7	405
	Ratio	15.56%	8.23%	5.29%	4.22%	3.40%	2.90%	1.85%	1.50%	0.81%	0.39%	2.93%
10	Non-Defaulted	248	468	836	1092	1275	1292	1525	1445	1540	1585	11306
	Defaulted	27	23	30	32	31	18	15	10	10	7	203
	Ratio	9.82%	4.68%	3.46%	2.85%	2.37%	1.37%	0.97%	0.69%	0.65%	0.44%	1.76%
11	Non-Defaulted	227	496	945	1274	1775	1921	2218	1700	1636	1266	13458
	Defaulted	17	23	16	23	24	15	15	6	3	1	143
	Ratio	6.97%	4.43%	1.66%	1.77%	1.33%	0.77%	0.67%	0.35%	0.18%	0.08%	1.05%
12	Non-Defaulted	179	359	735	1060	1403	1567	2027	1960	1963	1794	13047
	Defaulted											
	Ratio											
Total	Non-Defaulted	10142	10741	11653	10896	11825	11436	13045	11655	12097	11574	115064
	Defaulted	1576	918	694	484	341	228	208	124	101	60	4734
	Ratio	13.45%	7.87%	5.62%	4.25%	2.80%	1.95%	1.57%	1.05%	0.83%	0.52%	3.95%

4.3 Hypotheses

As mentioned before, automotive commercial loans had a humble start in China in late 1990s and only in 2003 did the country issued the measures, administration and regulations on auto financing companies. Overall, the history of auto loans are short, therefore limited sources can be found regarding this topic, and not many of the literature fulfill the jobs of examining the intermediary role of auto financing companies. Originally, the commercial banks would bear the risks of issuing loans to borrowers, but now the risks have been shifted to the auto financing companies. Therefore, in order to make profits, compared to commercial banks, auto financing companies had done a relatively better job analyzing borrowers' credit and controlling risks.

To assess borrowers' credit scores and ratings, various kinds of information are used by financing intermediaries, including personal information, asset information, loan information, past credit record history, any certifications could be used for guarantees as well as many other types of information. Different financial intermediaries use different credit rating systems and assigning different weights to each type of information. Among these types of information, some have larger influences on credits, and some have not. Based on this, the study hypothesizes as

H1: Compared with asset conditions, certifications and other types of information, personal information and loan information have much larger influences on borrowers' default probabilities.

Furthermore, auto financing companies are born out of the controlling of risks, whereby they have a better and comprehensive system of control risk than commercial banks. Compared with the public information used by commercial banks to evaluate borrowers, which can be seen and collected through the public channels, auto financing guarantee companies contains more information regarding the borrowers' credit that is used to evaluate the default possibilities of borrowers. Based on this, the study hypothesizes as:

H2: Compared with the public information such as the personal characteristics, asset status and credit history of the borrowers that are used by commercial banks to assess borrowers' risks, T company has other undisclosed information that provide them with a stronger explanatory power on the default probabilities of the borrower.

Financial intermediaries will screen the borrowers in terms of the risks of loans associated. Based on their credit rating system, they distinguish the borrowers in terms of

their credit scores, and then divide them into high-risk borrowers and non-high-risk borrowers by giving them a credit score after the assessment. Therefore, the division between high-risk borrowers and non-high-risk borrowers are largely affected by the credit rating system, in other words, the various types of information. Generally, it is less likely for high-risk borrowers to get loans because the public information they disclosed are more likely to be falsified and limited, therefore the public information has a weak explanatory power over their credit rating scores. Based on this, the study hypothesizes as:

H3: Compared with high-risk borrowers, various kinds of information have stronger explanatory power on the credit scores of non-high-risk borrowers.

4.4 Variable Definition

To analyze the factors that affect the defaults of borrowers, four types of information will be analyzed, including private information (PI), asset conditions (AC), other credit score systems (CS), and terms of loans (ToL). Private information contains four kinds of data for analysis, including age, marriage, sex and driving license. Asset conditions contains three kinds of data, including monthly income, monthly installment payment and bank credit report. Credit scores use three types of other credit scoring systems, including the online financial credit system (NFCS) of People's Bank of China, Wanxiang Scores* and Tongdun Scores* (the latter two use pseudonyms for confidentiality purposes). Terms of loans include three types of data, namely interest rates, loan amount and maturity. Apart from the four types of information that is available to analysis, extra information that remain undisclosed from the sources and organizations will also be analyzed.

In China, financial institutions generally have their own credit score systems, and there is no one single system has been universally used and adopted as industry standard credit scoring system as FICO credit scores. Financial institutions in the United States mostly use FICO credit scores to assess a borrower's credit standing, and FICO credit scores rely on a limited set of data variables.

The use of credit scoring system can help the credit party to make more fair decisions, rather than taking personal prejudice into account. Therefore, in our analysis of the company T as an intermediary, we consider other auto financing companies and their credit grading systems. One thing to mention here is that for the information of credit scores, only two types of credit score system will be used for analysis, namely Wanxiang Score* and Tongdun

Score*. Even though we have three credit scoring systems, but NFCS uses different credit system rather than scores, therefore it is not used for regression analysis. Table 4-2 shows the variables and their descriptions.

Table 4-2 Information categories and definition of variables

Information Category	Variable	Description
Loan performance	Default	Dependent variable 0: non-defaulted, 1: defaulted.
Private Information (PI)	Sex	Independent Variable 0: male, 1: female
	Marriage	Independent Variable 1: married, 0: else
	Age	0: (18,28], 1: (28,34], 2: (34,45], 3: (45,49], 4: (49+]
	Driving license	Independent Variable 1: yes, 0: no
Asset Conditions (AC)	Monthly Income	1: (0,1567], 2: (1567,1905], 3: (1905,2275], 4: (2275+]
	Monthly Installment payment	1: (0,3500], 2: (3500,4500], 3: (4500,9000], 4: (9000+).
	Bank Credit Report	1: (0,600], 2: (600,1913], 3: (1913+]
Credit Scores (CS)	NFCS	
	Wanxiang Score*	1: (0,584], 2: (584,654], 3: (654,692], 4: (692+]
	Tongdun Score*	1: (0,20], 2: (20,50], 3: (50,60], 4: (60,100]
Terms of Loan (ToL)	Interest Rate	1:（0%，27%], 2: (27%，29%], 3:（29%+]
	Loan Amount	1: (-inf,55000), 2: (55000,75000), 3: (75000,120000), 4: (120000,inf]
	Maturity	36
Undisclosed information	Extra	Measured as the residual of the first OLS regression in Equation (1)

Note: For names ending with *, the real names are not revealed due to confidentiality principle.

4.5 Regression Specification

To test H1, the Logit regression will be used, which aims to investigate the influence of each types of information on borrowers' default probabilities. Comparing the estimates and results of Pseudo-R2 of the Logit regression, we can find out which types of information have large influences on borrowers' default probabilities. In this case, there are only two

options with the loans, namely defaulted or non-defaulted, so it is a categorical variable, and the results are yes or no, pass or fail. Therefore, linear regression model is not an option. If we want to study the influence of factors (X) on the dependent variable (Y), where the dependent variable (Y) is a binary variable that has two and only two values coded as 1 (meaning yes or pass or success.) or 0 (opposite of 1), then binary Logistic regression analysis should be used. Logit regression model is a non-linear probability model, which overcomes the shortcomings of general linear regression models and has three main functions. Firstly, it identifies the influencing factors. Secondly it predicts the probability of a certain situation under different conditions and thirdly, it tells what the probability is of a situation according to the model.

In the Logit regression, loan performances or default, is the dependent variable (Y) and only two numbers are used to represent it, namely 1 and 0, and we assign 1 as defaulted and 0 as non-defaulted. Then we regress default on four types of independent variables (X), including private information (PI), asset conditions (AC), credit scores (CS) and terms of loans (ToL) in a manner that we gradually add each type of variables to run the regression in order to compare the results of regression R2. After that, we divide the total sample into high-risk and non-high-risk subsamples to compare the results of estimates of each variable and Pseudo-R2, in order to see whether these four types of information have different influence degrees on different samples of different risk levels. The samples were divided into high-risk and non-high-risk samples, where the average score below or equals 573 points is calculated as high risk, while the average score above 573 points is calculated as non-high-risk.

To test H2, which examines the intermediary role of auto financing guarantee companies, we use a two-stage regression model. As mentioned above, T company uses its own internal risk control management system to generate credit score T score. To analyze the role of T company in auto financing, we use two-stage regression analysis to produce our results, to observe the impact of undisclosed information on default and the intermediary role of T company scoring system. In the first stage, we run an Ordinary Least Squares (OLS). We regress T company’s score system on the other two types of scores, namely the Wanxiang Score and Tongdun Score. This OLS regression examines the relationships between T company’s score and other scoring systems in order to see how much the other two score systems contribute to explain T company’s score. Comparing the explanatory power of the third-party scores to the credit score of T score, and referring to the method of Iyer et al.

(2016), the regression residual which is not related to the two third-party credit scores after "orthogonalization" is regarded as the proxy variable of the unobservable additional information in the credit score：

$$\mathbf{Score}_i = \boldsymbol{\alpha} + \boldsymbol{\beta}_1 \mathbf{CS}_1 + \boldsymbol{\beta}_2 \mathbf{CS}_2 + \boldsymbol{\varepsilon}_i \quad (4.1)$$

Where $Score_i$ is the credit score of auto borrower; CS_1 is Wanxiang score; CS_2 is Tongdun score; regression residual $\hat{\varepsilon}_i \equiv Score_i - \hat{Score}_i$ is the additional information used by T company for credit score. This OLS regression analyzes the relationship between T company's T score and other scoring systems to understand how the other two third-party credit scoring systems contribute to the interpretation of T company's T score.

In the second stage, we run a Logit regression on default with the residual from the first stage to test if the undisclosed information of T company has large influence on the probability of default. The Logit regression is shown in the equation below, in which we gradually add other the four types of information. Furthermore, we add a dummy variable about borrowers' types into the model to allow for the comparison of high-risk and non-high-risk borrowers to see the predictive effectiveness of the undisclosed information controlled by T company on each type of borrowers.

$$\boldsymbol{Default}_i = \boldsymbol{a} + \boldsymbol{\gamma}_1 \boldsymbol{\varepsilon}_i + \boldsymbol{\gamma}_2 \boldsymbol{PI} + \boldsymbol{\gamma}_3 \boldsymbol{AC} + \boldsymbol{\gamma}_4 \boldsymbol{CS} + \boldsymbol{\gamma}_5 \boldsymbol{ToL} + \boldsymbol{\gamma}_6 \boldsymbol{Control}_i + \boldsymbol{\delta}_i \quad (4.2)$$

These two-stage regressions could tell whether the undisclosed information embedded in the four types of information can predict the probability of default and whether the public and whether undisclosed information has a much influence on high-risk borrowers or non-high-risk borrowers. Analyzing these results will give us some information on the role of the T scores and the intermediary role of T company.

Chapter 5: Results and Discussion

5.1 Introduction

A large part of the profits of financing guarantee institutions come from their own guarantee income. As an external risk control institution of banking financial subject, the level of its risk management determines its survival and development. Take T company as an example, the application of T score is the embodiment of its core competitiveness. In the credit scoring system of financing guarantee institutions, the comprehensive information that can reflect the credit status of auto borrowers is collected by business managers, which is then submitted to the credit scoring model of risk control department through the internal Office Automation (OA) system for processing. The credit scoring system created with the information represents the repayment ability and willingness of auto borrowers. The credit scoring system can reduce the information asymmetry between the financing guarantee agency and the auto borrowers, help them accurately identify and avoid the default risk of the borrowers in the guarantee business, which is also the embodiment of the credit intermediary role of the financing guarantee agency.

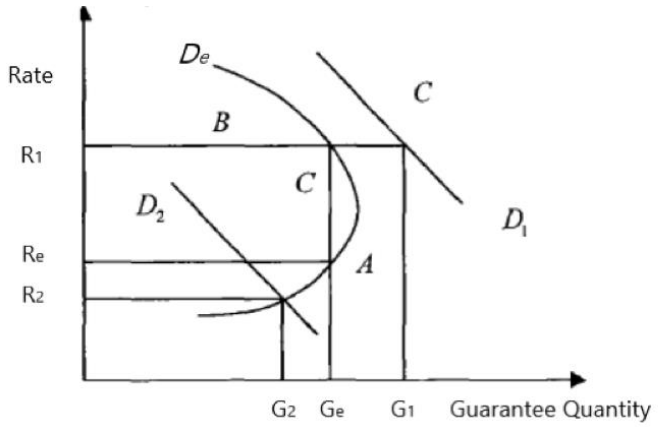


Figure 5-1 Financing guarantee business after credit rating

The process of solving the problem of financing guarantee business using credit scoring is shown in Figure 5-1 above. The demand curve of automobile loan of financing guarantee institution is D1, and the amount of guarantee business that can be provided on the interest rate R1 is G1. If the guarantee business is carried out in full accordance with the process of banking financial entities, a large number of people will not get the loan due to the strict requirements and cumbersome loan process. Although the interest rate of auto loan is

reduced to R2, the demand curve of auto loan is D2, and the corresponding supply is reduced to G2. The difference between R1 and R2 will generate more demand for auto loans, which leads to the gap between supply and demand G1-G2. Credit score is used to evaluate the future repayment willingness and ability of the loan customers by processing all kinds of information of the auto borrowers, and the financing guarantee institution makes the final decision whether to guarantee or whether to adjust the interest rate and guarantee fee to provide guarantee according to the credit score. Therefore, the credit score of the financing guarantee institutions partly solves the information asymmetry between the bank financial subjects and the automobile borrowers in the automobile financial credit market.

Through the credit score, some auto borrowers whose scores are not up to standard are rejected to give loans. At this time, the demand curve of auto loans will move to De, the equilibrium interest rate determined by the supply-demand curve is re, and the guarantee amount of auto loans provided by the financing guarantee agency is Ge. At this time, G2 ＜ Ge ＜ G1,and R2 ＜ Re ＜ R1. Before using credit score, the income of financing guarantee institutions is G1 (1 + R1), the income of using banking financial institutions process to guarantee business is G2 (1 + R2), while after using credit score, the income of financing guarantee is Ge (1 + Re), obviously G2 (1 + R2) ＜ Ge (1 + Re) ＜ (1 + R1).

Although the income of financing guarantee institutions decreased after using credit score, the risk of obtaining guarantee income of financing guarantee institutions also decreased because of the decrease of default rate of automobile loans. At the same time, some customers who can't get auto loans according to the process of banking financial institutions can also get loans through the guarantee of financing guarantee institutions. This kind of customer mainly includes two types: one is the customer with repayment ability and willingness, but unable to meet the loan conditions of bank financial subject, such as unable to provide credit records or have no stable work; the second is the customer with repayment ability and willingness but unable to get auto loan due to processes and procedures and other reasons. Through credit scoring, not only the identification ability of the first type of customers is enhanced, but also the efficiency of the second type of customers can be improved. On this basis, T company identifies customers through T score, and actively reduces the interest rate and guarantee service fee for customers with high credit rating. Therefore, the high credit rating auto borrowers get the promise from T company that they can get auto loans at a lower interest rate, and still choose to make loans through T company, to a certain extent, to maximize Ge.

Under the premise of risk control, the maximization of Ge (1 + Re) of financing guarantee depends on T company's application of T score. In order to study whether T score is more persuasive to breach of contract than other third-party credit score, and whether T company has additional but undisclosed information in the process of providing loan service, and then it can play an intermediary role through credit score. We will combine the analysis of the previous chapter to test and analyze in the next part of this chapter.

5.2 Descriptive Statistics

As mentioned above, Table 4-1 shows the sample size distribution and default of each credit rating of T company. One thing to notice is that the analysis is based on the loans for the first 6 months, because the guarantee period of loans only lasts for 6 months. Even though loans normally have a period of 36 months, due to the definitions of default, we only collect and analyze loans for the first half of the year. We can see from Figure 5-2 below, the default rate below 573 is much higher than that of other grades, showing a double-digit default rate as high as 13.45%. At the highest credit grade, the total default rate is as low as 0.52%. Overall, with credit grade increases to a higher level, the default rate decreases gradually.

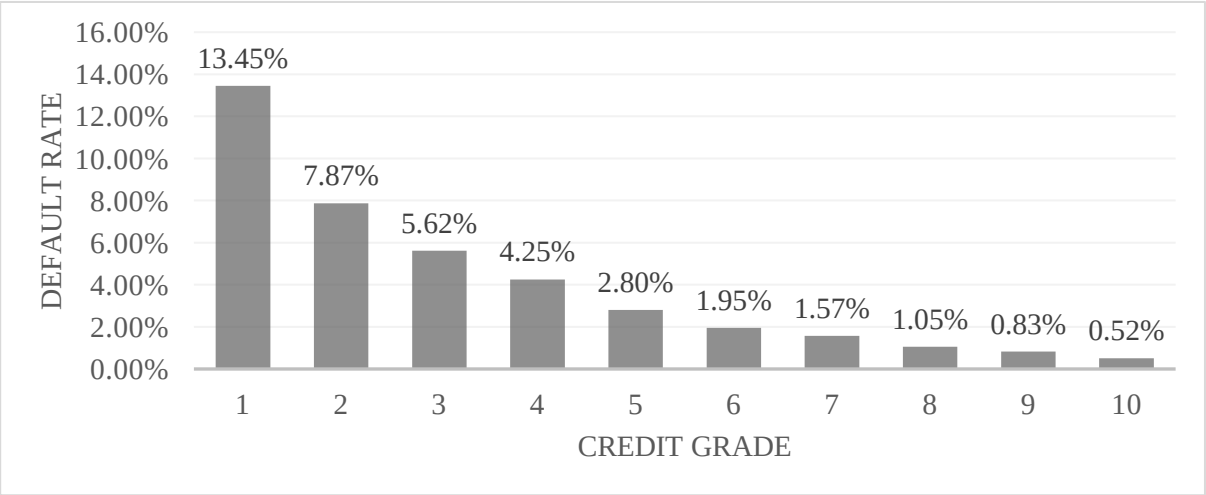


Figure 5-2 Trend of default rates for total sample by credit grade, 2018

Another interesting observation can be found in Figure 5-3 below, which shows the number of monthly issuing of loans collected for analysis for each grade. We can see that for lower grade levels, such as grade 1 and grade 2, there are large decrease of loans in the first half of the year, indicating that in the second half of the year 2018, few loans are offered to borrowers with low grade levels. For borrowers with higher grade levels, the number of loans increase gradually in the mid-2018 and overall throughout the year, the number of loans

issued for borrowers of grade 4 to grade 10 increase. This situation can be partly explained by the intermediary role of auto financing companies and T company, because in the mid-2018, several changes are made to the auto finance industry and intermediaries. As a result, as time passes by, the company's credit evaluation ability increases, thus it is less likely for borrowers with low credit grade levels to get passed by the evaluation of auto financing guarantee companies and to get loans. Therefore, the overall quality of customers continues to improve and their qualities increased.

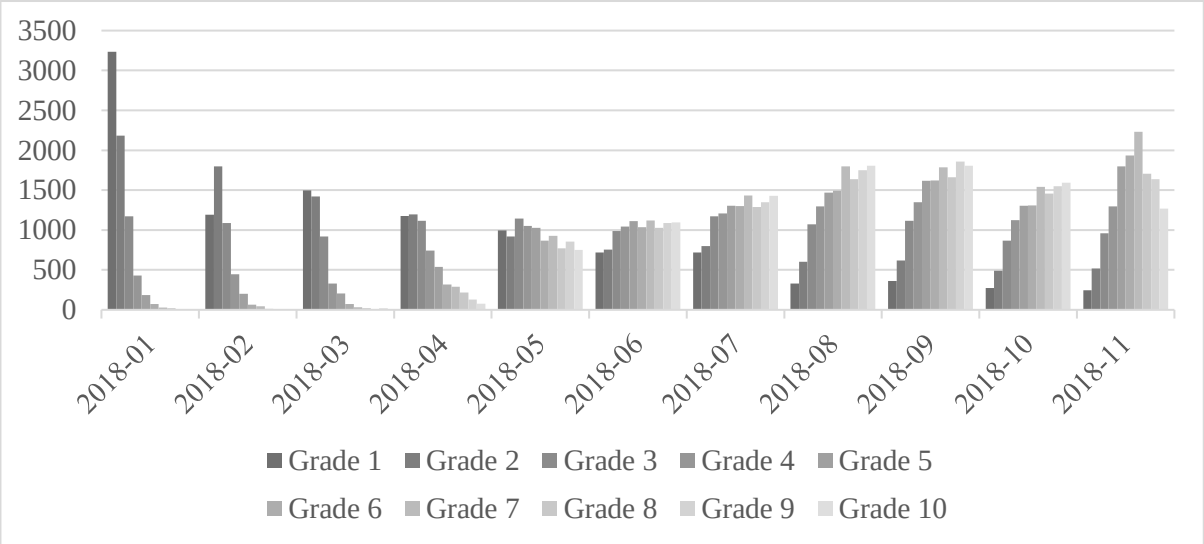


Figure 5-3 Number of samples collected for each grade, monthly 2018

The performance of loans of each grade by month can be seen from Figure 5-4. We can see that the default rate of each credit rating shows a convex shape in different months, with low level of default rates on both sides and large default rates in the middle. Also, we can see that for each credit grade, it does show a decreasing trend of default rates when comparing the end months with the beginning months, as says in Figure 5-4. For example, in January 2018, the credit grade 1 has a default rate of 13.67%, which increased to 19.05% in June, and then decreased to 6.97% in November.

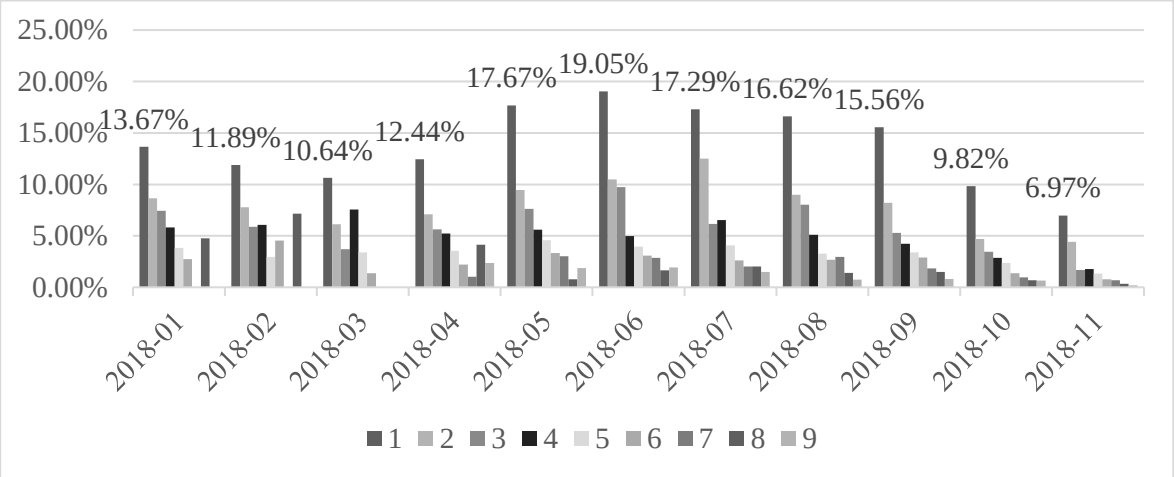


Figure 5-4 Trends of default rates by grade, monthly 2018

Figure 5-5 shows the trend of default rates for each grade per month, and we can see that in every month, the default rate of each month always decreases with the rise of the credit rating, with some abnormal inflection points when the credit grade are 9 and 10. This is a result of small number of samples and insignificant statistical indicators.

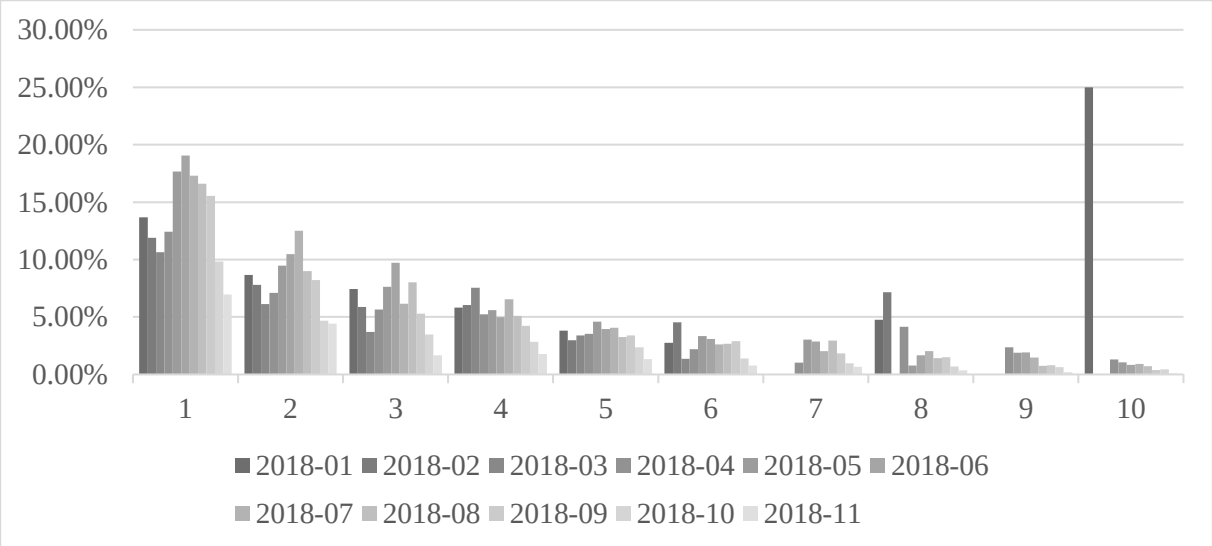


Figure 5-5 Trend of default rates each grade by month

Table 5-1 below shows the average value of each variable of the borrower's credit rating from 1 to 10. It can be found that different variables have various impacts on default rate, such as gender, driving license and marriage. The specific analysis of each variable is as follows:

1) Sex variables. As described in Table 5-2, 0 represents male and 1 represents female. Table 5-1 shows that the proportion of women is on the rise in general, from 0.17% of level 1 credit rating to 0.52% of level 10 credit rating. The pattern shows a positively correlated

relationship between credit grades and the proportion of women, whereby the higher the credit rating, the higher the proportion of women. This means that with the improvement of credit rating, there are more and more female borrowers; in the lowest risk credit rating, the proportion of female car buyers is close to half.

2) The mean of marriage variables shows an increasing trend, which means that as credit grade increases, the borrowers are more likely to be married people. Borrowers who are single are more likely to apply for high risk loans.

3) the influence of age variable on default rate is not obvious. Generally speaking, with the increase of age, the risk level increases correspondingly, indicating that the risk of default of customers who are relatively young with an average age of 32-33 years is relatively low.

4) for the variable of driving license, we can see that with the increase of credit rating, the increasing trend of customers with a driving license is obvious, which means that customers without driving license loan to buy a car, because their real demand for buying a car is not clear, it may be loans for others, or it may be that they have not yet obtained a driving license, so the higher the risk.

5) in the monthly income variables, there are some irregular trends, and the impact on default rate is not obvious. In general, the higher the income, the higher the risk. Generally speaking, the higher the monthly income, the stronger the repayment ability and the lower the default rate. But strictly speaking, Table 5-1 shows that the higher the monthly income, the higher the default rate. The emergence of such a situation may be based on three situations: one is that some high-risk clients tend to make higher monthly income to T business managers in the pre loan investigation stage, so as to obtain loan approval. In the second case, some high-income auto loan customers are not stable in income and are more likely to default. In the third case, part T public. The business manager of the company has moral hazard. Based on the understanding of the company's internal risk control policy, the materials of high-risk customers are packaged so that they can pass the loan approval.

6) variable of monthly payment, the higher the monthly payment, the higher the risk. It can be seen that the greater the pressure on high-risk customers' monthly repayment, the higher the default risk.

7) the total variable of the monthly credit supply of the people's Bank of China, the higher the total amount of the monthly credit supply of the people's Bank of China, the lower the loan risk. The influence of this variable is opposite to that of monthly repayment. The

reason may be that the total amount of credit monthly supply of the people's Bank of China is more based on the housing loan data. For customers with more monthly housing loan repayment, the default risk is relatively small, because the impact of default on individuals is greater than that of customers with less housing loan repayment or no housing loan.

8) for the third-party credit score variables, the higher the Wanxiang score, the lower the risk, and the higher the Tongdun score, the higher the risk.

9) variable of repayment interest rate, the lower the repayment interest rate, the lower the risk. Based on T company's loan policy, the lower the credit rating of customers, the lower the loan interest rate is given. As can be seen in Table 5-1, with the improvement of credit rating, the loan interest rate shows a downward trend.

To sum up, for high-risk loans, the sample shows that borrowers tend to be single and elderly, with a large proportion of men. In addition, borrowers with high-risk loans have lower proportion of driving licenses and higher MP level. Among the credit scores of other sources, the Wanxiang score of high-risk loan borrowers is lower, and the Tongdun score is higher, which all conform to the credit scoring system and rules. In addition, in each month of 2018, the credit rating of less than 586 points is level 1 and level 2, which are relatively high-risk borrowers. There are 2494 default loans and 20883 non default loans in this level, with a default rate of 11.94%. Those with a credit score of more than 586 are rated from level 3 to level 10, which are non high-risk borrowers. There are 94181 non defaulting loans and 2240 defaulting loans in this level, with a default rate of 2.37%. In the first six months of 2018, the high-risk borrowers was 17882, accounting for 76.49% of the total 23377 high-risk borrowers in the whole year, and only 23.51% in the second half of the year; while the total number of non-high-risk automobile borrowers was 24709 in January June, accounting for 25.63% of non-high-risk borrowers in 2018; and the proportion of non-high-risk borrowers in July December was 74.37%. It can be seen that T company is continuously optimizing T score and internal risk control, which is also a proof of T company's credit intermediary role.

Table 5-1 The average value of the variable varies with the trend of credit rating

Variable	1	2	3	4	5	6	7	8	9	10
PI										
Sex	0.167932417	0.316407925	0.339110715	0.370650264	0.325579484	0.327331962	0.326090237	0.341200441	0.434825381	0.523465704
Marriage	0.694513184	0.715155674	0.746497125	0.747012302	0.711737629	0.696073388	0.712162366	0.729179047	0.7487293	0.785714286
Age	36.45669426	35.96337593	35.67376691	35.43796134	34.49030084	33.3542524	33.35989135	33.22166568	32.5859977	32.71187898
Driver license	0.063230651	0.120078909	0.27626144	0.448945518	0.596005261	0.692644033	0.774181379	0.841752271	0.886702738	0.951091628
AC										
Monthly income	8992.859408	7750.972664	7556.332771	7667.724844	7559.355643	7601.344357	7801.221167	7711.097082	7990.790015	7761.60713
Monthly installment payment	2621.900674	2192.068702	2142.778165	2182.24007	2102.756863	2061.881259	2036.939867	1987.169879	1999.638383	1820.527677
Bank credit report	346.5428051	413.8246866	406.664778	490.920491	578.3902416	586.7049436	736.6190665	693.7663436	869.5802708	853.1521016
CS										

Variable	1	2	3	4	5	6	7	8	9	10
Wanxiang Score*	628.2817278	647.4734803	657.3669742	663.6023729	672.0372414	683.4696118	695.6149068	706.6177443	718.9422462	734.6741825
Tongdun Score*	49.62495065	24.39007092	14.73410028	8.308543756	5.183904867	3.931612903	2.717458359	2.274146777	1.672269764	1.082119337
ToL										
Interest rate	29.52683676	29.31992452	29.34340326	29.34973638	29.38837745	29.27349108	29.0140335	28.69776721	28.05902607	26.34528107

Table 5-2 below shows the average values of high-risk samples, non-high-risk samples and average total samples. We can see that for most variables, the average value of non-high-risk samples is closer to the total samples. In general, the mean difference shows that the borrowers for defaulted loans have a higher tendency than borrowers of non-defaulted loans of being single and older with a large proportion of males. There is not much difference in whether the borrowers have a driving license. Also, borrowers of defaulted loans have a high level of monthly installment payment. In their credit scoring from other sources, borrowers of defaulted loans have a lower Wanxiang score and a higher Tongdun score, which are in accordance with each of the credit scoring system and rules.

Table 5-2 Mean of defaulted loans and non-defaulted samples

Variable	Defaulted	Non-defaulted
PI		
Sex	0.167932417	0.366465891
Marriage	0.694513184	0.732191597
Age	36.45669426	34.07834865
Driving license	0.063230651	0.622745904
AC		
Monthly income	8992.859408	7714.423906
Monthly installment payment	2621.900674	2058.235111
Bank credit report	346.5428051	657.6015417
CS		
Wanxiang Score*	628.2817278	694.1721222
Tongdun Score*	49.62495065	4.897108856
ToL		
Interest rate	29.52683676	28.76062398

5.3 Logit Regression and Results

In this section, we did a Logit regression on four types of variables to see how much effect these variables would have on whether borrowers will default. Logit regression was proposed as an alternative model to OLS regression in the late 1960s and early 1970s, which is used to test the “hypotheses about relationships between a categorical outcome variable and one or more categorical or continuous predictor variables” (Peng, Lee, & Ingersoll, 2002). Logit regression is promoted because the relationship between a discrete variable and a predictor is non-linear. Similar to other regression models, Logit regression has several

assumptions.

Firstly, Logit regression assumes linearity of independent variables and log odds. Although Logit regression does not require the dependent and independent variables to be related linearly, it requires that the independent variables are linearly related to the log odds. Logit model is generally the model used for analyzing dependent variables that have only two possible outcomes. As for instance, in this research, the dependent variable -loan performance-only has two possible outcomes as defaulted or non-defaulted, Logit model is appropriate applied. For references, Li, Chen, and Zeng (2018) uses this model analyzing the credit scoring of P2P lending platforms in China,

Secondly, Logit regression requires there to be little or no multicollinearity among the independent variables. This means that the independent variables should not be too highly correlated with each other, though they are often correlated with each other on some levels. Referring to the correlation matrix in Appendix, we can see that, Age is significantly related to marriage with a correlation of 0.47, but it is not strong enough to cause any concerns or problems, as normally, values or correlation of 0.8 or more are considered to cause concerns. Therefore, we verify that multicollinearity is not a problem.

Thirdly, Logit regression requires the observations to be independent of each other, which means the observations should not come from repeated measurements or matched data. Since the sample is collected from each loan of individuals consumers', thus the observations are naturally independent of each other. Each observation stands for a different loan and each of the sample is unique, so it is not a repeated measurement.

Finally, Logit regression requires a large sample size. This model utilizes maximum likelihood estimate as its parameter estimation method, thus sufficient sample size is needed to ensure the accuracy of parameter estimation. Gao and Zhang (2018) mentioned two main ways to determine the sample size, which are events per variable (EPV) and sample size formulas proposed by Whittemore and Hsieh. EPV has been considered as the most frequently used method to decide the sample size. The logic behind EPV is that for every independent variable, we need to have at least 10 cases with the least frequent outcomes. Based on this, we have a total sample of 119,798, among which there are 115.064 non defaulted loans and 4.734 defaulted loans, so the default ratio is 3.95%, which is the least frequent outcomes. We use 10 independent variables to conduct the Logit regression and analysis. therefore, the sample size is determined by 10*10/3.95% to have 2532 samples. This verifies that we have sufficient samples.

To conduct the Logit regression, we add each type of variables to run the regression, and the results are listed in M1 to M4 respectively for each type of information. Firstly, a regression was performed on the total samples, and then the samples were divided into high-risk samples and non-high-risk samples for similar operations. The results can be seen in Table 5-3.

To begin with, let's take a look at the estimates of each types of variables in the total sample. We can see that the estimates for some variables are positive (variables include interest rate, loan amount, age, driving license and Tongdun Score*) while for some other variables (eg. marriage, sex, monthly income, bank credit rate and Wanxiang Score*), the signs are negative. In this case, the signs of positivity or negativity means that other variables being equal, the information that has a negative sign are less likely to cause a default of loans than the information with a positive sign. More specifically, in total sample, the estimates of marriage and sex are negative, indicating that borrowers' marital status and sex do not have much an impact on the default probability compared with the variables of interest rates, loan amount and borrowers' driving license. In addition, the estimates of monthly income and bank credit reports are both negative in the total sample. As for the two credit scoring systems, Wanxiang Score has less influence on default probability than Tongdun Score because the estimate of Wanxiang Score is negative.

Pseudo-R2 is used in Logit regression similar in the way as R2 used in linear regression, which tells the variation of model fit to the sample data. Pseudo-R2 indicates the level of fit of the model. In short, a higher Pseudo-R2 indicates a better model and a better fit of the model to the sample data. As we can see that from the bottom of each table, there is a Pseudo-R2 for each types of information. After introducing each type of information into the total sample, Pseudo-R2 increase gradually. Pseudo-R2 increases from 0.019 to 0.073 after introducing the four variables of private information, including age, marriage, sex and driving license. Pseudo-R2 increases from 0.073 to 0.081 after introducing two variables of asset conditions, namely monthly income and bank credit report. Pseudo-R2 increases from 0.081 to 0.116 after introducing two variables of credit scores (Tongdun Score* and Wanxiang Score*). The biggest increases can be found with the introduction of private information, among which variable driving license has made the biggest contribution with a positive sign and a large estimate. After that, Pseudo-R2 increases largely thanks to the marginal effect of Tongdun Score*.

The same pattern can be found in the non-high-risk sample, where the Pseudo-R2 increases from 0.008 to 0.045, to 0.054 and then to 0.079 respectively after introducing private information, asset conditions and credit scores in each step. In each case, the increase of Pseudo-R2 is much explained by adding the variable driving license and Tongdun Score* into the model. In short, in both samples here, variable driving license has the highest positive estimate, meaning that driving license has the most significant effect on the default rate compared with other information. As Table 4-1 shows, the default rate of the total sample is around 4%, which is close to the default rate of the non-high-risk sample as well. Therefore, the Logit regression analysis results are similar.

However, it is a different situation with the high-risk sample. As we can see from Table 4-1 that the default rate for high-risk sample (<573) is around 13.45%, which is very high. The interpretation is that the types of information that have affected the default rate of high-risk loans are different from those of the total sample and non-high-risk loans. In the high-risk sample, most estimates of the variables are negative except for variables interest rate, age, bank credit report and Tongdun Score*, indicating that only these four information items of borrowers are more likely to have effect on the default. In addition to that, the estimates of the variables are very low in numbers, meaning that the effects of the information on default is so limited, and among them, the Tongdun Score* has the most significant effect on the default rate of high-risk samples. It is obvious that the result is very different from the total sample and the non-high-risk samples about which information has more effect on the default rate.

For a range from 0 to1, the Pseudo-R2 for each sample is very low, especially with the high-risk samples. For the high-risk sample, the Pseudo-R2 is extremely low throughout the whole process, increasing from 0.003 to 0.008 to 0.010 and to 0.026. By adding each variable into the model, the increase of Pseudo-R2 is not very significant, indicating that the information has a weak fit to the data and is not strong enough to explain the default of high-risk sample. By comparing the Pseudo-R2, it is obvious that two types of information, namely driving license and Tongdun Score* have a much larger effect on borrowers' default probabilities. This supports the argument of part of H1, where personal information (in this case, the variable of driving license) has a much larger influence on borrower's default probabilities. The Pseudo-R2 of the total sample and the non-high-risk samples are much higher than those of the high-risk samples, indicating that for high-risk samples, there is other formation that remains unclear or undisclosed that has an effect on the default

probability. This support the argument of H3 that various type of information has stronger explanatory power on the credit scores of non-high-risk borrowers than those of high-risk samples.

Table 5-3 Effects of each type of public information on borrowers' default rate

	Total Sample				**High-risk sample**				**Non-High-Risk Sample**			
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
Interest rate	0.447 *** (19.370)	0.420 *** (17.848)	0.414*** (17.465)	0.411*** (17.057)	0.175** (3.131)	0.186*** (3.299)	0.189*** (3.350)	0.300*** (5.239)	0.323*** (12.183)	0.353*** (13.101)	0.368*** (13.570)	0.375*** (13.703)
Loan amount	0.562 *** (17.560)	0.633 *** (19.440)	0.681*** (20.362)	0.742*** (21.781)	-0.137 (-1.878)	-0.120 (-1.602)	-0.101 (-1.321)	0.071 (0.919)	0.363*** (9.237)	0.555*** (13.822)	0.640*** (14.994)	0.752*** (13.822)
Age		0.121 *** (8.734)	0.125*** (8.951)	0.160*** (11.259)		-0.120 (0.302)	0.002 (0.091)	0.065** (2.704)		0.131*** (7.458)	0.138*** (7.802)	0.131*** (7.458)
Married		-0.355 *** (-9.330)	-0.360*** (-9.432)	-0.358*** (-9.313)		-0.075 (-1.093)	-0.063 (-0.916)	-0.135 (-1.944)		-0.324*** (-6.930)	-0.338*** (-7.209)	-0.347*** (-7.359)
Sex		-0.576 *** (-16.749)	-0.516*** (-14.927)	-0.450*** (-12.881)		-0.056 (-0.731)	-0.079 (-1.032)	-0.164* (-2.113)		-0.449*** (-11.00)	-0.430*** (-10.497)	-0.413*** (-9.998)
Driving License		1.239 *** (37.439)	0.994*** (27.231)	1.022*** (27.874)		-0.577*** (-6.043)	-0.486*** (-4.747)	0.051 (0.448)		1.098*** (28.274)	0.913*** (22.196)	1.009*** (28.274)
Monthly income			-0.030* (-2.448)	-0.048*** (-3.832)			-0.028 (-1.540)	-0.058** (-3.160)			0.020 (1.138)	0.008 (0.432)
Bank Credit Report			-0.351*** (-14.378)	-0.494*** (-17.912)			0.141** (3.024)	-0.116* (-2.041)			-0.401*** (-13.792)	-0.524*** (-16.350)
Wanxiang Score*				-0.177*** (-15.736)				-0.039 (-1.166)				-0.173*** (-13.648)
Tongdun Score*				0.650*** (36.182)				0.325*** (9.827)				0.682*** (25.625)
Intercept	-10.521*** (-28.520)	-11.233*** (-29.817)	-11.307*** (-29.677)	-12.224*** (-31.520)	-0.784 (-0.914)	-0.373 (-0.424)	-0.641 (-0.721)	-3.438*** (-3.751)	-8.297*** (-18.405)	-10.489*** (-22.707)	-11.080*** (-23.295)	-12.532*** (-25.782)
Pseudo-R2	0.019	0.073	0.081	0.116	0.003	0.008	0.010	0.026	0.008	0.045	0.054	0.079

Note: *, **,*significant at 1%, 5% and 10% respectively**

5.4 Two-Stage Regression and Results

The Two -Stage Regression comprised of a first stage OLS regression and a second stage Logit Regression. As mentioned before, the two-stage regression is used to test the mediating role of auto financing companies using their credit scoring system. The first stage OLS regression tests whether there is additional information contained in auto financing companies' credit scores, which is represented by the residuals. The second stage Logit regression tests whether the additional information (residuals from the first step) of auto financing guarantee companies has significant power explaining the post-loan performance.

Similar to the assumptions of Logit regression, OLS regression also have some assumptions. Unlike the linearity assumptions of Logit regression, OLS assumes there is linear relationship between dependent variable and independent variables. Also, OLS assumes there is no multicollinearity. OLS regressions deals with the error terms, which assumes that the error term has a population mean of zero and is normally distributed.

Comparing the results of Pseudo-R2 in Table 5-4 below, we find significant impact of the four types of information on credit scores. Firstly, for the total sample results of model 1 to model 4, the Pseudo-R2 increases from 0.271 to 0.339 after introducing variable monthly income and bank credit report, then increases to 0.591 after introducing private information and finally increases to 0.782 after introducing variables of interest rate and loan amount. After introducing all the variables to the regression, Pseudo-R2 is about 0.782, meaning that about 22% percent of data cannot be explained by these four types of information, and there are other factors contained in T company' score to explain the rest 22%. From these results of Pseudo-R2, we calculated that the biggest increase happens after adding the private information into the model, which indicates that the private information, including variable age, marriage, sex and driving license has a much large weight deciding a borrowers' credit scores. In addition, we can see that one of the third-party scores and four variables of private information, ToL, including Tongdun Score, age, driving license, interest rate and loan amount, are negatively related to credit score, indicating that these variables of information have been used by the intermediary companies to deduct borrower's credit scores. This certifies that intuitively private information will be used as the most important criteria to collect information on borrowers' credit scores.

Model 5 to Model 12 show the results of the two-stage analysis of samples of high-risk loans and non-high-risk loans respectively. For high-risk loans, the Pseudo-R2 increases from 0.094 to 0.118 to 0.233 to 0.397, and for non-high-risk loans, the Pseudo-R2 increases from 0.236 to 0.281 to 0.515 to 0.735 after introducing each type of information into regression. We can see that the Pseudo-R2 for high-risk loans are much smaller than that for non-high-risk loans, which means that the explanatory power of each type of information on borrowers' credit score on high-risk loans are less than half of that on the non-high-risk loans. One explanation is that high-risk borrowers' information disclosure is much poorer than that for the non-high-risk loans, meaning that the non-high-risk borrowers have done much better in disclosing their information and their disclosed information has a higher quality of than that of the high-risk borrowers.

In the second-stage Logit regression, the dependent variable is default probability and the independent variable is the residuals, which represent the undisclosed information embedded in the credit scores. In the Logit regression, each type of information and variables are gradually included and during this second stage, the four types of formation are controlled. We can see from the results that in the last column of Table 5-5, in Model 1, Pseudo-R2 is 0.105, indicating that the residual of Wanxiang Score* and Tongdun Score* still contains a large amount of information about whether the default is predicted. In Model 2, 3 and 4, we can see that Pseudo-R2 is 0.086, 0.051 and 0.029 respectively, meaning that after introducing each types of information, each type of information can explain some default probability. Also, from the results of Pseudo-R2, it is clear that each type of variables contains similar information in predicting default probability, as the changes in Pseudo-R2 is around 0.03 in each round. Yet after all types of variables are removed from the T score, Pseudo-R2 is still around 0.029, which means that the residual still has explanatory power for the default and there is some potential information that are not identified for predicting default. There are two explanations for this result. Firstly, T score has extra information that has influences on default probability and secondly, T company's processing of this extra information as well as its T scores has its unique role when predicting default. This supports the argument of H2, that compared with commercial banks, T company's credit rating system contains extra information that has a stronger explanatory power of borrower's default probability, which shows the intermediary role of T company and other auto financing guarantee companies.

Table 5-4 Effects of public and undisclosed information on the default probability

	Total sample				**High-risk sample**				**Non-high-risk sample**			
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
Wanxiang Score*	8.597 (200.957)	7.346 (171.38)	5.802 (168.570)	6.136 (240.630)	1.438 (14.20)	1.204 (11.768)	1.521 (15.830)	1.934 (22.600)	6.435 (165.660)	5.931 (151.990)	5.091 (156.753)	5.653 (230.266)
Tongdun Score*	0.564 (5.683)	-2.061 (-21.02)	-3.680 (-46.860)	-3.793 (-66.230)	-2.833 (-34.260)	-3.313 (-36.812)	-4.916 (-51.130)	-6.218 (-70.350)	3.100 (31.290)	1.449 (14.580)	-0.287 (-3.451)	-0.424 (-6.892)
Monthly income		-0.876 (-14.54)	-0.821 (-17.290)	0.890 (25.150)		0.763 (14.795)	0.854 (17.640)	1.384 (31.390)		-1.892 (-31.980)	-1.701 (-34.942)	0.159 (4.296)
Bank credit report		10.560 (110.41)	5.114 (65.080)	5.085 (88.750)		1.214 (7.307)	1.631 (10.270)	2.242 (15.860)		7.200 (81.370)	3.601 (48.033)	4.208 (75.917)
Age			-2.794 (-54.250)	-2.826 (-75.270)			-1.701 (-26.410)	-2.129 (-36.940)			-2.138 (-41.793)	-2.360 (-62.416)
Marriage			6.337 (47.350)	7.716 (78.980)			4.013 (21.450)	5.693 (33.740)			5.050 (38.757)	6.745 (69.915)
Sex			13.505 (117.820)	14.951 (178.540)			4.206 (20.640)	6.353 (34.400)			11.057 (99.697)	13.612 (164.885)
Driving License			-29.483 (-249.590)	-28.002 (-324.680)			-9.657 (-26.730)	-11.937 (-36.970)			-24.624 (-214.879)	-25.317 (-298.819)
Interest rate				-11.613 (-222.730)				-4.831 (-35.850)				-11.151 (-222.428)
Loan amount				-22.55 (-257.360)				-9.530 (-50.210)				-20.339 (-228.007)
Adjusted-R2/Pseudo-R2	0.271	0.339	0.591	0.782	0.094	0.118	0.233	0.397	0.236	0.281	0.515	0.735
(Intercept)	-3.559 (-182.940)	-3.491 (-187.000)	-3.366 (-196.280)	-3.285 (-204.800)	-1.879 (-68.015)	-1.877 (-68.042)	-1.877 (-68.023)	-1.875 (-68.063)	-3.801 (-165.520)	-3.745 (-169.700)	-3.631 (-180.070)	-3.568 (-187.030)

	Total sample				High-risk sample				Non-high-risk sample			
Adjusted-R2/Pseudo-R2 (Logit Regression)	0.105	0.086	0.051	0.029	0.014	0.013	0.013	0.012	0.072	0.059	0.033	0.018

Note: All estimates have a significance level of 1% with three ***

5.5 Robustness Tests

Stratified sampling method is used to test robustness and the results can be found in Table 5-5 below. Stratified sampling means to divide the study population up into subgroups in order to select a stratified sample. Stratified sampling is used because we want to see if the selected small group within the population is adequate to represent the sample and show the same results as the large group. Default is the stratification variable, where 1 denotes for defaulted and 0 denotes for non-defaulted. Before stratified sampling, the total sample is 119653, among which the "1" sample is 4727 and the "0" sample is 114926. The high-risk sample is 11633 and the low-risk sample is 108020. After stratified sampling, the total sample is 54727, among which the "1" sample is 4727, and the "0" sample is 50000. The high-risk sample is 5954 and the low-risk sample is 48773.

The stratified sample results show that Pseudo-R2 increases from 0.026 to 0.096 to 0.105 and then to 0.150. The largest increases of Pseudo-R2 happens when introducing private information and the third-party scores into the model. Among the variables in private information and credit scoring systems, variable driver license and Tongdun Score* have the largest contributions to the increases in Pseudo-R2. This stratified sample show a same pattern as the total sample, high-risk sample and non-high-risk samples, indicating that the Logit regression results are robust.

Table 5-5 Logit regression analysis and results, stratified sampling

			Total stratified sample			Stratified high-risk sample			Stratified non-high-risk sample			
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
Interest rate	0.454*** (19.220)	0.430*** (17.686)	0.424*** (17.312)	0.415*** (16.581)	0.198** (3.290)	0.207*** (3.408)	0.210*** (3.453)	0.319*** (5.134)	0.328*** (12.187)	0.359*** (13.035)	0.374*** (13.445)	0.376*** (13.353)
Loan amount	0.589*** (17.610)	0.666*** (19.315)	0.715*** (20.152)	0.791*** (21.663)	-0.088 (-1.106)	-0.077 (-0.942)	-0.064 (-0.764)	0.107 (1.251)	0.382*** (9.433)	0.574*** (13.799)	0.664*** (14.943)	0.789*** (17.149)
Age		0.118*** (8.153)	0.121*** (8.333)	0.157*** (10.586)		-0.000 (-0.008)	-0.006 (-0.238)	0.057* (2.217)		0.129*** (7.134)	0.136*** (7.487)	0.164*** (8.937)
Marriage		-0.331*** (-8.349)	-0.333*** (-0.841)	-0.334*** (-8.301)		-0.075 (-1.014)	-0.062 (-0.834)	-0.131 (-1.740)		-0.298*** (-6.202)	-0.311*** (-6.445)	-0.318*** (-6.552)
Sex		-0.568*** (-15.970)	-0.510*** (-14.243)	-0.435*** (-11.941)		-0.049 (-0.591)	-0.075 (-0.894)	-0.138 (-1.638)		-0.440*** (-10.521)	-0.422*** (-10.033)	-0.401*** (-9.428)
Driving License		1.239*** (36.4280)	0.999*** (26.658)	1.037*** (27.167)		-0.573*** (-5.341)	-0.455*** (-3.976)	0.087 (0.680)		1.097*** (27.581)	0.913*** (21.689)	1.010*** (23.503)
Monthly income			-0.025 (-1.930)	-0.043** (-3.230)			-0.018 (-0.947)	-0.047* (-2.365)			0.021 (1.140)	0.005 (0.284)
Bank credit report			-0.351*** (-13.891)	-0.494*** (-17.177)			0.169** (3.263)	-0.098 (-1.569)			-0.404*** (-13.490)	-0.522*** (-15.798)
Wanxiang Score*				-0.186*** (-15.898)				-0.045 (-1.223)				-0.179*** (-13.691)
Tongdun Score*				0.666*** (33.771)				0.330*** (8.830)				0.681*** (24.516)

			Total stratified sample			Stratified high-risk sample			Stratified non-high-risk sample			
Pseudo-R2	0.026	0.096	0.105	0.150	0.003	0.011	0.013	0.034	0.012	0.058	0.069	0.102
Sample number	54727	54727	54727	54727	5954	5954	5954	5954	48773	48773	48773	48773

Note: *,**,*significant at 1%, 5% and 10% respectively**

Stratified sampling method is used to test robustness and the results can be found in Table 5-6 below. According to the results, in the first stage OLS regression analysis, Pseudo-R2 increases from 0.27 to 0.345, to 0.596 and then to 0.786, after introducing each types of information into the model respectively. We can see that the biggest increase happens when Pseudo-R2 increases from 0.345 to 0.596 after introducing private information into the model, meaning that private information has the largest influence on T company's credit scores. Also, after all four types information haven been included in the model, the Pseudo-R2 is 0.786, meaning that there are still about 22% of model cannot be explained by these four types of information, thus T company's credit system still has some undisclosed information that has influence on credit scores.

In the second-stage Logit regression, the results of Pseudo-R2 show an decreasing trend from 0.133 to 0.107 to 0.062, and then to 0.034 in each step. After introducing each types of information into the Logit model, the decreasing trend of Pseudo-R2 meaning that these four types of information can explain some of the default probabilities. After all, four types of information has been included, we still generate a Pseudo-R2 of 0.034, meaning that there are still some part of the default probability cannot be explained by the four types of information and T company has some undisclosed information that is not identified for predicting default. The robustness tests are in accordance with the two-stage regression analysis, indicating that the two-stage regression analysis is robust.

Table 5-6 The results of two-stage regression, stratified sample

	Total stratified sample				High-risk sample				Non-high-risk sample			
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
Wanxiang Score	8.883 (137.555)	7.473 (115.917)	5.867 (113.458)	6.191 (161.64)	1.392 (9.46)	1.172 (7.942)	1.501 (10.830)	1.937 (15.750)	6.496 (111.030)	5.937 (101.325)	5.088 (104.411)	5.660 (153.289)
Tongdun Score	-0.355 (-2.435)	-3.136 (-21.921)	-4.610 (-40.291)	-4.634 (-55.58)	-2.820 (-24.030)	-3.398 (-26.289)	-5.033 (-36.449)	-6.385 (-50.580)	2.626 (17.840)	0.878 (5.961)	-0.829 (-6.724)	-0.940 (-10.302)
Monthly income		-0.705 (-7.885)	-0.661 (-9.398)	1.045 (19.95)		0.758 (10.154)	0.862 (12.308)	1.395 (22.010)		-1.931 (-21.796)	-1.699 (-23.317)	0.230 (4.138)
Bank credit report		11.351 (78.499)	5.558 (46.752)	5.440 (62.8)		1.541 (6.368)	1.961 (8.485)	2.576 (12.590)		7.693 (57.503)	3.906 (34.435)	4.480 (53.346)
Age			-2.843 (-37.185)	-2.876 (-51.64)			-1.833 (-19.743)	-2.245 (-27.190)			-2.124 (-27.834)	-2.380 (-42.147)
Marriage			6.155 (30.842)	7.495 (51.50)			4.037 (14.927)	5.604 (23.160)			4.871 (25.017)	6.550 (45.370)
Sex			13.913 (80.902)	15.188 (121.05)			4.294 (14.406)	6.533 (24.320)			11.275 (67.743)	13.740 (110.839)
Driving License			-29.866 (-169.016)	-28.214 (-218.79)			-9.543 (-18.815)	-12.142 (-26.860)			-24.763 (-144.564)	-25.381 (-200.146)
Interest rate				-11.649 (-148.96)				-5.261 (-27.000)				-11.134 -147.963)
Loan amount				-23.004 (-174.99)				-10.076 (-36.430)				-20.580 (-152.950)

	Total stratified sample				High-risk sample				Non-high-risk sample			
Sample number	54727	54727	54727	54727	5954	5954	5954	5954	48773	48773	48773	48773
Pseudo-R2	0.270	0.345	0.596	0.786	0.092	0.117	0.233	0.403	0.231	0.281	0.516	0.735
Pseudo-R2 (Logit Regression)	0.133	0.107	0.062	0.034	0.019	0.018	0.018	0.015	0.092	0.075	0.042	0.023

Note: All estimates have a significance level of 1% with three ***

Chapter 6: Conclusion and Prospect

6.1 Main conclusions

The first objective of this study is to examine the credit scoring systems of the auto financing industry and the second objective is to analyze the intermediary role of the auto financing guarantee companies in China. Based on these two objectives, we offered three hypotheses. The first hypothesis is that compared with asset conditions, certifications and other types of information, personal information and loan information have much larger influences on borrowers' default probabilities. The second hypothesis is that compared with the public information such as the personal characteristics, asset status and credit history of the borrowers that are used by commercial banks to assess borrowers' risks, T company has other undisclosed information that provide them with a stronger explanatory power on the default probabilities of the borrower. The third hypothesis is that compared with high-risk borrowers, various kinds of information have stronger explanatory power on the credit scores of non-high-risk borrowers.

To test these hypotheses, two regression analysis are conducted, namely the Logit regression analysis and the two-stage regression analysis. The Logit regression analyzes the influence of each types of information on borrowers' default probabilities and the two-stage regression aims to examine the intermediary role of auto financing guarantee companies. The two-stage regression analysis is mainly designed to test the mediating role of auto financing companies, by controlling and eliminate the personal information, pubic available information and the third party scores to see whether there is undisclosed information merely available to the auto financing guarantee companies and whether the undisclosed information can significantly explain the default of non-default behaviors of borrowers. With the 119,798 samples of loans collected from T company, four types of information are analyzed, including personal information, asset conditions, third-party credit scoring systems and terms of loans.

The regression results supported the argument of the three hypotheses. The main conclusions are that personal information, especially driving license and terms of loans have a much larger influences on borrowers' default probabilities than other types of information. The two-stage regression results show that after eliminating the effects of personal information, public available information and the third-party credit scores, T company's credit rating system contains extra information and evaluation factors that have a stronger explanatory power on

borrowers' default probabilities. This means that T company plays an intermediary role by providing credit scores and evaluation services that lead to final decisions made by financial institutions. Moreover, the various types of information have a much larger explanatory power on the credit scores of non-high-risk borrowers than they have on the high-risk borrowers.

To sum up, based on the conclusions of empirical analysis and theoretical model test, combined with the contents of each chapter, the main management implications are as follows:

(1) Before the loan: first, after assessing the profit and risk preference of the auto loan business, the financial entities with low risk preference can choose the financing guarantee institution as the intermediary of auto loan. For example, similar financing guarantee companies as T company master other undisclosed information, which can explain the borrower's default more effectively and is also the embodiment of its intermediary role. Secondly, in the process of business acceptance, auto loan institutions should strictly manage and require the business manager to provide the borrowers ' personal information, especially the driving license information, because it has the largest effect on borrowers' default probability. Finally, financing guarantee institutions should effectively distinguish customers by credit score similar to T score and take different risk management measures for different scores of borrowers, from refusing loans to reducing loan interest rate, so as to reduce default risk, and effectively conduct pre loan investigation and evaluation through credit evaluation.

(2) In the process of loan: first, the bank financial entities use financing guarantee institutions as loan intermediary and can refer to their credit scoring system for appropriate decentralization. Second, the auto loan institutions can use third-party credit scoring systems such as T score, combined with their own risk control means, to assess the comprehensive default risk of the borrowers. Finally, based on the requirements of COSO (2017) for risk management, the financing guarantee institutions adjust the loan requirements of the borrowers using credit score, because the impact of loan conditions on the borrower's default probability is more significant than other types of information.

(3) Post loan: because all kinds of information can explain the credit score of non-high-risk borrowers much better than that of high-risk borrowers. Therefore, in the post loan processing, the credit score is used to manage the borrowers by category. There is different vehicle supervision, post loan inspection, post vehicle service and risk early warning measures for different risk level customers. In particular, the supervision of high-risk customers should

be stricter and timelier. When default happens, the borrowers of different risk categories should be identified, and the loan call and disposal should be targeted.

This thesis studies the credit scoring and intermediary function of auto financing guarantee institutions, answers the question as why banks choose financing guarantee institutions for auto loan intermediary, and clarifies the effectiveness and intermediary function of their credit scoring. It provides a practical solution to the credit scoring and intermediary problems of China's auto credit business, especially the financing guarantee institutions.

6.2 Research limitations

Based on the theory of credit scoring, econometric theory, risk management and other economic theories, this research summarizes, rethinks and draws lessons from the latest research on credit rating and intermediary role of China's financing guarantee institutions. Through the combination of empirical analysis and theoretical modeling, the Logit model is used to evaluate the internal T score of T company, and a two-stage model is used to analyze the intermediary role of the financing guarantee institutions, represented by T company. Although this research draws some valuable conclusions, which are of practical significance for the establishment and improvement of China's auto loan credit rating and intermediary mechanism of financing guarantee institutions, there are still some deficiencies in the research, and there are many aspects for researchers to be further explored and discussed in the future.

First, there are limitations in the study sample. The research method adopted in this research is a single case study. Although the selected case, company T, is a representative and typical case of China's auto loan financing guarantee institutions, it is only a case and itself has limitations to represent the whole industry. Different auto financing guarantee institutions have different processes and stages. The insurance industry still needs further discussion. In addition, there are many different financial guarantee institutions serve the intermediary roles in auto financing, such as auto financing companies, financial leasing companies and network platforms. They have the same credit rating and financing guarantee problems, but the management system between the major players in auto finance is very different from the borrowers' needs, especially in the design of auto loan products and the requirements of guarantee. The questions remain as whether the conclusions of this research could be extended to China's auto loan financing guarantee industry.

Secondly, the limitations lie in the mismatch between the development of borrowers information and credit score. This research spent a lot of time and energy to collect and sort out 119,798 loan data of T company in 2018, use T score for credit scoring, and the first-hand data obtained basically meets the needs of research. However, T company's credit score is also constantly improving with the passage of time, the borrower is also constantly changing, the cooperative banking financial subjects and auto dealers are also constantly adjusting, the development strategy of T company in each stage is different, and the requirements for credit score are evolving. This research uses a set of credit scoring standards and borrower information, ignoring the fact that over time credit scores change, the demand of car purchase by the borrower and the demand of the market for the financing guarantee institution have certain limitations from a practical point of view.

Finally, this research is only based on the empirical research and data analysis of the financing guarantee institutions in the automobile financial credit institutions, and the samples and sources of the data have certain limitations. The application of credit scoring model, analysis of risk causes, risk types of default, risk prevention and control, and suggestions on regulatory measures are all limited to specific conditions and market subjects, which cannot be considered comprehensively. There are inevitably many deficiencies and omissions, which are also the areas to be improved and further studied in the future.

6.3 Discussion and Prospect

The development of China's automobile consumption loan industry is becoming more and more mature and standardized, and the competition is becoming more and more fierce. No matter the bank financial subject or the financing guarantee company and other intermediary institutions, the management of loan risk is gradually changing from simple and extensive to professional and fine. When the real personal credit system is established, a series of problems of credit scoring and intermediary effect will follow the research on China's automobile loan credit rating and the intermediary role of financing guarantee institutions will gradually become one of the research hotspots in this field. We believe that in the near future, the research on this field will continue to emerge. The research in this research is just to draw lessons from others, but it needs to be further improved and deepened in the future. For example, the credit scoring system mentioned in this research can still be further improved, such as the ability of financing guarantee company as an intermediary to cope with market changes and complex environment,

which are not considered in this study. On the other hand, this research only studies the evaluation effect of T score, and how to use credit score to manage the loan risk is a continuous optimization system engineering, how to use the COSO (2017) management framework to manage the risk of financing guarantee companies and other automobile institutions, which is also one of the main directions of follow-up research. In addition, as an intermediary after the establishment of its own credit rating system, how to effectively transfer and share the bank financial subjects and other financial institutions, as well as the profit distribution after the transfer and other issues are not studied in detail in this research. On the other hand, the lack of existing research also shows that there is still a lot of room for further research in this field We should also strive to improve and deepen the research results on the basis of this research. We believe that the research results will play a certain role in promoting the system construction and management practice of China's auto finance industry.

Bibliography

Aizcorbe, A. (1997). *Vehicle Ownership, Vehicle Acquisitions and the Growth of Auto Leasing: Evidence from Consumer Surveys.* America: Federal Reserve Board.

Antzoulatos, A. A. (1996). Consumer credit and consumption forecasts. *International Journal of Forecasting*, 12(4), 439-453

Aunders, B. & Anthony, D. (2000). *Financial Institutions Management*. New York: McGraw-Hill.

Ba, S. S. & Wang, C. (2005). Automobile consumer credit market: risk control and game theory. *Journal of Hangzhou Institute of finance*, 3, 17-21. (in Chinese).

Ba, S. S. (2003). Measurement of operational risk and capital restraint under the framework of the new capital accord. *Economic theory and economic management*, 2, 17-24. (in Chinese).

Ba, S. S., Xing, Y. J., & Zhu Y. Q. (2010). *Basel New Capital Accord in the Financial Crisis: Challenges and Integration*. Beijing: China Financial Press.

Baesens, B., Gestel, T., & Viaene, S. (2003). Benchmarking state-of-the-art classification algorithms for credit scoring. *Journal of the operational research society*, 54 (6), 627-635.

Banner, P. H. (1958). Competition, credit policies and the captive finance company. *The Quarterly Journal of Economics*, 72 (2), 5.

Belhumeur, P. N., Kriegman, D., & Yuille, A. (1999). The bas-relief ambiguity. *International Journal of Computer Vision*, 35, 33-44.

Bellotti, C. J. (2008). Support vector machines for credit scoring and discovery of significant features. *Expert Systems with Applications*, 36 (2), 3302-3308.

Cao, J. (2008). *Personal credit risk control model of commercial banks based on artificial neural network.* Doctorial Thesis, Beijing University of Chemical Technology.

Carroll, D. C. (1992). How does future income affect current consumption?. *The Quarterly Journal of Economics*, (109), 111-147.

Chang, Z. F. (2018). *Research on the construction of Internet financial credit system and risk management*. Doctorial Thesis, Nanjing University.

Chemmanur, T. J. & Wilhelm, W. J. (2002). New technologies, financial innovation, and intermediation. *Journal of Financial Intermediation*, 11 (1), 2-8.

Chen, D. S. (1991). A distinctive work on the history of economics. *Economic Review*, (01), 2. (in Chinese).

Chen, G. H., Liu, Z. Y., & Liu, L. J. (2006). Risk measurement is the key to credit risk management of commercial banks. *Shenzhen Finance*, 06 (7), 45-48. (in Chinese).

Cheng, B. & Titterington, D. M. (1994). Neural networks: A review from a statistical perspective. *Statistical Science*, 9, 2-30. (in Chinese).

China Automobile Dealers Association. (2019). *China Automobile Distribution Industry Report* (No.2018-2019). Beijing, China Automobile Dealers Association.

China Automobile Dealers Association. (2019). *Used Car Industry* (No.2019). Beijing, China

Automobile Dealers Association.

Commons, J. R. (1961). *Institutional Economics.* London: University of Wisconsin Press.

Cui, J. (2005). *Personal credit risk assessment of commercial banks*. Doctorial Thesis, Tianjin University.

Dasgupta, S., Siddarth, S. M., & Silva, R. J. (2007). Lease or buy?: A structural model of the vehicle acquisition decision. *Journal of Marketing Research*, 44 (3), 490-502.

Davis, S. & Albright, T. (2004). An investigation of the effect of balanced score car implementation on financial performance. *Management Accounting Research*, 04 (15), 135-153.

Desai, V. S., Crook, J. N., & Overstreet, G. A. (1996). A comparison of neural networks and linear scoring models in the credit union environment. *European Journal of Operational Research*, 95 (1), 24-37.

Ding, Z. G. (2014). *Finance.* Beijing: China Machine Press.

Du, Y. S. (2014). *Study on the segmentation of credit card consumer market.* Doctorial Thesis, Beijing University of technology.

Duca, J. V. (2000). Financial technology shocks and the case of the missing m2. *Journal of Money Credit & Banking*, 32 (4), 820-839.

Duffie, D. & Rahi, R. (1995). Financial market innovation and security design: An introduction. *Journal of Economic Theory*, 65 (1), 1-42.

Durand, D. (1941). *Risk elements in consumer installment financing*. New York: National Bureau of Economic Research.

Einav, L., Jenkins, M., & Levin, J. (2013). The impact of credit scoring on consumer lending. *RAND Journal of Economics*, 44 (2), 249-274.

Fisher, I. (1963). *Interest Theory*. Shanghai: People's Publishing House.

Fisher, R. A. (1936). The use of multiple measurements in taxonomies problem. *Annuals of Eugenie*, 36(7), 179-188.

Fitzpatrick, D. B. (1976). An analysis of bank credit card profit. *Bank Reviews*, 7, 199-205.

Fogarty, I. (1993). Evolving Bayesian classifiers for credit control—a comparison with other machine-learning methods. *IMA Journal of Management Mathematics*, 93 (5), 63-75.

Frame, W. S. & White, L. J. (2004). Empirical studies of financial innovation: Lots of talk, little action?. *Journal of Economic Literature*, 42 (1), 116-144.

Freed, N. & Glover, F. (1986). Evaluating alternative linear programming models to solve the two-group discriminant problem. *Decision Science*, 17(2), 151-162.

Gao, J. M. & Li, M. (2019). Risk management model construction of China's commercial banks based on the new COSO (2017) framework. *Business accounting*, 000 (06), 41-44. (in Chinese).

Gao, Y. & Zhang, J. (2018). Determination of sample size in logistic regression analysis. *The Journal of Evidence-Based Medicine*, 18 (2), 122-124. (in Chinese).

George, A. (1970). The market for lemon: Quality uncertainty and the market mechanism. *Quarterly Journal of Economics*, 70(8), 488-500.

Govaerts, M. J. (1989). A credit scoring model for personal loans. *Insurance Mathematics and Economics*, 98, 31-34.

Grinblatt, M. & Longstaff, F. A. (2000). Financial innovation and the role of derivative securities: An empirical analysis of the treasury STRIPS program. *Journal of Finance*, 55 (3), 1415-1436.

Gu, H. F. (2012). Institutional financial innovation and the development of financing guarantee system for small and medium-sized enterprises in China. *Nanfang finance*, 12(3), 18-22. (in Chinese).

Guo, G. M. (2017). *Research on user credit profile based on social big data*. Doctorial Thesis, University of Science and Technology of China.

Guo, M. (2006). Game Analysis of personal automobile consumption credit behavior. *Contemporary Manager*, (7), 59-60. (in Chinese).

Han, S. & Li, J. R. (2016). Research on the development risk of China's financing guarantee industry at this stage and suggestions. *Bond*, 15(02), 55-60. (in Chinese).

Hand, D. J. & Henley, W. E. (1997). Statistical Classification Methods in Consumer Credit Scoring: A Review. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 160 (3), 523-541.

Harris, D. (2010). Risk-based pricing of interest rates for consumer loans. *Journal of Monetary Economics*, (53), 229-245.

Hart, O. (1996). *Firms, Contracts, and Financial Structure.* Oxford: Clarendon Press.

Hassler, J. (2001). Uncertainty and the timing of automobile purchase. *The Scandinavian Journal of Economics*, 103 (2), 351-366.

Hawtreg, R. G. (1947). *On the Operation of the Central Bank*. Chicago: World book office.

Hellmann, T. F., Murdock, K. C., & Stiglitz, J. (1997). *Financial Restraint: Toward a New Paradigm.* Oxford: Clarendon Press.

Henley, W. E. (1995). *Statistical aspects of credit scoring.* Doctorial Thesis, The Open University.

Hirshleifer, J. (1958), On the theory of optimal investment decision. *Journal of Political Economy*, 58(66), 329-352.

Holland, J. H. (1992). *Adaptation in Natural and Artificial Systems: An Introductory Analysis with Applications to Biology, Control and Artificial Intelligence.* Massachusetts: MIT Press.

Hong, C. W. (2018). *Research on the impact of financial innovation on monetary demand*. Doctorial Thesis, University of Foreign Economic and Trade.

Hu, M. (2007). *Application of data mining technology in personal credit risk prediction and control*. Doctorial Thesis, Xiamen University.

Huang, H. Z., Zhou, Z. F., & Yu, J. K. (2010). ILMBP neural network model and its application in personal credit evaluation. *Management Scientist*, 10(10), 1-3. (in Chinese).

Huang, L., Ni, M., & Sun, F. S. (2005). On the financing and social functions of credit guarantee institutions: Theory and case study. *Financial Research*,05 (3), 183-187. (in Chinese).

Iyer, R., Khwaja, A. I., Luttmer, E. F. P., & Shue, K. (2016). Screening peers softly: Inferring the quality of small borrowers. *Management Science*, 62 (6), 1554-1577.

Jiang, L. (2006). Review of FICO scoring system in the United States. *Business Research*, (20), 81-83. (in Chinese).

Jiang, M. (2003). *Research on the calculation model and algorithm optimization of credit risk control of commercial banks*. Doctorial Thesis, Central South University.

Jiang, M. H. (2006). *Research on the combination forecasting method of personal credit evaluation of commercial banks.* Doctorial Thesis, Harbin University of technology.

Jiang, P. (2011). A study on the market structure of financing guarantee for small and medium-sized enterprises in China from the perspective of market concentration and product differentiation. *Journal of Central University of Finance and Economics*, 11(6), 46-50. (in Chinese).

Lai, H. (2017). *Research on credit risk of personal credit in the context of new personal loan*. Doctorial Thesis, University of Electronic Science and Technology.

Leonard, K. J. (1995). The development of a rule based expert system model for fraud alert in consumer credit. *European Journal of Operational Research*, 80 (2), 350-356.

Li, D. (2018). Analysis on the development of auto finance business of commercial banks. *Business economy*, (02), 163-164. (in Chinese).

Li, G. R. & Li, H. (2010). Successful experience of auto financial service construction in developed countries. *Beijing Car*, 10(02), 32-36. (in Chinese).

Li, H. Y. (2018). *Research on transmission mechanism and effectiveness evaluation of consumer credit policy*. Doctorial Thesis, Southwest University.

Li, Q., Chen, L., & Zeng, Y. (2018) The mechanism and effectiveness of credit scoring of P2P lending platform: Evidence from Renrendai.com. *China Finance Review International*, 8 (3), 256-274. (in Chinese).

Li, S. G. (2003). Application of neural network in consumer credit rating. *Technical economy*, (3), 50-52. (in Chinese).

Li, W. C., Song, D. M., & Chen, B. (2006). Artificial neural network based on genetic algorithm. *Computer Engineering and Design*, 27 (2), 316-318. (in Chinese).

Li, X. G. (2004). *Credit Theory*. Beijing: Founder press of China.

Li, Y. N. (2019). Structural adjustment and private enterprise innovation. *New Economy Guide*, (01), 8-10. (in Chinese).

Liao, L., Li, M. G., & Wang, Z. W. (2014). Research on regional discrimination of Internet Finance in China. *Quantitative Economy and Technological Economy*, (5), 54-70. (in Chinese).

Liu, C. (2010). *Research on credit scoring theory and application*. Doctorial Thesis, Hunan University.

Liu, J. Y. (2016). Analysis on the credit risk of China's automobile finance. *China Business Theory*, (03), 68-70. (in Chinese).

Liu, X. G., Zhang, M. Y., & Tong, J. (2007). The game relationship between banks and insurance companies in automobile consumer credit. *Productivity Research*, (18), 53-55. (in Chinese).

Liu, X. P. (2017). *Credit structure, credit efficiency and economic growth*. Doctorial Thesis, Zhejiang University.

Liu, X. Y. (2015). Exploration of financing guarantee mode -- Taking Anhui as an example. *China Finance*, (20), 91-93. (in Chinese).

Liu, Y. (2008). *Credit, contract and civilization.* Doctorial Thesis, Southwest University of Finance and Economics.

Liu, Y. Y. (2017). Current situation, problems and development suggestions of automobile consumption credit business of commercial banks. *Southwest Finance*, (02), 53-57. (in Chinese).

Lucas, D. (1992). Updating scorecards: Removing the mystique. *In Credit Scoring and Credit Control*, 138-147.

Luo, K. W. (2005). Measurement of probability of default: Key to credit risk management of commercial banks. *China Finance*, 06, 51-52. (in Chinese).

Luo, W. C. (2004). *Research on the credit scoring method of national student loan*. Doctorial Thesis, North University of technology.

Luo, Z. H. & Song, J. Y. (2015). Study on the system reconstruction of financing guarantee business in China -- Based on the investigation of financing guarantee business in Sichuan Province. *Southwest Finance*, (02), 3-6. (in Chinese).

Ma, B. J. & Mao, Y. S. (2007). Asset specificity and transaction cost saving -- on enterprise as the carrier of credit. *Economic Journal*, (03), 81-84. (in Chinese).

Makowski, P. (1965). Credit Scoring Branches Out. *The Credit World*, 75, 30-37.

Malhotra, D. K. (2003). Evaluating consumer loans using neural networks. *Omega*, 31 (2), 83-96.

Michalewicz, Z. (1996). Evolutionary algorithms for constrained parameter optimization Problems. *Evolutionary computation*, 4, 1-32.

Morton, H. (2011). Municipal credit rating modelling by neural networks. *Decision Support Systems*, 51 (1), 108-118.

Myers, J. H. & Forgy, E. W. (1963). The development of numerical credit evaluation systems. *Journal of the American Statistical Association*, 58 (303), 799-806.

Niu, D. Y. (2008). *Research on the construction of automobile financial service professional organization by independent brand automobile group*. Doctorial Thesis, Harbin Engineering University.

Orgler, Y. (1970). A credit scoring model for commercial loans. *Journal of Money*, 2, 435-445.

Ouyang, R. P. (2000,). *The theory of symbiosis of justice and profit: a study of Chinese enterprise ethics.* Changsha: Hunan people's publishing house.

Pang, S. L., Li, R. Z., & Xu, J. M. (2005). Application of BP algorithm in credit risk analysis. *Control Theory and Application*, 22 (01), 139-143. (in Chinese).

Peng, J., Lee, K. L., & Ingersoll, G. M. (2002). An introduction to logistic regression analysis and reporting. *The Journal of Educational Research*, 96 (1), 3-14. (in Chinese).

Robert, P. S. (1963). The Price of New Automobile Financing. *The Journal of Finance*, 19 (2), 205-221.

Rosenberg, E. & Gleit, A. (1994). Quantitative methods in credit management: A survey. *Operations Research*, 42, 589-613.

Ross, L. (1997). Financial development and economic growth: View and agenda. *Journal of Economic Literature*, (35), 688-726.

Schebesch, K. B. & Stecking, R. (2005). Support vector machines for classifying and describing

credit applicants: Detecting typical and critical regions. *Journal of the Operational Research Society*, 56, 1082-1088.

Schumpeter, J. A. (1911). *Theory of Economic Development.* Cambridge: Harvard University Press.

Shen, C. H. (2004). *Research on personal credit evaluation method in consumer credit based on support vector machine*. Doctorial Thesis, China Agricultural University.

Sheng, S. C. & Zhai, C. (2015). *Central Bank and Money Supply.* Beijing: China Financial Press.

Shi, Q. Y. & Jin, Y. H. (2003). Summary of main models and methods of personal credit scoring. *Statistical Research*, 20 (8), 36-39. (in Chinese).

Shi, Y., Peng, Y., Xu, W. X., & Tang, X. W. (2002). Data mining via multiple criteria linear programming: applications in credit card portfolio management. *International Journal of Information Technology & Decision Making*, 1 (1), 131-151. (in Chinese).

Shiller, R. J. (2012). *Finance and the Good Society*. Princeton: Princeton University Press.

Shu, Y. & Yang, Q. Y. (2017). Research on default prediction of auto loan based on large sample data model. *Management Review*, 29 (09), 59-71. (in Chinese).

Shuai, L. (2015). *Research on the theory and method of personal credit risk assessment.* Doctorial Thesis, University of Electronic Science and technology.

Song, C. & Ding, W. (2007). The relationship between enterprise risk management and internal control. *Academic Exchange*, (02), 93-96. (in Chinese).

Song, Y. (2001). Establishment of credit system and improvement of restraint mechanism. *Journal of Beijing Institute of Finance and Trade Management*, (01), 21-24. (in Chinese).

Stiglitz, J. E. & Weiss, A. (1981). Credit rationing in markets with imperfect information. *American Economic Review*, 17, 393-410.

Stiglitz, J. E. (2012). *The Price of Inequality.* London: Penguin Books.

Sun, L. (2008). *Economic analysis of the evolution of credit system*. Doctorial Thesis, Southwest University of Finance and Economics.

Wang, C. H. (2019). Discussion on the relationship between enterprise financial risk management and internal control. *Taxation*, 13 (07), 94-95. (in Chinese).

Wang, J. Y. & Wang, J. T. (2003). Research on personal credit decision-making model based on possibility satisfaction method. *System Engineering*, 21 (3), 113-117. (in Chinese).

Wang, L, Zheng, Z. R., & Hao, J. X. (2005). Application of BP neural network in credit risk assessment. *Journal of Taiyuan University of Technology*, 2, 216-219. (in Chinese).

Wang, Q. (2002). Prediction and analysis of the future of automobile consumption loan in China. *Operation Research and Management*, (02), 117-121. (in Chinese).

Wang, Q. (2014). *Research on credit risk management of American commercial banks*. Doctorial Thesis, Jilin University.

Wang, S. Q. (2003). On the characteristics of legal credit and moral credit. *Morality and Civilization*, (05), 54-57. (in Chinese).

Wang, X. M. (2004). *Applied Multivariate Analysis.* Shanghai: Shanghai University of Finance and Economics Press.

Wang, Y. J. (2010). On the difference and connection between risk management and internal control. *Shanghai Guozi*, (06), 74-75. (in Chinese).

Wang, Y., Nie, G. L., & Shi, Y. (2012). Study on the probability of customer default of Chinese Commercial Banks Based on the credit scoring model. *Management Review*, 24 (02), 78-87. (in Chinese).

Wang, Z. X. (2003). *Automotive finance research.* Doctorial Thesis, Graduate School of Chinese Academy of Social Sciences.

Wei, C. Y. (2001). Looking at China's personal credit evaluation system from FICO. *China Credit Card*, 67 (12), 10-13. (in Chinese).

Wei, H. K. (2005). *Theory and Method of Neural Network Structure Design.* Beijing: National Defense Industry Press.

Wei, W. (2002). *Reconstruction of China's credit system in the gradual transition.* Doctorial Thesis, Northwest University.

Wei, X. L. & Zhou, Z. F. (2014). Research on SMEs' willingness to repay debts based on prospect theory. *Systems Engineering*, 32 (7), 69-74. (in Chinese).

West, D. (2000). Neural network credit scoring models. *Computers & Operations Research*, 27 (11-12), 1131-1152.

White, L. J. (1997). Technological change, financial innovation, and financial regulation in the U.S.: The challenges for public policy. *Australian Journal of Earth Sciences*, 37 (37), 459-469.

Wiginton, J. C. (1980). A note on the comparison of Logit and discriminant models of consumer credit behavior. *The Journal of Financial and Quantitative Analysis*, 15, 757-770.

Xia, Y. F. (2018). *Research on personal credit risk management of P2P network lending in China.* Doctorial Thesis, China University of Mining and Technology.

Xiang, H. (2011). *Research and application of personal credit scoring combination model.* Doctorial Thesis, Hunan University.

Xiao, W. B. & Fei, Q. (2006). Research on personal credit evaluation model and optimal parameter selection based on support vector machine. *Theory and Practice of System Engineering*, 10, 73-79. (in Chinese).

Xie, M. (2007) *Analysis of credit risk of consumer credit and Research on its countermeasures*. Doctorial Thesis, Wuhan University of Technology.

Xu, P. (2017). *Research on the optimization of personal credit scoring system of commercial banks.* Doctorial Thesis, Harbin University of Technology.

Yan, F. (2010). Analysis of credit risk management of commercial credit institutions in China. *China Business*, 5, 140-141. (in Chinese).

Zhang, J. (2012). *Research on the personal credit evaluation model of commercial banks.* Doctorial Thesis, Guangxi University.

Zhang, W. J. (2016). *Research on personal credit risk assessment model based on big data*. Doctorial Thesis, Medical University.

Zhang, Z. (2004). *Interpretation of Basel II*. Beijing: China Economic Press.

Zhao, X. J. (2003). The bank is close to the edge of the storm by seizing the bad credit of the money bag and car loan. *China Business Daily*, 9, 16. (in Chinese).

Zheng, T., Liang, J. M., & Ma, L. (2005). The establishment of consumer credit in personal credit evaluation system. *Journal of Yanshan University*, 6, 77-79. (in Chinese).

Zhong, B. & Xiao, Z. (2005). Credit evaluation method based on. *Statistical Research*, 11, 29-31. (in Chinese).

Zhou, J. H. (2019). Bank risk management from the perspective of enterprise risk management framework 2017. *China Management Informatization*, 22 (06), 107-108. (in Chinese).

Zhou, J. L., Duan, Z. C., & Deng, J. C. (2004). Neural network optimization based on particle swarm optimization and its application in boring. *China Mechanical Engineering*, 15 (21), 1927-1929. (in Chinese).

Zhou, Z. F. & Chen, L. (2005). On credit standardization system. *World standardization and Quality Management*, 12, 30. (in Chinese).

Zweig. F. (1936). *Consumer Credit Theory*. Beijing: Commercial Press.

Appendix

Correlation Matrix

	Interest Rate									
Interest Rate	1.00	Loan_amount								
Loan_amount	-0.12	1.00	Age							
Age	0.03	0.00	1.00	Marriage						
Marriage	0.03	0.05	0.47	1.00	Sex					
Sex	0.01	0.08	0.03	0.18	1.00	Driving license				
Driving license	0.06	-0.01	0.09	0.03	0.21	1.00	Monthly income			
Monthly income	-0.06	0.24	-0.02	-0.01	-0.05	-0.16	1.00	Bank Credit report		
Bank Credit report	-0.05	0.09	-0.03	0.02	-0.01	-0.37	0.31	1.00	Wanxiang Score	
Wanxiang Score	-0.14	0.19	-0.15	-0.07	0.05	-0.26	0.24	0.35	1.00	Tongdun Score
Tongdun Score	-0.04	0.05	-0.18	-0.10	-0.06	-0.23	0.19	0.32	0.27	1.00