



**Instituto Universitário de Lisboa**

**Establishment of Risk Control Mechanisms for Farmers’  
Microcredit in China’s Rural Areas: The Case of HN Province**

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Thesis submitted as partial requirement for the conferral of the degree of

**Doctor of Management**

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July, 2019



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The Case of HN Province

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- Spine -

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## Abstract

This thesis aims to address the practical and institutional problems in the development of farmers' microcredit to ultimately contribute to achieve sustainable development. The author, based on his long-term work experience in rural finance, analyzes the current situation of microcredit in rural areas and presents a set of mechanisms for risk management and scientific pricing of farmers' in the framework of the construction of an iterative model with the support of statistical analysis.

To be specific, based on improving farmers' scheduled repayment rate and a study of farmers' microcredit factors, criteria are formulated for selecting credible borrowers among farmers; Making full use of the decisive role of the market, an effective risk management model is gradually formulated that helps to foster a credit-based financial service environment in rural areas. Besides, software engineering is utilized to optimize and control farmers' microcredit risk management and scientific pricing of credit products.

The study suggests that the farmers' microcredit risk control mechanisms established can effectively enable farmers' microcredit financial institutions to function as a main market player, while overcoming theoretical and practical difficulties in microcredit for farmers. Four suggestions are also presented. First, ensure that farmers enjoy the "right of approval" when applying for loans; second, transfer the "right of pricing" loan interests to farmers; third, transfer the "right of salary distribution" and risk control of loans to loan officers; and fourth, entrust the "management right" of loans to the system.

**Keywords:** farmers' microcredit; risk management; scientific pricing of credit products; sustainable development

**JEL:** M19; D23





## Resumo

Esta tese tem como objetivo abordar os problemas práticos e institucionais no desenvolvimento do microcrédito dos agricultores para, finalmente, contribuir para alcançar o desenvolvimento sustentável. O autor, com base em sua experiência do trabalho de longo prazo em finanças rurais, analisa a situação atual do microcrédito em áreas rurais e apresenta um conjunto de mecanismos para a gestão do risco e a determinação científica de preços para o microcrédito dos agricultores no quadro da construção de um modelo interativo com o apoio da análise estatística.

Mais especificamente, com base na melhoria da previsão da taxa de reembolso do microcrédito pelos agricultores e em um estudo dos fatores condicionantes desse reembolso, são formulados critérios para selecionar mutuários confiáveis entre os agricultores; Fazendo pleno uso do papel decisivo do mercado, é formulado gradualmente um modelo eficaz de gestão de risco que ajuda a promover nas áreas rurais um ambiente favorável de serviços financeiros baseados no crédito. Além disso, a engenharia de software é utilizada para otimizar e controlar a gestão de riscos de microcrédito dos agricultores e a determinação científica dos preços dos produtos de crédito.

O estudo demonstra que o mecanismo de controle de risco de microcrédito dos agricultores assim estabelecido pode efetivamente permitir que as instituições financeiras de microcrédito funcionem como um participante principal do mercado, ultrapassando dificuldades que a teoria e a prática têm revelado no microcrédito para os agricultores. Quatro sugestões são ainda apresentadas. Em primeiro lugar, garantir que os agricultores desfrutem do “direito de aprovação” quando solicitam empréstimos. Em segundo lugar, transferir para os agricultores “direito de determinação do preço” da taxa de juro do empréstimo. Em terceiro lugar, passar o “direito de distribuição salarial” e o controle de risco dos empréstimos para os agentes de crédito. Em quarto lugar, confiar ao sistema o “direito de gestão” dos empréstimos.

**Palavras-chaves:** microcrédito de agricultores; gestão de risco; determinação científica dos preços dos produtos de crédito; desenvolvimento sustentável

**JEL:** M19; D23



## 摘要

本论文旨在破解农户小额信贷发展的实践困境和制度难题，最终达到可持续发展的目的。

笔者结合长期从事农村金融的工作经验，通过分析农村地区农户小额信贷的现状，采用构建迭代模型和统计分析的研究方法，从风险管理和科学定价两个维度构建农户小额信贷机制。

通过构建贷款农户选择机制，实现农户小额信贷科学定价；加强风险管理机制设计，构建风险防控长效机制；基于软件工程的方法，对优化风险管理、科学定价。

从而，切实打破了农民小额贷款的理论和实践困境，为金融机构实现风险可控、成本可担的可持续发展提供了保障。

**关键词：**利率市场化；农户小额信贷；风险管理；信贷产品定价

**JEL:**M19; D23



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# Contents

<b>Chapter 1: Introduction.....</b>	<b>1</b>
1.1 Research background.....	1
1.2 Theoretical framework of microcredit.....	3
1.2.1 Microcredit .....	3
1.2.2 Main characteristics of microcredit .....	3
1.2.3 Types of microcredit.....	4
1.2.4 Microcredit theories.....	5
1.3 Microcredit development at home and abroad .....	8
1.3.1 Microcredit development abroad .....	8
1.3.2 Microcredit development in Chinap .....	9
1.4 Research ideas, research methods and sources of data.....	10
1.4.1 Research ideas .....	10
1.4.2 Research Methods.....	14
1.4.3 Research data samples .....	15
1.5 Chapter summary.....	15
<b>Chapter 2: Theoretical Basis of Microcredit Risk Management.....</b>	<b>17</b>
2.1 Comprehensive risk management theory of commercial banks .....	17
2.1.1 Risk factors of commercial banks.....	17
2.1.2 Risk categorization of commercial banks.....	18
2.1.3 Risk identification of commercial banks .....	20
2.1.4 Risk measurement of commercial banks .....	1
2.2 Integrated asset and liability management theory .....	26
2.2.1 Asset-liability management theory .....	26
2.2.2 Measurement of asset and liability management.....	27
2.3 Project management theory based on continuous improvement of IDEAL model .....	30
2.3.1 IDEAL model overview .....	31
2.3.2 An analysis of the process improvement features of IDEAL model .....	32
2.3.3 Management characteristics of IDEAL model .....	33
2.3.4 Project stages and milestone characteristics of IDEAL model.....	35
2.4 Chapter summary.....	37

<b>Chapter 3: Existing System of Microcredit Risk Management of Rural Credit Cooperatives .....</b>	<b>39</b>
3.1 Microcredit risk of rural credit cooperatives .....	39
3.2 Microcredit interest rate risk management .....	41
3.2.1 Microcredit interest rate mechanism .....	41
3.2.2 Measurement methods of microcredit interest rate .....	42
3.2.3 2.3-time interest rate premium.....	43
3.2.4 Farmers’ microcredit rate: a theoretical model related to output rate .....	44
3.3 Risk indicator system of rural credit cooperatives .....	44
3.3.1 Macroeconomic environmental indicator system.....	44
3.3.2 Regulatory indicator system of banking regulatory authority .....	46
3.3.3 Client default and operational failure risk assessment indicator system .....	46
3.4 Chapter summary.....	49
<b>Chapter 4: Establishment of the Continuous Improvement System of Microcredit Risk Management of Rural Credit Cooperatives.....</b>	<b>51</b>
4.1 Business requirements analysis .....	52
4.1.1 Microcredit risk management model .....	52
4.1.2 Basic functions through microcredit risk management software .....	53
4.1.3 Microcredit risk management platform based on process improvement model .....	55
4.2 Functional requirements analysis .....	56
4.2.1 System management function.....	57
4.2.2 Management function of the authorized organization .....	61
4.2.3 Statistical analysis functions.....	62
4.2.4 Management function of credit data collection .....	64
4.3 Performance requirements analysis .....	65
4.4 Use case modeling of the risk management system of farmers’ microcredit .....	66
4.4.1 Case modeling .....	66
4.4.2 Description of some use cases .....	68
4.5 Chapter summary.....	69
<b>Chapter 5: Design and Implementation of the Platform for the New Microcredit Risk Management System .....</b>	<b>71</b>
5.1 Structural design of the microcredit risk management system.....	71
5.2 Object-oriented design of the microcredit risk management system.....	73
5.2.1 Object-oriented static design .....	73
5.2.2 Object-oriented dynamic design .....	74
5.3 Chapter summary.....	79

<b>Chapter 6: Empirical Contribution for the Improvement of Microcredit Service for Farmers and the Risk Management System .....</b>	<b>81</b>
6.1 Characteristics analysis of farmers in the microcredit system in HN Province .....	81
6.1.1 A large agricultural population .....	82
6.1.2 Basic characteristics of farmers .....	82
6.2 Selection of farmers in microcredit service .....	84
6.2.1 Design and data description of the Logistic model .....	86
6.2.2 Analysis of factors influencing the loan acquisition rate.....	88
6.2.3 Analysis of factors influencing the loan repayment rate .....	89
6.2.4 Analysis of the importance of variables .....	90
6.3 Determination of the number of microcredit joint guarantors.....	93
6.3.1 Analysis of repayment without joint guarantees .....	93
6.3.2 Relationship between the rate of repayment on schedule, the loan acquisition rate and the number of joint guarantors .....	93
6.3.3 Determination of the number of joint guarantors .....	95
6.4 Chapter summary .....	96
<b>Chapter 7: Institutional Mechanisms and Procedures for the Improvement of Microcredit Service for Farmers and the Risk Management System .....</b>	<b>99</b>
7.1 Farmers' microcredit integrity cultivation function system .....	99
7.2 Farmers' microcredit interest rate incentive system.....	101
7.3 Integrity reward system for farmers' loans.....	105
7.4 Improvement of the loan compensation reserve and reward and punishment system for microcredit financial institutions .....	108
7.5 Creation of a proprietary model for microcredit in rural areas.....	111
7.6 Chapter summary .....	116
<b>Chapter 8: Conclusions and Research Prospects .....</b>	<b>119</b>
8.1 Research conclusions.....	119
8.1.1 Microcredit interest rate pricing system for farmers .....	120
8.1.2 Farmers' microcredit risk management system.....	120
8.2 Research prospects.....	121
<b>Bibliography .....</b>	<b>125</b>
<b>Webliography .....</b>	<b>130</b>
<b>Other References .....</b>	<b>130</b>
<b>Appendices .....</b>	<b>131</b>
Appendix 1 Environmental requirements analysis .....	131
Appendix 2 Implementation of software functions .....	134



## List of Tables

Table 2-1 Comparative analysis of VaR calculation methods .....	25
Table 3-1 Bank regulatory indicator system.....	47
Table 3-2 Farmers' default evaluation index system.....	48
Table 3-3 Enterprise default evaluation index system.....	49
Table 4-1 Functional chart of the management part of bank microcredit risk management system .....	57
Table 4-2 Management part functions of the authorized organization of bank microcredit risk management system.....	61
Table 4-3 Functional chart of management part of the credit data collection process of bank microcredit risk management system.....	64
Table 4-4 Description of the use cases of bank microcredit risk management .....	68
Table 6-1 Historical employment figures in the three industries: number (in ten-thousands) and proportion (%) of employed people.....	83
Table 6-2 Sample distribution of loan applicants in different cities and counties .....	84
Table 6-3 Housing structure and housing area of farmers that apply for loans.....	85
Table 6-4 Production and operation status of farmers that apply for loans.....	86
Table 6-5 Logistic regression results of loan acquisition rates .....	89
Table 6-6 Logistic regression results of loan repayment rate.....	90
Table 6-7 The importance of explanatory variables .....	92
Table 6-8 Model summary and parameter estimation .....	94
Table 6-9 Model summary and parameter estimation .....	95
Table 1 System architecture diagram .....	132



## List of Figures

Figure 1-1 Technical roadmap.....	13
Figure 2-1 Risk measurement methods of commercial banks .....	21
Figure 2-2 IDEAL model flow chart.....	32
Figure 2-3 An introduction to project implementation content.....	34
Figure 2-4 Project milestone curve .....	36
Figure 4-1 Use case diagram of bank microcredit risk management system.....	67
Figure 5-1 Software function module diagram .....	72
Figure 5-2 Static design class diagram of customer microcredit risk management system.....	73
Figure 5-3 Sequence diagram of the setting and generation of risk factors and risk dynamic weights .....	75
Figure 5-4 Sequence diagram of credit task evaluation and risk identification .....	76
Figure 5-5 Sequence diagram of statistical analysis .....	77
Figure 5-6 Status diagram of risk factor and risk dynamic weight setting and generation.....	78
Figure 5-7 Status diagram of credit task evaluation and risk identification.....	79
Figure 6-1 Histogram of on-schedule loan repayment rate .....	94
Figure 6-2 Fitting graph of on-schedule repayment rate.....	95
Figure 6-3 Diagram of the number of joint guarantees .....	97
Figure 1 System network structure.....	132
Figure 1 Working interface of the definition layer of the risk control system model .....	134
Figure 2 Working interface of the risk control execution system .....	135
Figure 3 Working interface of the credit execution operation system.....	135
Figure 4 Software function implementation diagram of risk factor and risk dynamic weight setting.....	136
Figure 5 Software function implementation diagram of risk factor and risk dynamic weight filling.....	136
Figure 6 Software function implementation diagram of individual linear analysis.....	137
Figure 7 Software function implementation diagram of estimated parameters of the rate of repayment on schedule and number of joint guarantors.....	138





## **List of Abbreviations**

HN: Hainan

RCC: Rural credit cooperative

MSE: Micro-and-small enterprise

CGAP: Consultative Group to Assist the Poor

MDG: Millennium Development Goals:

UNFPA: United Nations Population Fund

ERM: Enterprise-wide risk management

VaR: Value at risk

ROA: Return on assets

RONA: Return on net assets

SDI: Subsidy Dependence Index

OSS: Operational self-sufficiency

CBRC: China Banking Regulatory Commission

FSS: Financial self-sufficiency

OLAP: Online Analytical Processing

LAN: Local area network

WAN: Wide area network



## **Chapter 1: Introduction**

### **1.1 Research background**

The five years from 2020 to 2025 will be a decisive period for China to develop into a well-off society in all respects. The key to whether the well-off society is rich or not lies in the farmers. And the key to developing into a well-off society in all respects lies in the rural areas. Poverty in China's rural areas is caused by many factors. A notable factor is that under the current financial system it is difficult for farmers, agriculture and rural areas to obtain financial support, which makes it hard for them to seize valuable development opportunities. It is explicitly pointed out in the Proposal of the CPC Central Committee on the Formulation of the 13<sup>th</sup> Five-Year Plan for China's Economic and Social Development adopted at the Fifth Plenary Session of the 18<sup>th</sup> Central Committee of the Communist Party of China (Xi, 2015) that efforts should be made to develop package plans with a focus on financial services (Liu, 2016).

As the main financial force for promoting agricultural efficiency as well as increasing farmers' income and rural development, rural credit cooperatives (hereinafter referred to as "RCCs") have, through granting microcredit loans, facilitated the progress of financial poverty alleviation, reduced rural poverty, promoted rural harmony and stability, accelerated industry structure adjustment in rural areas, increased the degree of rural economic organization in rural areas and generated great social and political benefits (Lin, 2007). In the process of serving "farmers, agriculture and rural areas", RCCs have also developed and expanded, with significant improvement of assets quality (Wang, 2006). They have transformed from institutions on the verge of bankruptcy into the most competitive financial institutions.

Seen from the entire development process of RCCs, especially since the national reform of RCCs in 2003, the reasons why RCCs have turned losses into gains and achieved

rapid development are three-fold. The first is operation flexibility and management synergy; the second has to do with preferential policies; and the third is attributable to their unique branches. However, with China's market-oriented reform and the adjustment of the economic system, in particular interest rates liberalization, the abovementioned three advantages of RCCs are gradually disappearing. As the interest rate liberalization deepens, financial institutions will fully enter the era of perfect market competition (Han, 2008). This will be a severe test for the management and survival of RCCs. The profit of Chinese-funded banks mainly comes from the interest income of credit business, while the ultimately full liberalization of interest rates means that financial institutions will have greater loan autonomy.

It was put forward in the Comprehensive Implementation Plan for Deepening Rural Reform (Rural Financial Services Research Group of the People's Bank of China, 2013), printed and distributed in November 2015, that: "Efforts should be made to accelerate rural financial system innovation. The combination of commercial finance, cooperative finance and policy-based finance should be adhered to. Measures should be taken to improve policy support, fair access and differentiated regulatory systems, expand the scale and coverage of rural financial services, innovate rural financial service models, upgrade rural financial services, and popularize inclusive finance. A modern rural financial system characterized by multiple levels, a wide coverage, sustainability, moderate competition and controllable risks shall be established with accelerated progress (Niu, Zhang, & Li, 2009).

The main businesses of RCCs are deposits and loans. Faced with the challenge of interest rate liberalization, RCCs' ability to cope with the risks in the new situation has become the decisive factor for it to accelerate transformation and upgrading as well as achieve sustained and stable development in the new context. Besides, the whole process of credit risk management plays a decisive role in the comprehensive risk management implementation of commercial banks. Therefore, the establishment of a complete comprehensive risk management information system based on process improvement is crucial for RCCs to cope with complex risk environments and sustain stable development.

To be specific, efforts should be made to tap and unleash RCCs' potential and effectiveness in controlling the risks in microcredit, and differentiate their services with those of other banks, so as to identify the optimal point of balance between risk and return. This will provide a reference for solving RCCs' development issues in the next step.

## **1.2 Theoretical framework of microcredit**

### **1.2.1 Microcredit**

In essence, microcredit is the extension of very small loans to low-and-middle-income groups and micro-enterprises (Zhu, 2012). mainly in the form of unsecured small loans (Li, 2011). In other words, microcredit is a financial service activity aimed at providing short-term loans of small amount and low interest rates to most low-and-middle-income earners as well as micro-and-small enterprises (MSEs). In China, microcredit mainly serves farmers, agriculture and MSEs. Besides, microcredit companies consist of not only individuals and company legal persons but also private lenders, pawnshops, circular savings, credit associations and mutual funds. Currently, the major providers of microcredit are RCCs, branches of agricultural banks and some city commercial banks (CGAP, 2010). In the context of interest rate liberalization, establishing a microcredit risk control system suitable for grassroots RCCs is especially important for the stable progress of the credit business of RCCs and the establishment of an inclusive financial system.

For a long time, the lack of financial services, especially credit services, has stood in the way of the development of China's rural economy. For RCCs with farmers as main clients, the main responsibility is to serve farmers well and provide them with financial services. In short, microcredit is an innovative lending service and it cannot cover the clients of traditional commercial banks.

### **1.2.2 Main characteristics of microcredit**

Compared with commercial lending, microcredit has the following distinctive characteristics:

1. The loans are only applicable to individuals, households enjoying the minimum living guarantee and MSEs. Due to the broken capital chain, it is difficult for MSEs to sustain production and operation. However, most commercial loans are targeted at large companies and large customers. The emergence of microcredit is out of the awareness that disbursing small loans can help meet the financial needs of individuals and MSEs.

2. Borrowing is quick, effective and in small amount. Microcredit is targeted at low-and-middle-income residents, especially poor people in rural areas, to meet their seasonal demand for production. Because microcredit itself is so targeted, its amount is usually not too big.

3. Micro loans do not need to be guaranteed or collateralized.

4. The lending risk is higher and interest rates are higher compared to commercial banks. The small amount and short repayment period are the reasons why low-and-middle-income residents cannot obtain general commercial loans. Microcredit mainly helps low-and-middle-income residents. But when borrowers fail to repay loans on time, the risks microcredit has to undertake will increase unprecedently. Therefore, to prevent this from happening, borrowers must pay back their loans in instalments, which will safeguard the capital chain of microcredit enterprises. However, due to the unsustainable capital supply and poor repayment ability of the low-and-middle-income residents, plus the high risks microcredit has to undertake, the interest rates of microcredit have been increasing continuously and even higher than those of commercial banks. As a result, microcredit needs to obtain higher interest rates to justify its costs and risks.

### **1.2.3 Types of microcredit**

Different goals of microcredit will result in different types of credit. One type of representative organizations mainly operates in the forms of small amount, short time, safe storage, convenient assessment and no need for mortgage to increase savings business. In comparison, the other type of representative institutions mainly focuses on low-income groups. By setting up voluntary service teams, they adopt such ways as provision of

short-term loans in small amounts to help alleviate the poor out of poverty, thus promoting the development of local finance.

In light of China's reality, RCCs mainly provide rural households with welfare-oriented micro loans to help them address financial difficulties, solve production problems and get rid of poverty. RCCs have highlighted "agricultural" services, regarding microcredit for rural households as an integrated platform for supporting agriculture and farmers, allocating more financial resources to the grassroots households in rural areas, developing practical cooperative finance and disbursing petty loans, so as to facilitate the development of the well-off rural society in all respects.

#### **1.2.4 Microcredit theories**

Relevant theoretical basis of microcredit has emerged to analyze factors that explain why the poorest segments of society are further removed from financial systems. This is considered in the following sections.

##### **1.2.4.1 Financial repression theory and financial deepening theory**

In the 1990s, the renowned "financial repression" and "financial deepening" theories were put forward by the American economists McKinnon and Edward (Molho, 1986). They believed that the huge difference between modern finance and traditional finance had caused most low-income groups (mainly rural residents) to be denied access to the financial market, which remained a constraint on rural development and led to the lack of stability of the rural financial market. According to these theories, the risks of market segmentation and suppression have been constant in such under-developed economies as rural areas. As the basic unit of traditional rural production, peasant households have relatively weak risk tolerance due to their monotonous form of organization and fragility. Surveys and practice indicate that natural risks and personal safety risk are the main risks faced by farmers in production and operation. And these risks will directly lead to losses in their normal production activities and lower productivity, which further impairs their contract performance ability and ultimately results in the possibility where the financial institutions

have to suffer a loss due to farmers' inability to repay loans due. The risk renders most financial institutions reluctant to lend money to rural residents.

The poor people engaged in agricultural production in rural areas are in urgent need of loans due to their lack of funds (Tan, 1998). However, due to some of their own limitations, their expectations cannot be met, making the economic situation severe. Therefore, they are in urgent need of funds to change the status quo, which creates conditions for the emergence of financing channels. Rural microcredit is a more effective way of distribution, which not only meets the fund demand in rural areas but can also help raise farmers' credit awareness.

#### **1.2.4.2 Theory of imperfect competition**

The theory of imperfect competition, which came into being in the 1930s, states that in order to foster effective financial markets, it is generally accepted that some social and non-market elements are still needed (Boyd, Nicolò, & Jalal, 2006). The financial market of developing countries is an imperfect market. It is impossible to fully rely on the market mechanism to foster a financial market needed by the society. In this case, external forces such as appropriate government intervention can remedy the dysfunctions of the financial market.

In China, especially in rural areas, most financial institutions cannot fully grasp the basic situation of rural households (Wang, 2008). In addition, such problems of microcredit for rural households as numerous loan purposes, dispersed residence, sporadic quotas and a large total demand aggravate the imperfect competition market in rural areas. The microcredit model for peasant households proposed in this study emphasizes the need to address the information asymmetry in the rural financial market and the high transaction cost in rural areas.

#### **1.2.4.3 Transaction cost theory**

The transaction cost theory was put forward by Nobel laureate Ronald Coase in 1937 (Madhok, 2002). Transaction cost refers to the cost paid by people who voluntarily communicate and cooperate with each other in a certain social network (Yunus & Jolis,



2008). In essence, there will be transaction cost if there are human exchanges. Transaction costs are an inseparable part of human social life (Yin & Cao, 2010). In 1975, Williamson specifically divided transaction costs into search cost, information cost, bargaining cost, decision-making cost, supervision cost and default cost (Huang, 2008). In 1985, Williamson further divided transaction costs into ex ante transaction costs and ex post transaction costs. Among them, ex ante transaction costs refer to costs that need to be paid in order to clarify the rights, responsibilities and obligations of both parties due to the uncertainty of future situation (Jing, 2011). Ex post transaction costs refer to the costs that occur after the transaction (Berger & Frame, 2007). They usually refer to the costs paid to maintain the long-term cooperative relationship between the two parties, or the loss paid due to transaction cancellation by the two parties.

Williamson believes that the main reason for transaction costs is the transaction difficulty caused by the market failure resulting from the interactions between human nature factors and transaction environment factors (Sun, 2008). Specifically, there are six sources, namely, bounded rationality, opportunism, uncertainty and complexity, specific investment, information asymmetry and atmosphere. Further research reveals that transaction costs are derived from the three characteristics of transaction itself: the specificity of transaction commodities or assets, transaction uncertainty and transaction frequency (Huang, 2008).

According to the transaction cost theory, due to the natural conditions in rural areas and the restrictions of farmers themselves, the transaction cost of microcredit in rural areas is relatively high, which leads to financial institutions' low enthusiasm for developing microcredit business. This has become an important factor restricting the development of rural finance and economy. In China's rural areas, farmers live in scattered areas, and there is a serious information asymmetry between financial institutions and rural households. As a result, it is more costly to offer financial services in rural areas. Thus, many financial institutions are reluctant to extend their services to rural areas. Instead, they cluster in urban areas with a concentrated population. Besides, due to the lack of knowledge about finance and credit, Chinese farmers often fail to pay attention to the interest rates they need to pay

and their own risk tolerance while exploiting the convenience of borrowing loans.

#### **1.2.4.4 Institutional change theory**

The mutual substitution and transformation process of two different systems is called institutional change theory (Du, 2004). It can also be seen as a process to improve the system structure of transactions between people. It is a process to produce a more effective system. Institutional change can be divided into induced change and forced change. Induced change is a process of natural evolution, recognized by national laws and regulations or orders. It has the following characteristics: First, it is profitable. In other words, system reform pursues profit. Second, it is spontaneous. Third, it is gradual. In other words, the change unfolds gradually from point to surface, from bottom to top and from parts to whole. On the contrary, forced institutional change is implemented by the coercive force of the state. As the power holder, the state promotes new systems by making laws and regulations. In general, organizations have some disadvantages in comparison to states, because the latter can occupy advantages by providing system supply and technology monopoly.

In China, over the past years since the Reform and Opening-up, over 200 rules and regulations have been promulgated and improved for RCCs. As a result, all businesses have rules to follow and are under effective management. These efforts have strengthened national policies. Besides, different credit systems have also been formulated according to the characteristics of different regions.

### **1.3 Microcredit development at home and abroad**

#### **1.3.1 Microcredit development abroad**

In the 1970s, Dr. Mohamed Yunus from Bangladesh began experimenting with microcredit and won the title of the “Father of Microcredit” (Nobel Peace Prize winner in 2006) (Azad & Munisamy, 2016). The boom of microcredit already began in the later years of the 1980s. The donor-supported credit model aimed at alleviating poverty continued to be criticized. The gradual expansion of services was emphasized, and attention was shifted to

financial self-reliance and sustainable development as a substitution for the reliance on donors. Meanwhile, the microcredit model was born on the basis of the successful establishment of state-owned banks. In the 1990s, the world microcredit movement entered the big stage of international trade with the establishment of the Consultative Group to Assist the Poor (CGAP). Some experts also began to fully support microcredit projects.

In the 1990s, some major international conferences and summits of government leaders began to discuss the global development direction in the new century. And they set what were known as the “international development goals”. In September 2000, the United Nations consolidated and renamed these goals as the Millennium Development Goals (MDGs) as specific guidelines for global development planning in the 21<sup>st</sup> century. “Eradicating extreme poverty and hunger” ranks the first among the MDGs, highlighting the UN’s determination to eradicate poverty and improve people’s lives (Huang & Lv, 2013). Microcredit, as an effective means and a powerful force for poverty reduction, began to enter the UN’s vision. In the 1990s, the United Nations General Assembly designated 2005 as the “International Year of Microcredit”. November 8, 2005 saw the official launch of the International Year of Microcredit at the United Nations headquarter in New York. The vigorous development of the financial industry in various countries cannot be possible without the push by the government and the attention from financial institutions. And it also pushed microcredit to the climax of development (Bank of China, 2002).

### **1.3.2 Microcredit development in China**

The first stage is the early stage (1990s) (Wu & Li, 2016). In 1989, the United Nations Population Fund (UNFPA) projects carried out in Longxi, Gansu Province, Qinghai, and Ningxia adopted microcredit (Sun, 2015). However, as such project-style microcredit fully relied on this project, it eventually stepped back from history upon the conclusion of the project.

The second stage is the expansion stage (1990-2000). In 1994, China selected Hebei Province as the experimental site for domestic microcredit with references to the model of

Grameen Bank, a rural Bank in Bangladesh, and then regarded Henan Province as the promotional place (Casselman, Sama, & Stefanidis, 2015). Such organizations as China International Center for Economic and Technical Exchanges and China Foundation for Poverty Alleviation also started to expand the development of microcredit by imitating the Grameen Bank model in Bangladesh.

The third stage is the institutionalization stage (2000-2005) (Hudon & Traca, 2011). With the intervention of local formal financial institutions, microcredit entered the stage of institutionalized development. Under the government support, local financial institutions represented by RCCs began to operate fully and fully support co-guarantee loans and microcredit. Microcredit for rural households also gained rapid development, characterized by continuously increasing coverage, while urban microcredit also entered the "fast lane" (Du, 2013).

The fourth stage is the diversification stage (since 2005) (Gabriel, 2006). Since 2005, regulatory policies have been gradually eased. Private capital and even overseas capital have been allowed to enter the field of microcredit, resulting in the diversified development pattern of microcredit institutions.

China's continuous integration with international microcredit is aimed at not only bringing financial convenience to customers. Moreover, it is meant to increase the income of financial institutions and prosper the national economy. As an important aspect of development balance, it promotes the diversity of different customer groups in financial institutions and supports the sustainability assessment of financial services (Wu & Dong, 2007). China encourages innovation and supports new strategic partnerships to establish microcredit and expand microcredit service scope.

## **1.4 Research ideas, research methods and sources of data**

### **1.4.1 Research ideas**

In the context of interest rate liberalization it is of vital significance to the

differentiated management as well as the realization of continuous and stable development of RCCs to mine and continue releasing the potential and efficacy of RCCs in microcredit risk control, strengthen the status of financial services in rural areas, establish a sound microcredit risk management information system for RCCs, and fully embody the reasonable allocation of interest rates among farmers and clients from different regions, in different industries and of different integrity standards. The interest rate difference in rural microcredit also represents that RCCs have a more localized risk management system, which is more in line with the needs of farmers in China's rural or poverty-stricken areas.

Based on the current operation of RCCs in HN Province and drawing on existing theories and practices, this thesis presents the following general structure.

First, domestic and foreign studies on microcredit and microcredit risk management theories are considered to give a general understanding, the basic ideas and methods, as well as the development background and characteristics of the research field. Then relevant microcredit risk management websites are consulted and browsed through to give an understanding of relevant practices and experience.

Second, based on microcredit management theory, comprehensive risk management theory and asset and liability management theory and according to project management requirements, the comprehensive model for microcredit risk management ability is presented.

Third, through the development and use of software system, an information-based support environment for microcredit risk management and improvement is considered in the context of interest rate liberalization. These achievements can be well applied in the improvement of the development process to establish the technical support conditions and process improvement environment for risk management. In this context, empirical research can be carried out in the form of process improvement.

Based on the current microcredit management standards of credit cooperatives in HN Province, the IDEAL model (Wan, Guo, & Xia, 2001) is utilized to continuously improve model method, thoroughly implement the whole-process-oriented risk control information

model for the work nodes before, during and after lending, and set up an information system of microcredit operation to support the interactions between credit risk management research and practice with an information-based environment. In this way, the model can be continuously perfected based on continuous process improvement.

With the strong support of the decision-making departments of HN credit cooperatives and the development of pilot innovation projects, and based on the first-hand materials accumulated, microcredit risk management and control can be carried out in practical work. On this basis, problems can be analyzed in a comprehensive way from points to surface. And under the support of the computer software platform, risks can be controlled from three processes, namely, pre-lending, lending and post-lending. Then, the credit risk management should be optimized before lending, covering risk factors, organization guarantee and human resources support. Process management should be updated timely during lending, including the microcredit risk management information system and real-time feedback on risk identification and tracking should be given after lending. Efforts should be made to continuously better interest rate changes, so as to summarize experience, identify the deficiencies in the management or tracking system or services, put forward improvement measures, and implement them in the subsequent work.

Introducing a higher specification, the technical roadmap of this thesis is as follows (see Figure 1-1):

1. Through the methodology of the project management process improvement theory guided by the IDEAL model method, according to the principle, indicators and requirements of the comprehensive risk management theory of commercial banks, and focusing on the integrated asset and liability management theory, the top-level design and verification of the risk credit indicator system is carried out. Besides, within the level of understanding and analysis, continuous improvement method is adopted to continuously integrate and improve so as to consolidate the top-level design as well as scientificity, objectivity, constructiveness, professionalism and guidance, laying the foundation for the feasibility of the establishment of microcredit risk management mechanism in the context of

interest rate liberalization.

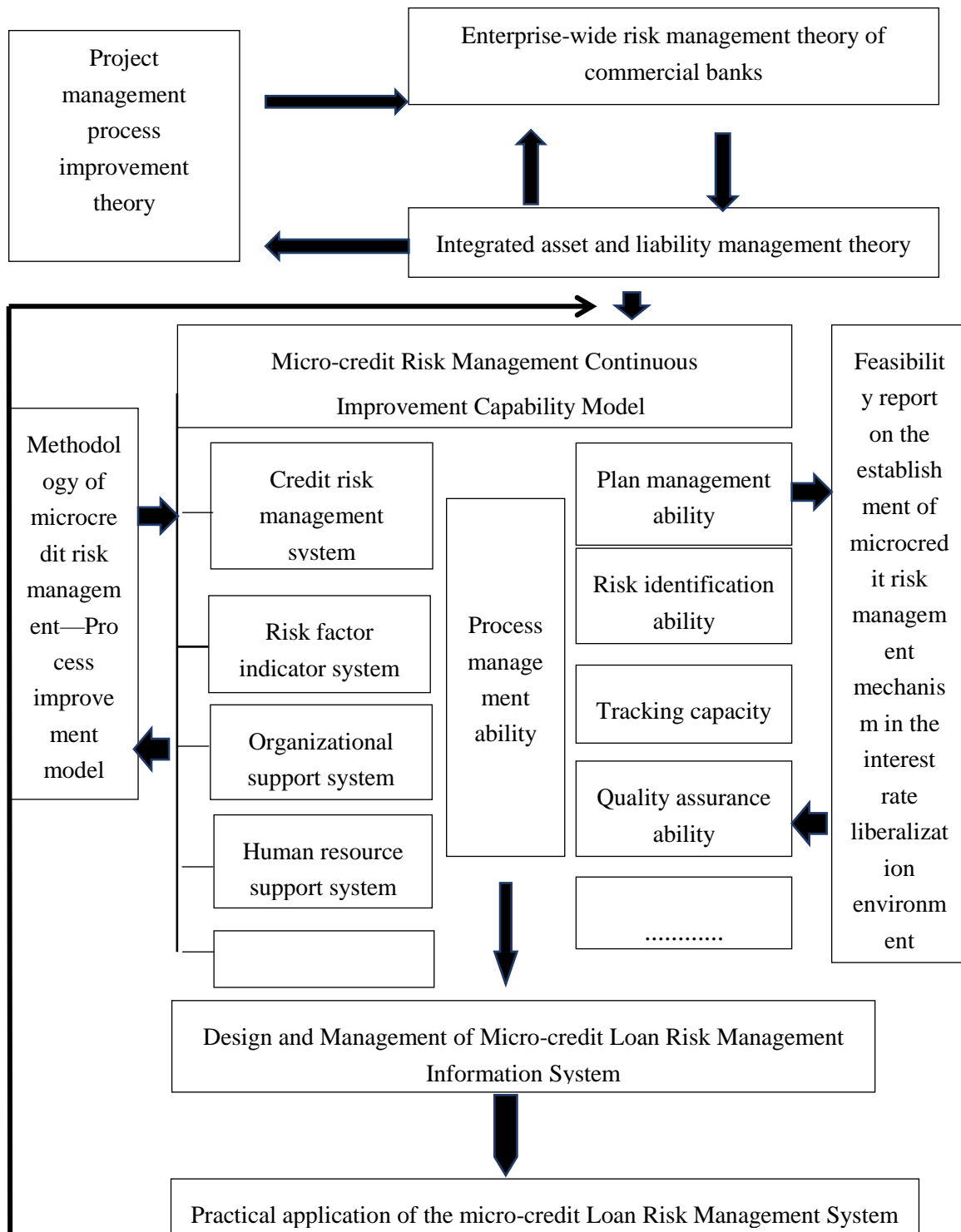


Figure 1-1 Technical roadmap

2. As a support guarantee for the feasibility of practical verification, the system support capability foundation of the process in the “microcredit risk management continuous

improvement capability model” is used as the basis, including the static support ability of the organizational system (“credit risk management system” – “risk factor” indicator” – “organizational support system”, “human resources support system”, etc.) and dynamic process management capabilities of the organizational system (“plan management ability” – “risk identification ability” – “tracking capacity” – “quality assurance ability” etc.) to structure, stratify and modularize the business requirements and objectives of microcredit risk management, and construct digital, functional, modular and systematic examples of the “methodology of microcredit risk management - process improvement model” so as to establish an information model featured by mapping, transformation and interactions from the real world to the conceptual world and establish a technical feasibility basis.

3. Guided by the feasibility analysis conclusions of the first and second points, information technology, computer technology, network technology and software technology application are used to conduct demand analysis, system design, code preparation, test and run of the “microcredit loan risk management information system” from the software engineering perspective, so as to build business and process support tools to support the microcredit loan risk management in the real world, and realize the integration of people, processes and systems.

4. The practical application of the “microcredit lending risk management system” ensures completion of the business, supports the business process and contributes to achieve sustainable improvement of business practice. Milestone summaries are made by stages for sublimation, so as to build a digital and integrated model of the systematic “microcredit lending risk management” featured by continuous improvement. This effort has practical value, theoretical significance and innovative value.

### **1.4.2 Research Methods**

Proceeding from the capability factor analysis of the IDEAL process improvement model (Ebert, Dumke, Bundschuh, & Schmietendorf, 2005), this thesis presents and describes the capability model for microcredit risk management by combining theory and



empirical work. By using computer software as the design integration model platform, the information-based environment is built, providing a process improvement model for risk management implementation and execution, thereby setting up a work mechanism for microcredit risk control.

### **1.4.3 Research data samples**

Complete client credit files are available with the microcredit client data of RCCs in HN Province. On this basis and through sample process data tracking, the data collection efficiency and credit data quality in the stage process may be continuously improved, so as to ensure the periodical data analysis results and quality to support subsequent data acquisition and data analysis (HN Rural Credit Cooperatives, 2007-2018). Data collection, data comparison, data review and data analysis may be performed and improved. The authenticity, objectivity and integrity of data collection methods, data processing steps, as well as of data analysis and demonstration may be improved from data quality, covering data granularity, data composition and data structure integrity, so as to ensure the objectivity, scientificity and professionalism of data analysis. This will help ensure the sustainability and authority of the data way as much as possible.

## **1.5 Chapter summary**

In the special context of microcredit in China's rural areas and in conjunction with the development history and background of microcredit at home and abroad, this thesis analyzes the current situation of microcredit in China's rural areas and the problems faced by financial institutions in rural areas with reference to imperfect competition theory, transaction cost theory and institutional change theory. Due to such main reasons as the high cost, information asymmetry and weak risk resistance ability of individual farmers in rural areas, microcredit financial institutions will face higher operating costs and undertake higher risks when issuing loans to rural households, which makes loans hardly accessible to rural households. Therefore, the establishment of an effective microcredit risk management

system is of vital importance for financial institutions to develop microcredit business in rural areas. On this basis, this chapter puts forward the research ideas, research methods and research data samples considered in this thesis, with a view to establishing a new microcredit risk management mechanism for farmers, constantly optimizing the microcredit risk management model, and better driving the development of finance and economy in rural areas.

## **Chapter 2: Theoretical Basis of Microcredit Risk Management**

### **2.1 Comprehensive risk management theory of commercial banks**

Enterprise-wide risk management (ERM) of commercial banks refers to the situation where the business units at all levels of an organization comprehensively manage various types of risks by drawing on the “New Capital Agreement” and the “Integrated Capital Management Framework” issued by COSO (Committee of Sponsoring Organizations of the Treadway Commission) (Yin, 2007). All commercial bank activities must be backed up by risk control ability. An ERM system requires commercial banks to formulate a unified risk management strategy from the macro-management level, as well as a consistent external risk management strategy, system and culture. At the micro-operational level, commercial banks need to identify, measure and prevent all risks involved in all processes in all organizations, businesses and systems (Varian, 1990).

#### **2.1.1 Risk factors of commercial banks**

Commercial banks face various risks in the course of their operations. The causes of risks are multifaceted and can be divided into internal and external aspects. Internal reasons refer to bank risks due to poor management and uncontrollable factors for commercial banks. Internal risks can be weakened or eliminated by improving their own management and strengthening internal control (He & Miao, 2015). The external causes of risk depend on the macroeconomic situation, national economic conditions, market factors and financial supervision. The macroeconomic cycle changes and external financial environment are the main external reasons for commercial banks' risks. From a micro perspective, external reasons for commercial bank risks include market prices, social credit, horizontal competition, information asymmetry between borrowers and banks, and other microeconomic factors. Besides, war and natural environmental disasters may also expose commercial banks to unpredictable risks (Yunus, Moingeon, & Lehmann-Ortega, 2010).

### **2.1.2 Risk categorization of commercial banks**

As the world economic integration deepens and financial access gradually opens up, more and more foreign banks will join the competition in the Chinese market. Local government intervention has been a long-standing issue and one of the biggest reasons for credit risk (Sui & Han, 2005). Chaotic corporate governance structure has also become the main reason for the credit risk of RCCs. The management systems of provincial associations, prefecture-level offices and county-level corporate credit cooperatives have seriously deviated from the modern corporate governance structure. In this context, efforts need to be made to fundamentally change the existing three-level management system of RCCs, transform the administrative functions of provincial associations and municipal governments into service functions, restructure RCCs as rural commercial banks, and establish a modern corporate governance structure. Besides, measures should be taken to give play to the three-tier governance mechanism, improve the internal compliance mechanism, and eliminate crises in such aspects as credit, market, exchange rate, capital chain, and environment (Lee & Hartungi, 2007).

The following are some considerations about risks that affect financial institutions, according to a typology that distinguishes between endogenous (financial and nonfinancial) and exogenous risks.

#### Endogenous financial risks

Credit risk - It is the main risk for commercial banks. Commercial banking businesses are getting increasingly diversified, involving not only traditional lending risk, but also discounts and overdrafts, with credit crisis being the deadliest risk.

Interest rate risk - It refers to the possibility of economic losses to the debt costs and capital gains of commercial banks caused by the interest rate fluctuations in the monetary market and the capital market through such businesses as deposits, loans and inter-bank lending. Interest rate risk is a fundamental risk faced by modern commercial banks. In essence, interest rate risk is a result of the mismatch between capital, debt period and debt

forms. For example, commercial banks are susceptible to interest rate risk if they pay back long-term loans with short-term funds. Interest rate risk management is mainly realized through asset and liability management. And interest risk is mainly affected by the macroeconomic environment, central bank policies and international economy (Teply, Vrabel, & Jessica, 2007).

Market risk – It is the risk commercial banks undertake when they invest in or buy or sell movable property or real estate due to market value fluctuations (Peng, 2001). Market risk arises from the uncertainty of such market factors as commodities, currencies, capital, real estate, futures and options.

Liquidity risk - If a bank's own liquidity is enough for paying its debts due (Shao, 2003), the bank does not have liquidity risk. And the bank will not take risks due to the loss of repayment ability. The biggest risk commercial banks need to pay attention to is liquidity risk. It may be caused by such factors as credit risk, business risk, interest rate risk, market risk, exchange rate risk, laws and regulations, management system, competition risk and national development level.

Exchange rate risk – It refers to the risk to the capital chain of commercial banks caused by different exchange rates between the currencies of different regions.

#### Endogenous nonfinancial risks

Legal risk refers to the risk brought to people's production and life by imperfect, unspecific, inexhaustive and impractical laws and regulations (Torre & Vishwanath, 2012).

Operational risk refers to the risk faced by commercial banks in daily operations, such as natural disasters, accidents, uncontrolled procedures, employee turnover and fraud (Torre & Vishwanath, 2012).

Management risk refers to risk brought by the imperfect market economy management system or managers' lack of experience (Crabb, 2011).

#### Exogenous risks

Macroeconomic environment - As economy continues to develop, income will increase

and investment opportunities and market capital demand will also increase, resulting in higher interest rates. On the contrary, when economy stagnates and the society falls into recession, investment willingness will decrease.

International economy - In today's world characterized by global economic integration, changes in the economic parameters of one country such as exchange rates and interest rates will also spread to other countries. Besides, the development status of the international securities market also determines the risks that international banks need to bear.

National risk, also known as national credit, refers to the loss caused by borrowers' inability to repay the principal and interests in accordance with the contract due to changes in its economic, political and social environments.

Central bank policies - In general, when the central bank increases money supply, the total amount of loanable funds will increase. On the contrary, when the central bank tightens the monetary policy to reduce money supply, the total amount of loanable funds will decrease.

Competition risk refers to the risk of increasing crises for other enterprises due to the decreased quality of banks' deposits and decreased bank profits.

Similar to commercial banks, microcredit risk also has the same risk classification. But because microcredit is mainly targeted at low-and-middle-income earners, management risk and operational risk are more prominent (see Section 3.1).

### **2.1.3 Risk identification of commercial banks**

Effective management cannot be realized without effective risk identification. Risk identification ability, which refers to commercial banks' ability to quickly and effectively identify external environmental risks and internal business risks, is the core and top priority for commercial banks to conduct risk management and control (Wu & Liu, 2015). Risk identification is aimed at not only the risks in bank management but also the causes of these risks.

Since the forms and influencing factors of risks differ, it is necessary to timely adjust the methods for effective response. There are two main ways of risk identification. The first is through financial statements, which is the most direct and effective method for risk identification. The second is through risk environment identification, which means to identify risk factors from the internal and external environments of bank management. To be specific, the following types of methods are commonly used (Chen, 2009):

CART risk classification (Classification and Regression Tree analytical techniques): These techniques are able to determine the complex interactions among variables in a decision tree and the relative importance of different variables in the dataset. Enterprise financial ratios are the standard foothold for risk classification.

Delphi expert opinion method: In the 1950s, famous American consulting companies introduced the expert opinion method characterized by predictive and decision-making functions. It is a very effective risk identification method for identifying more complex and more impactful reasons that cannot be identified through financial ratio analysis.

Risk derivation method: The risk derivation method identifies risks by directly verifying the element information of each action point of an enterprise and analyzing specific situation specifically.

#### 2.1.4 Risk measurement of commercial banks

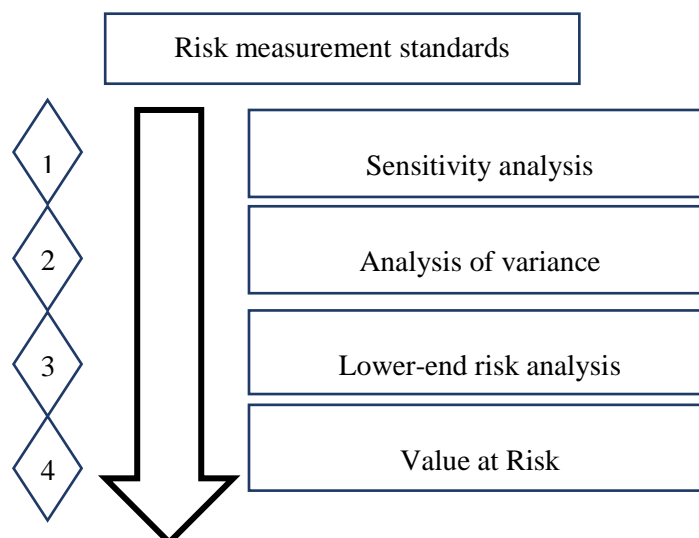


Figure 2-1 Risk measurement methods of commercial banks

Risk measurement refers to the use of numerical values to interpret risks and quantify the size of risks. Risk measurement determines risk management and control. In risk management practices, risk indicators are affected by many factors, as shown in Figure 2-1.

But the degree of return or market value of financial assets remains unchanged in the market economy. Risk measurement ways include: sensitivity analysis, analysis of variance, lower-end risk analysis and value at risk.

#### **2.1.4.1 Sensitivity analysis**

Sensitivity refers to the ratio of change of interest rates, exchange rates or stock prices when the rate of return, spread or market value of financial instruments or market conditions change (Berger & Frame, 2007). It mainly indicates the degree of change of the target variable when certain market factor changes. Since it is straightforward and convenient, it is widely used to analyze market risks. But it is not the most effective risk indicator in the risk management system. The sensitivity standard has the following limitations:

Additivity: Different transactions tend to integrate, and the same market factor has a tendency to add up. Yet the differences in market factors make the changes in market factors completely synchronized. Otherwise there is no additivity.

Multi-element standard: When multiple market factors affect the value of a portfolio, it is necessary to analyze each factor one by one and calculate their impact on the portfolio.

Approximate metrics: When the target variable only changes slightly, the sensitivity measurement is the ratio of the change value of the yield to the change value of the target variable.

Local metrics: when the target variable changes, it changes accordingly.

#### **2.1.4.2 Analysis of variance**

Variance is the most commonly used statistic for measuring the dispersion of random variables around the mean. For commercial banks, it refers to the profit or market value gap to the expected value due to changes in environmental conditions. Error of mean square is also referred to as volatility (Xing, 2016).



### **2.1.4.3 Lower-end risk analysis**

Volatility only applies to measuring the uncertainty of returns. But it cannot identify real risks. The risk is just the loss of lower-than-expected returns. Such loss is known as lower-end risk (Yang, Liang, & Li, 2006).

Losses occur due to uncertainty. The more unstable the market environment factors are, the more possible it is for losses to occur (Shao, 2003). However, if changes in the subject matter value will remain no lower than a certain standard regardless of the changes in market conditions, then there is indeed risk if measured according to volatility standards. But there is no lower-end risk if measurement is conducted according to the lower-end risk standards. Volatility and lower-end risk are two measurement standards that are correlated to the uncertainty of returns or market value. But the two are not equivalent. Compared to volatility, lower-end risk is a better standard for measuring real risks (Peng, 2001).

### **2.1.4.4 Value at risk and risk capital**

The value at risk (VaR) is defined as the maximum potential loss caused to a certain fund position, asset portfolio or institution when such market risk elements as interest rates or exchange rates change in a certain holding period or below the given confidence level  $\alpha$  (Zhou, 2003; Berger & Frame, 2007; Chen, 2014; Azad & Munisamy, 2016). Capital at Risk (CaR), which is the application of VaR in the asset field, refers to the capital that needs to be made up for the unexpected bank loss at a given time and confidence level (Huang, 2010; Yunus & Jolis, 2008).

The analysis and calculation of portfolio value volatility is the essence of VaR. The core is to establish the laws of portfolio value changes. It predicts the future through the volatility of the combined values. But the deduction of future value volatility is also uncertain. Therefore, when calculating VaR, diversified combinations of "market factors" are reflected in each asset. Such market factors as interest rates, exchange rates, stock indices or commodity prices may all affect the fundamental variables of asset value (Schicks, 2007; Sun, 2013).

Based on the above basic ideas, the basic steps of VaR calculation include: first, identify market factors and indicate all assets in the portfolio with market factors; second, speculate on the future change scenarios of market factors in some time to come; third, estimate the future value of the portfolio according to the future scenarios of the market factors; fourth, calculate the profit and loss distribution and calculate the VaR value at a given confidence level (Hartungi, 2007).

There are two keys to the calculation: One is the possibility of future market factor change. The other is whether the portfolio value will change if the market factors remain unchanged. There are four main ways to predict future market factor changes (Liu & Huang, 1993). The first is basic simulation, which refers to direct introduction of future scenarios of market factors under specific market factors. The second is to use Monte Carlo simulation to simulate future scenarios (Matsuda & Setoguchi, 2014). The third is the variance-covariance analysis method, which refers to the available variance and correlation coefficient method used to describe future market factor changes under the normal distribution of market factors. The sensitivity of market factors can reflect the portfolio value change. The linear function of market factor changes is also the value change of most assets. The fourth is the use of scenarios such as stress tests.

The calculation methods and types of VaR differ in different circumstances (see Table 2-1 for a comparative analysis).

Historic simulation method - Risk value calculation can be intuitively represented by historical simulations. The historical data of asset return can be used to weigh the current investment portfolio so as to arrive at the probability distribution graph. The advantages include convenience for understanding and use, a wide range of application, and the ability to improve the efficiency of difficult calculation tools. The disadvantages are virtuality, insufficiently rigorous data, huge technology input and lack of objectivity of historical data.

Variance-covariance method - Since the calculation basis of historical simulation is very complicated, the calculation process tends to be very cumbersome. Therefore, the variance-covariance method assumes that market factor changes are correlated to the

statistical laws of normal distribution. The variance-covariance matrix based on return on assets calculation is the fundamental footing of this method. Different models can be obtained according to the simplified feature calculation.

Table 2-1 Comparative analysis of VaR calculation methods

<b>Content of comparative analysis</b>	<b>Historical simulation method</b>	<b>Variance-covariance method</b>	<b>Monte Carlo method</b>	<b>Scenario analysis</b>
<b>Calculation speed</b>	Fast	Fast	Slow	Fast
<b>Method realization</b>	Relatively simple	Simple	Difficult	Simple
<b>Data collection</b>	Difficult	Simple	Simple	Relatively simple
<b>Market instability</b>	Deviation	Deviation	Deviation	Deviation
<b>Higher-level analysis</b>	Simple	Relatively simple	Difficult	Simple
<b>The ability to test other hypotheses</b>	Unavailable	Able to test the standard deviation and correlation coefficient; unable to test the distribution hypothesis.	Available	Unavailable

Monte Carlo simulation method - Similar to historical simulation method, Monte Carlo simulation method is mainly used to simulate future market factor changes (Du, 2006). Monte Carlo simulation method was introduced to obtain the possible return on assets. Its specific representations are: first, it derives the average rate of return, volatility and correlation coefficient of assets based on historical data; second, it identifies the virtual data of all market factors; third, it adjusts the probability of market data; fourth, it estimates the profit or loss of the portfolio. Results are obtained to draw the distribution map through the selection of different data for permutation and combination. The ability to describe various potential risks is a major advantage of this method compared to other methods. But its limitations are its higher cost and risks as well as longer time needed. In addition, this

method also applies to estimating expected fluctuations.

Scenario analysis and stress test - Factors causing uncertainty in the environmental and financial markets abound, none of which can be accurately measured. Unexpected events can cause markets to change dramatically due to these factors, which will lead to a huge bankruptcy crisis. The only effective way to control such risks is to leverage on scenario analysis and stress test. The generation of scenario analysis relies on variants of the simulation method. It mainly studies whether return on assets is affected by drastic financial variable fluctuations. This analysis method can effectively assess risk value and is not dependent on historical data. The advantage of scenario analysis is the ability to quickly and efficiently deal with potential problems in historical data. Its disadvantages, namely, independent choice and virtuality, also keep unfolding in the course of its development. First, the scenarios to be analyzed are based on independent choices and different people choose differently (Hao & Wang, 2012). Second, the scenarios chosen may not be objective enough.

## **2.2 Integrated asset and liability management theory**

### **2.2.1 Asset-liability management theory**

The asset-liability management theory originated in the mid-1970s (Wang, 2005). under the circumstances that the limitations of asset management theory and liability management theory were becoming more and more obvious. It is the combination of asset management theory and liability management theory at a higher level (Matsuda & Setoguchi, 2014; Bao, 2015). It links assets and liabilities and gives them a holistic consideration by putting them under common objectives and in an equivalent economic environment in order to achieve optimal match of assets and liabilities, rationalize the structure of funds, and maintain a balance between the profitability, liquidity and security of bank funds, thereby seeking to maximize operating income and minimize business risk (World Bank, 2002; World Bank, 2003; Yunus *et al.*, 2010). According to the theory, it is

difficult for commercial banks to strike a balance between security, liquidity and profitability by relying on asset management or debt management alone (Azad & Munisamy, 2016). Only through the integrated and coordinated management of assets and liabilities according to the changes in economic conditions can the requirements of general business policies be met and the business objectives reached. The basic principle is that gross balance and structure correspondence are reached through symmetry of the repayment period, substitution of business objectives and diversification of assets. The integrated asset and liability management theory has become a basic method and means widely used by modern commercial banks.

The asset and liability management of commercial banks can be seen in either the narrow or the broad sense. In the narrow sense, asset and liability management is viewed as an aspect of focusing on security, efficiency and liquidity, often defined from two perspectives. First, from the perspective of interest rate risk, the management of interest rate risk by commercial banks in the production and operation process is the top priority of asset and liability management. Second, taking liquidity risk as the foothold, mastering liquidity security is the core of asset and liability management.

With strengthened comprehensive risk management, banks actively emphasize the balance between bank safety, efficiency and liquidity, making asset and liability management more and more important. In the broad sense, asset and liability management is a comprehensive management tool, which, plans, dominates and controls the bank's asset and liability business and its portfolio while taking into account different interest rates, liquidity and early repayment assumptions, so as to strike a balance between security, efficiency and liquidity. Management must comply with the unity of safety, efficiency and liquidity. Simply following safety, efficiency or profitability is by no means what modern financial institution management is all about.

### **2.2.2 Measurement of asset and liability management**

The fundamental goal of the asset-liability management theory of commercial banks is

to resolve the conflicts between security, efficiency and liquidity. In order to achieve the best combination of these three principles, the asset and liability management of commercial banks is actually achieved in a comprehensive manner. Therefore, a bank's asset and liability management is measured by the comprehensive development level of its security, efficiency and liquidity.

#### **2.2.2.1 Safety indicator**

Z index value is used to assess bank security. This comprehensive measurement method takes into account both the risks related to banking business and the capital commitment of these risks. The results of the research indicate that if the profit is assumed to follow a normal distribution, then the Z index value is inversely proportional to the ruin probability. This is because Z represents the standard deviation of the return on assets (ROA). And when the stock is significantly reduced or bankrupt, the return on the bank's assets will be lower than expected. Roy (1952) points out that Z index value can be estimated using the probability of default. This was further developed by Goyeau and Tarazi (1992).

Z index is considered to be the index of bank security and stability. A higher Z index will result in less likelihood of bank default, lower bankruptcy risk and higher security, whereas a lower Z index will lead to more likelihood of bank default, higher bankruptcy risk and lower security. However, Z value is not the only basis for judging the financial status of an enterprise. The trend of Z value should also be properly considered. The trend and speed of change of Z value should be grasped to arrive at the business status of an enterprise, thus achieving accurate early-warning of risks and minimizing the loss caused by the risk.

#### **2.2.2.2 Benefit indicator**

A commercial bank's profitability refers to its ability to gain the maximum economic profits through the optimal allocation of funds. From the perspective of accounting indicators, it is possible to comprehensively analyze the indicators of commercial banks'

profitability from such aspects as total ROA, return on net assets (RONA), profit margin and profit cost. To be specific, ROA comprehensively reflects a bank's profitability, including not only the bank's capital gains, but also its debt income. Therefore, in this study ROA was chosen as the indicator to measure a bank's profitability.

### 2.2.2.3 Liquidity indicators

RMB (Chinese currency) excess reserve ratio refers to the proportion of monetary fund commercial banks use to ensure payment and liquidation, so as to meet the needs of capital operation. It can be used to reflect the cash status of a bank and measure the liquidity of the bank. The higher the RMB excess reserve ratio, the stronger the liquidity of the bank.

A low ratio means that the bank's liquidity is insufficient, which may affect the bank's normal redemption. The reason for focusing on a bank's RMB excess reserve ratio is to monitor whether the bank has normal payment ability and ensure there is a certain proportion of cash and liquid assets to meet the clients' withdrawal demand.

$$\begin{aligned} \text{RMB excess reserve ratio(ER)} &= \frac{\text{Excess reserve deposit + cash}}{\text{Various deposit balances}} \times 100\% \\ &= \left( \frac{\text{Cash and deposits with the central bank}}{\text{Various deposit balances}} - \text{Statutory deposit reserve ratio} \right) \times 100\% \end{aligned} \quad (2.1)$$

In order to make a comprehensive analysis of a bank's liquidity from its balance sheet, the following indicators generally need to be relied on:

Liquidity gap -Liquidity gap refers to the shortage of fund caused by the difference between fund application and fund channels in a certain period. Liquidity gap can be either positive or negative. If a liquidity gap is positive, then fund supply cannot guarantee the flexible flow of the capital chain, and new fund must be added to ensure the normal flow. If a liquidity gap is negative, then it is necessary to ensure that the net value is stable enough to cope with such variables as assets and liabilities.

Ratio of core deposit to total assets -Fixed deposit, which is also referred to as core deposit, is not affected by changes in interest rates or the economic environment. A commercial banks' access to stable fund is based on the flexibility of its financial deposit.

Non-core deposit, also known as volatile deposit, is strongly affected by external factors. The adverse changes of commercial banks often produce a butterfly effect on non-core deposit.

Ratio of current assets to total assets - Short term, high credibility and high liquidity are the notable characteristic of liquid assets. The greater the ratio of current assets to total assets, the stronger the demand for adapting to market liquidity.

Ratio of volatile deposit to total assets - In commercial banks, deposits that are easily affected by interest rates are known as volatile deposits, which mainly include bonds under sale (under repurchase agreements) and certificates of large-amount deposits. Once commercial banks are affected by market interest rate regulation, volatile deposit might be lost. The ratio of volatile deposit to total assets measures the extent to which a commercial bank relies on unstable deposit to obtain the fund it needs. In general, when other ratios are the same, the bigger the ratio of volatile deposit to a commercial bank's total assets, the greater the liquidity risk faced by the commercial bank.

### **2.3 Project management theory based on continuous improvement of IDEAL model**

The traditional credit model consists of three stages, namely, pre-loan, during-loan, post-loan stages, in other words, “loan investigation”, “loan review” and “post-loan verification”. From the credit risk control dimension, this management model is effective. But in such dimensions as “cost accounting of operations”, “operational sustainability”, “appropriate and effective loan limit” and “beneficiary inclusiveness”, the traditional model cannot meet the requirements. This is because the traditional loan risk control model only pays attention to the three time points in the entire loan process, whereas credit risk control should be integrated, processed and continuously iterated. This study, drawing on the continuously improving project management theory of the IDEAL model, aims at continuously iterating the goals and requirements of farmers' microcredit from the whole process, so as to find effective ways to solve these problems.



### 2.3.1 IDEAL model overview

The IDEAL model represents a life cycle of process management activities and it has been widely adopted as a fundamental strategy (Chen, 1997). The project management blueprint is set through transforming specific models. It usually starts with the implementation and planning of the model to develop the concrete steps involved in the successful continuous improvement project model. This provides a useful model for the reference of our research on the risk iteration process of farmers' microcredit.

The IDEAL model is named after the five stages of process improvement:

I-Initiating: The preparation of basic procedures and relevant facilities in the early stage is the key to the success of this project implementation.

D-Diagnosing: Set clear goals and understand the organization's level of competence in the current stage.

E-Establishing: Draw up a scientific and reasonable plan to achieve the target level.

A-Acting: Carry out the specific implementation actions of the plan.

L-Learning: Keep improving the project objective, summarize and apply the years of experience accumulated, and implement specific processes with new tools and new technologies.

Figure 2-2 vividly demonstrates the entire work framework of the IDEAL model. The study of IDEAL model at the Institute of Software Engineering at Carnegie Mellon University in the United States shows that it is able to continuously support improvements and is a representative among improvement models. The framework integrity can be represented by the IDEAL model, describing the necessary resources required for successful process improvement. The IDEAL model describes in detail the activities in the process improvement plan and provides a series of perspectives and opinions that should be included in the process of translating process improvement ideas into enterprise practices.

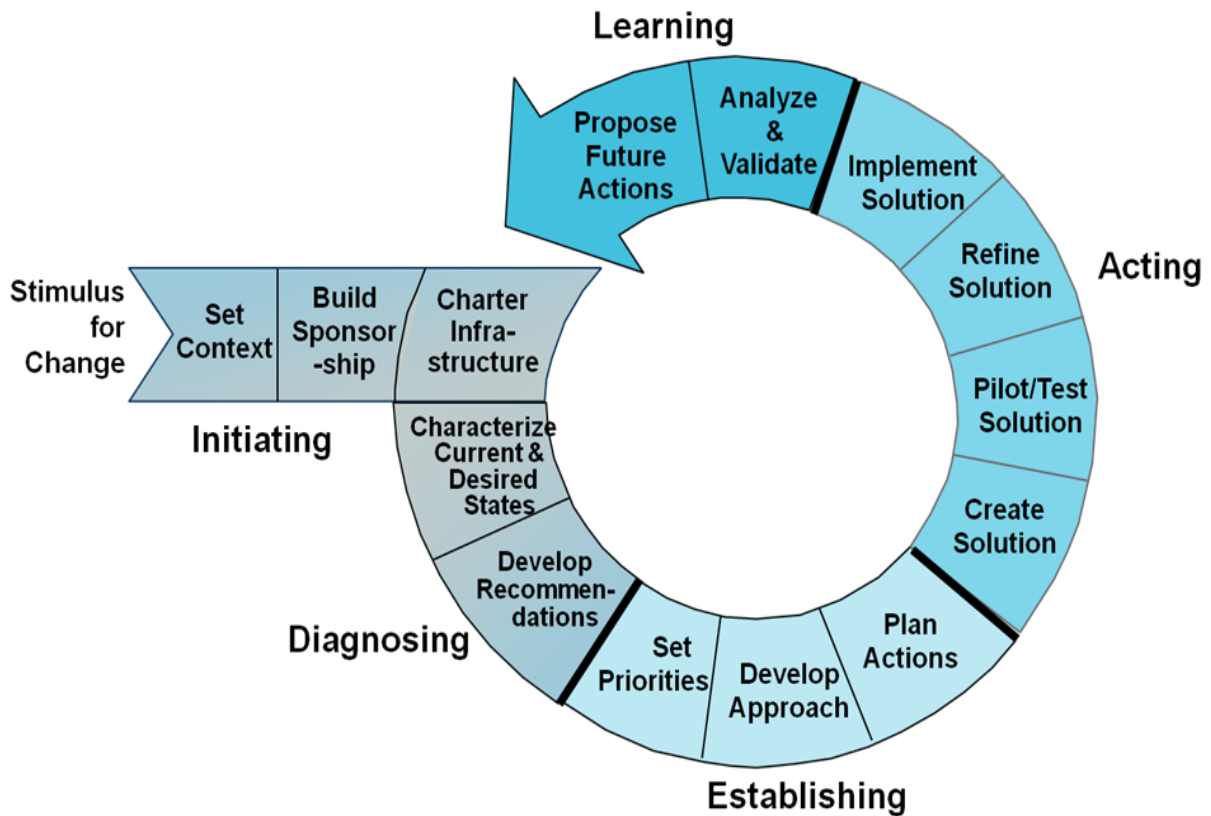


Figure 2-2 IDEAL model flow chart

Source: Hainan Rural Cooperatives (2010)

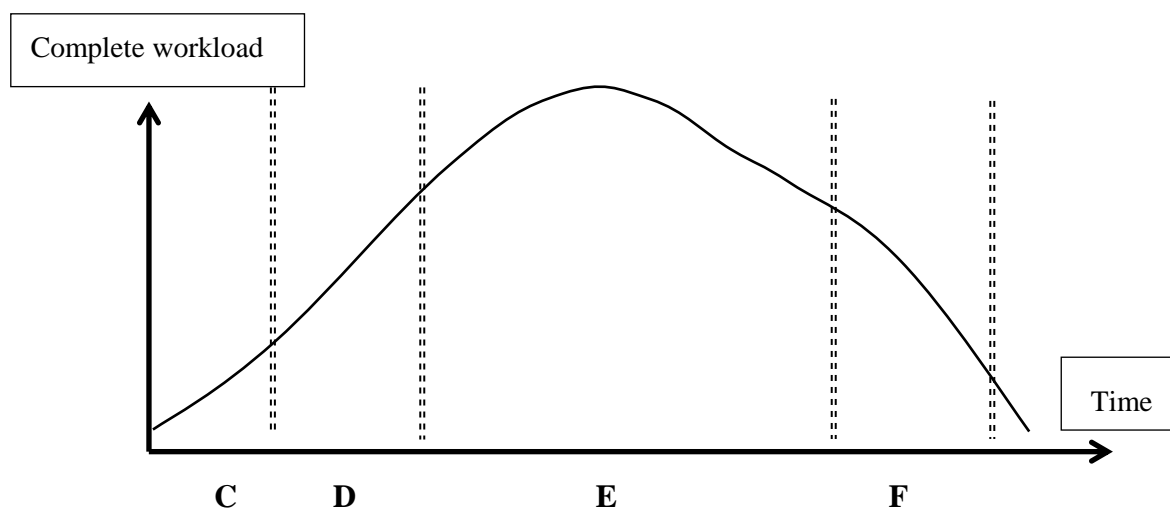
### 2.3.2 An analysis of the process improvement features of IDEAL model

The IDEAL model has a certain life cycle with projects as its management units. Implementation of projects is a milestone and can also achieve sustainable work improvement. Projects are mainly aimed at solving people's urgent problems. There are two types of projects, demand projects and demanded projects. According to the IDEAL model framework, project implementation can be divided into four aspects: first, the project conceptual model is built on the basis of summary; second, the project can be divided into several different tasks from the conceptual model perspective; third, complete each task; fourth, the project results come from integrating the equipment results. Each piece of work is constantly looping the following five patterns, from initiating to diagnosing, then to establishing, acting and finally to learning. Only the combination of human resources, process support capabilities and organizational capabilities can elevate the improvement

process to a strategic level. The focuses of this process improvement are guiding ability, marketing adaptability and process execution ability. Process improvement management is realized through such abilities as quality assurance ability, cost control ability, project planning ability and risk management ability.

### 2.3.3 Management characteristics of IDEAL model

The project implementation process can be divided into four different stages, namely, conceptual stage, development stage, implementation stage and completion stage (Zhang, 2012). Management and content differ at different stages. Figure 2-3 provides detailed descriptions of the four stages.



C-Conceptual stage	D-Development stage	E-Implementation stage	F- Final stage
<ul style="list-style-type: none"> <li>●Identify needs and plan projects;</li> <li>●Conduct research and collect data;</li> <li>●Identify target;</li> <li>●Carry out feasibility study;</li> <li>●Establish partnership;</li> </ul>	<ul style="list-style-type: none"> <li>●Identify main members of the project team;</li> <li>● Define the scope of the project's final products;</li> <li>● Study the plan;</li> <li>● Determine the project quality standards;</li> <li>● Guarantee the project resources;</li> </ul>	<ul style="list-style-type: none"> <li>● Establish project organization;</li> <li>● Establish and improve project communication channels;</li> <li>● Implement the project incentive mechanism;</li> <li>● Establish project work packages to detail technical requirements;</li> </ul>	<ul style="list-style-type: none"> <li>●Final product completion;</li> <li>● Evaluation and acceptance;</li> <li>●Final account liquidation;</li> <li>●Project</li> </ul>

<ul style="list-style-type: none"> <li>● <b>Determine risk level;</b></li> <li>● <b>Formulate a strategic plan;</b></li> <li>● <b>Estimate resources;</b></li> <li>● <b>Propose setting up a project team;</b></li> <li>● <b>Propose project proposal;</b></li> <li>● <b>Gain approval to the next stage.</b></li> </ul>	<ul style="list-style-type: none"> <li>● Guarantee the project environment;</li> <li>● Formulate the main plan;                             <ul style="list-style-type: none"> <li>● Estimate the project budget and cash flow;</li> <li>● Work Breakdown Structure (WBS);</li> </ul> </li> <li>● Formulate project policies and procedures;                             <ul style="list-style-type: none"> <li>● Carry out risk assessment;</li> </ul> </li> <li>● Confirm project validity;</li> <li>● Propose project briefing and gain approval to the next stage.</li> </ul>	<ul style="list-style-type: none"> <li>● Establish project information control system;</li> <li>● Execute the work of WBS;</li> <li>● Obtain ordered items and services;</li> <li>● Guide/Supervise? Forecast/Control: scope, quality, progress, cost</li> <li>● Solve problems in implementation.</li> </ul>	<ul style="list-style-type: none"> <li>evaluation;</li> <li>● Document summary;</li> <li>● Resource cleanup;                             <ul style="list-style-type: none"> <li>● Shift product owners;</li> </ul> </li> <li>● Dissolve the project team.</li> </ul>
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Figure 2-3 An introduction to project implementation content

Source: Lin (2007)

In the C-conceptual stage, the project feasibility should be studied. Planning, feasibility study, data collection, risk assessment and recommendations for the project are all included in the feasibility study. The key to the success of the project lies in the identification of risks and the formulation of organizational plans.

Based on the IDEAL model, the financial and personnel situation of the feasible project is developed. The overall project plan includes selection of materials as well as preparation of all software and hardware. The root of the successful project implementation lies in the work preparation at the development stage, covering planning of project tasks and allocation of resources. Then corresponding objectives are set, and the scope is identified. The project team needs the participation of technical members to strengthen technology development (Shi, 2018). Members of various departments should perform their own duties before identifying the overall plan and specific implementation plan of the project.

E-Establishing stage is the stage with the longest duration, largest amount of workload

and largest consumption of resources in the project life cycle. In this stage, it is necessary to combine the specific links of the network plan and the project work structure, so as to complete various tasks according to quality and quantity requirements and get maintenance. The management focus in this stage is to organically integrate prediction, supervision and management, guidance and control. It is difficult to implement this stage as various factors come into play, such as smooth project completion, control and prediction of risks, grasp of project details tracking, as well as the organization, development and coordination abilities.

F-Final stage is the closing stage, where relevant work of project completion is carried out and the final products delivered. The project organizer shall organize project core persons and coordinate the financial staff of the institution to complete the project. Project completion activities usually include financial liquidation of the project, document cleanup and transfer of information. Final stage work is the key to ensuring the complete closure of the milestone stage of the project, supporting the project as an enterprise asset, and enabling process reuse.

Systematically and comprehensively analyzing project management according to the specific project management content and different life cycles and in conjunction with different methods and strategies is the top priority of project management.

#### **2.3.4 Project stages and milestone characteristics of IDEAL model**

Under the guidance of the IDEAL framework, the management and control of execution projects and implementation projects are enhanced through enhancing the management of each project stage. Meanwhile, project implementation methods and stage milestone management are leveraged to reduce pre-existing project deviation (Johnson, Wu, Escalante, & Li, 2016). In this way, the project deviation will be minimized to ensure successful implementation. See Figure 2-4 for a vivid illustration.

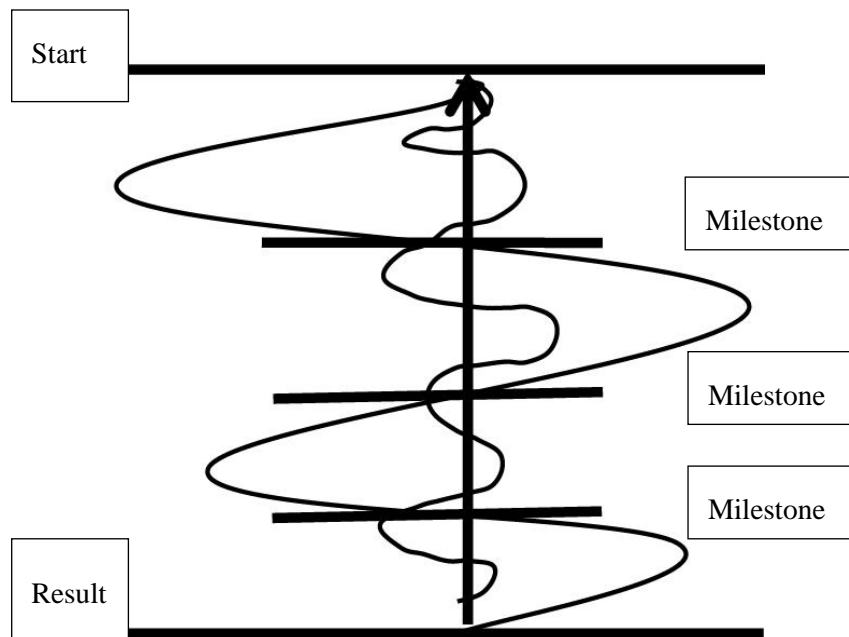


Figure 2-4 Project milestone curve

In Figure 2-4, the project implementation is not only affected by one-time factors, but also has a long implementation period, and its outcome remains uncertain. According to the IDEAL model, the division of each project period must be clear, and successful experience of previous projects should be continuously drawn on to track the project cycle from both time and event-driven aspects. The purpose is to control the project target deviation within the controllable range and avoid the risks in the project implementation process.

### 2.3.5 An analysis of the process improvement elements of IDEAL model

According to the analysis of project institutional capability elements, IDEAL model combines the role of traditional corporate functions with the role of project activity processes. Project institutions can be divided into matrix structure, network structure, business department structure and linear functional structure according to different levels, namely, management level, decision-making level and execution level that are often referred to. The IDEAL project can be used to improve structural requirements to re-plan the staffing and identify the management scope of functional department management.

The IDEAL model has a strong organizational structure, which can be flexibly

managed as the environment changes. Therefore, it has inherent advantages for process improvement. It can be seen from the thousands of years of Chinese history that the concept of hierarchy is very strong. And it is exactly this hierarchical structure that guarantees the stability of the system. In spite of this, the three-layer structure is currently the most perfect structure. It has a very strong adaptability to the organizational process to improve the labor force and flexibility. Such issues of the project as financial problems, administrative management problems, human resource allocation problem and project implementation services can all be improved due to the perfection of the organizational abilities.

## **2.4 Chapter summary**

This chapter first briefly describes two theoretical areas that support microcredit risk management mechanisms, namely, the comprehensive risk management theory of commercial banks and the integrated assets and liabilities management theory. It mainly introduces the risk classification, risk identification and risk measurement of commercial banks, as well as the measurement indicators of asset and liability management. Besides, this chapter elaborates on the project management theory based on the continuous improvement of IDEAL model, including its specific meaning, the project management process and the specific implementation content of each process.

The above presentation provides a theoretical basis and research direction to analyze the problems existing in RCCs' microcredit business in rural areas and to contribute to overcome by exploring a new path, a new model and a new experience suitable for the development of microcredit for farmers. These efforts aim to facilitate the healthy and sustainable development of microcredit in China's rural areas.

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## **Chapter 3: Existing System of Microcredit Risk Management of Rural Credit Cooperatives**

### **3.1 Microcredit risk of rural credit cooperatives**

The rural financial market is full of risks. Therefore, RCCs and microcredit institutions are confronted with numerous risks, including credit risk, interest rate risk, legal risk, operational risk and management risk. Adverse selection and moral hazard also need to be considered (Zhu & Zhang, 2011).

Credit risk - Credit is the standard for evaluating a person's moral quality. Failure to repay in time or failure to invest in the agreed project is a breach of contract. Credit is like a person's reputation, which he/she uses as a guarantee to borrow loans from a bank. Farmers borrow loans with their personal credit as a guarantee and repay the principal and interest when the loans are due (Liang, 1998). However, in China's rural areas, the credit system is not perfect and farmers' credit awareness is weak, which leads to the highest credit risk in rural microcredit. From the perspective of RCCs, there are a small number of farmers with a higher level of credit rating. Farmers' credit rating is often evaluated on the basis of relevant information provided by village committees or village groups, and their loan amount is verified accordingly. However, in order to obtain loans, farmers will conceal the unfavorable information. As a result, the assessment may not be correct. Even if a reasonable and rigorous assessment of farmers' credit has been carried out, there is no guarantee that farmers will not pose moral hazard risks after obtaining the loan.

Interest rate risk - The People's Bank of China, China's highest financial authority, set a unified currency lending rate, which is the sum of the benchmark interest rate and the floating interest rate of RCCs loans (it provides that the benchmark interest rate should be four times lower than the floating interest rate) (Editorial Committee of *Microcredit in*

*China*, 2013). Practice shows that RCCs adopt a preferential interest rate policy for most rural micro loans. This microcredit floating rate remains unchanged, which forms a stark contrast to the high operating cost of credit unions. Credit cooperatives continue to lower lending rates to help rural areas get rid of poverty. However, the implementation effect of low interest rate policies is not satisfactory. Many opportunities are seized by enterprises and wealthy people.

Legal risk - Current microcredit ratings are subjective, including credit users, credit villages and credit towns. Seen from the current practice, in the evaluation process, credit unions and local government departments have no supervision or restraints over farmer representatives, village cadres or loan officers. As there is no assessment from an intermediary organization, the rating of clients' credit is based only on their credit and operating conditions over the past few years. This may lead to legal disputes and even legal risks.

Operational risk - Due to the vast area of land and scattered households in China's rural areas, carrying out microcredit requires a lot of time and efforts (Ha, 2012). In addition, farmers' credit and loan amount are all assessed by manual operations and their files are created manually. The workload is so huge that it is difficult for loan officers to go door-to-door to identify needs and note down details. And because farmers' locations are scattered, it is difficult to concentrate the supervision and management work after loan disbursement. Moreover, there is a lack of objective data as the theoretical support in the process of credit evaluation of borrowers. In consequence, these factors will bring potential credit risk to loans and credit cooperatives.

Management risk - The decision-making management of rural credit institutions is not rigorous and their supervision mechanism is not sound. The borrowing rights are often concentrated in a small number of people. Besides, since the rural microcredit incentive mechanism cannot attract high-end customers, such problems have been caused as the mismatch between profits and responsibilities, and limited rights of small institutions. As a result, the lending risk and cost of rural microcredit companies cannot be effectively

controlled.

Adverse selection - Adverse selection in the rural microcredit market refers to the provision of loans to borrowers who have the biggest risk and are least likely to repay the loans because they are the most active and willing to pay high interest rates (Zhu & Zhang, 2011). However, the result is often credit failure and market shrinkage. Borrowers without mortgage as a prerequisite for loan application are more willing to borrow to invest. And borrowers with high risks have a higher initiative to borrow loans. As a result, high-risk borrowers crowd low-risk counterparts out of the market, increasing the overall risk of the market.

Moral hazard - Rural microcredit has clear requirements for borrowers' investment projects. If a borrower fails to invest in accordance with the contract after receiving the loan, the situation is considered a credit moral hazard (Wang, 2005). What is worse, the borrower is very likely to use the loan to invest in other high-risk projects, which will eventually result in his/her inability of repayment on time.

### **3.2 Microcredit interest rate risk management**

Interest rate is an important part of microcredit business. Whether microcredit institutions can implement repayment measures for farmers, effectively implement non-financial businesses and maintain sustainable development, is more or less related to the interest income of micro loans, which is what is known as interest rate level (Feng, 2016). When interest rates are low, it is hard to meet the needs of high-income farmers, the operational structure of microcredit will be affected, and microcredit institutions will find it difficult to sustain their current financial situation. Therefore, from a comprehensive perspective, the key for microcredit institutions is the interest rate level.

#### **3.2.1 Microcredit interest rate mechanism**

Relevant studies on microcredit risk by international scholars usually regard the sustainability of microcredit finance as the only measurement standard (Han, 2008).

International research institutions use Subsidy Dependence Index (SDI) to measure the commercialization level and sustainable development ability of microcredit. SDI refers to the ratio of the subsidies obtained by microcredit institutions to their interest income. When  $SDI=0$ , the microcredit institution assumes sole responsibility for its profits or losses; when  $SDI=100\%$ , doubling interest rates can help the microcredit institution realize self-financing; when  $SDI \leq 0$ , it indicates not only that the microcredit institution has been fully commercialized, but also that the profit rate after the cost reduction exceeds the total fiscal subsidy. Moreover,  $SDI \leq 0$  also means that in the context of receiving no subsidies, the microcredit institution will lower the average loan interest rate (Dexu & Miao, 2015).

The other indicator measuring the sustainability of microcredit institutions is “self-sufficiency”. It has two layers of meaning. First, the minimum standard for achieving sustainable development - operational self-sufficiency (OSS), measures whether the income of a microcredit institution can cover its operating cost. In this model, when  $OSS > 100\%$ , it means the credit institution has achieved sustainability (Chen, 1997). Second, financial self-sufficiency (FSS) measures a microcredit institution's self-survival and development ability without relying on any subsidy. When  $FSS > 100\%$ , it means the credit institution has financial sustainability. The above models can be used to study and measure the commercialization level of microcredit institutions to lay a fundamental research method for commercializing microcredit.

### **3.2.2 Measurement methods of microcredit interest rate**

There are three microcredit interest rate calculation methods: The first is based on the bank's benchmark interest rate. The second uses the inflation rate as microcredit interest rate. And the third, which is based on the benchmark interest rate, determines the microcredit interest rate according to the control level set by the Supervisory Board of the Central Bank of Republic of China (between 2.88% and 11% at this time). In short, microcredit interest income must cover its cost.

### 3.2.3 2.3-time interest rate premium

Currently, many theorists have clearly noticed the drawbacks of interest rate suppression in rural areas. They start to put forward suggestions to open up loan interest rates in rural areas. Policy makers also begin to release interest rate control. For example, the People's Bank of China permitted the increase of loan interest rate to 2.3 times of the benchmark interest rate (5.37%) to around 12%. However, this interest rate might still be a suppressed interest rate, and the faults of the low interest rate policy cannot be effectively eliminated. Interest rate suppression makes farmers face overall credit rationing, rendering many farmers unable to obtain loans. Coupled with such factors as information asymmetry and moral hazard, credit institutions may trigger adverse selection in lending. Credit institutions will be unable to clean up the market environment by raising interest rates. When interest rates are raised, high-quality low-risk clients will choose to exit the current market and find alternatives to obtain funds. Only high-risk clients will choose to stay. Therefore, credit institutions often choose to use the "menu-style" supply method to avoid risks:

- (1) Provide low-interest loans to clients who can provide effective mortgages. Their credit needs will be fully met and there is no need for credit rationing.
- (2) Some clients do not have collateral while borrowing. In this case, only partial fund should be supplied to them and the fund must be under strict monitoring, so as to force borrowers to invest fund in the project and prevent the moral hazard where borrowers pursue "bad projects".
- (3) Raise interest rates close to the highest point of expected earnings and carry out the second method of credit rationing.

In adopting the second type of credit rationing, financial institutions are free to determine the level of interest rates as one of the necessary conditions for providing supply. Applying this simple model to the rural microfinance equilibrium interest rate is very appropriate. For microfinance demand without effective collateral, if loan risk control is to be carried out, interest rate levels must be raised to compensate for possible credit default risk as well as high management and regulatory costs.

### **3.2.4 Farmers' microcredit rate: a theoretical model related to output rate**

The high interest rates of rural micro loans are determined by two key factors. The first is the marginal output of capital and the second is the leisure effect of farmers. The first factor can be illustrated by the neoclassical growth model, with high margins of capital output and low capital. Under certain circumstances, if rural areas can effectively increase the amount of investment, low-income farmers' demand for micro loans will increase. The second factor is to use the leisure time of farmers. Low-income farmers have no leisure time. They need to work more to improve their current living environment. So, the second factor is a compulsive behavior for farmers, and they do not consider leisure to be valuable. After a comprehensive analysis, even if microcredit interest rates are very high, the demand for micro loans in many rural areas will still increase, and higher interest rates will also bring income to borrowers.

### **3.3 Risk indicator system of rural credit cooperatives**

At present, the risk assessment of commercial banks in China is mainly based on three aspects. The first is the impact of macroeconomic environment changes on the operation of commercial banks. The second is the requirement of commercial supervisory banks for commercial banks. When commercial banks fail to meet the requirements of the regulatory authority, they may face the risk of being punished or even going into bankruptcy; The third is the risk of losses to commercial banks caused by customer defaults or operation failure. RCC risk assessment system is mainly established from the above three aspects.

#### **3.3.1 Macroeconomic environmental indicator system**

Rural economic development, local government intervention and financial market development form the main external environment affecting credit risk control. The specific impacts of the external environment on the operation risk of RCCs include:

(1) Rural economic development - The more developed the county economy of RCCs, the lower the credit risk. The economic development level of various counties and areas depends on the per-capita income of rural residents, which will affect the project selection

by RCCs.

(2) Importance the government attaches to agriculture - Local government's financial support for agriculture reflects its financial support for the development of agriculture, rural areas and farmers. The greater the government's support for agriculture, the lower the credit risk of RCCs.

(3) Degree of local government intervention - The greater the county government's intervention in the allocation of financial resources of RCCs, the higher the credit risk. The difference between local government fiscal revenue and expenditure shows its financial pressure. It reflects the possibility of the local government's intervention in the allocation of financial resources and concealing debts of RCCs.

(4) Development level of rural financial markets - The better the county financial market development, the lower the credit risk. Since county-level RCCs and other banking institutions have the same business in the field of agricultural loans, when selecting agricultural loans from county-level RCCs, the market share will be the ratio of their agricultural loans to all agricultural loans. In this way, data of rural cooperative projects can be fed back.

(5) Development of the external financial market environment for financial institutions.

Through the above evaluation indicators, the external environmental impact model of RCCs can be established to evaluate the impact of the external environment on their operation risks, thereby effectively managing the external environmental risks through improving the external environment.

According to historical experience and data, regression models of the non-performing loan ratio of RCCs in a certain region may be established in connection with such factors as rural economic development in the region, degree of local government intervention and development level of the rural financial market. These models are used to establish the external environment impact model of RCCs and give early warnings of non-performing loans for RCCs according to the external environment development.

### **3.3.2 Regulatory indicator system of banking regulatory authority**

Since 2011, China Banking Regulatory Commission (CBRC) has successively introduced five regulations, namely, “Guiding Opinions on the Implementation of New Regulatory Standards in China’s Banking Industry”, “Measures for the Administration of the Leverage Ratio of Commercial Banks”, “Administrative Measures for the Loan Loss Reserves of Commercial Banks”, “Administrative Measures for the Capital of Commercial Banks (for Trial Implementation)” and “Measures for the Liquidity Risk Management of Commercial Banks (for Trial Implementation)”. These regulations set a series of regulatory indicators in four aspects, namely, asset quality, liquidity, profitability and capital adequacy ratio, and also set the target supervision values for each indicator from the perspective of supervision (Chen, 2011) (see Table 3-1).

### **3.3.3 Client default and operational failure risk assessment indicator system**

#### **3.3.3.1 Farmers’ default evaluation index system for rural credit cooperatives**

The individual characteristics, household income, expenditure structure, default perception and loan characteristics of farmers jointly determine the possibility of their default (Table 3-2). Based on the corresponding indices, a model is built to analyze farmers’ default probability and farmers’ credit files are established to evaluate the default risk of new applicants, in order to reduce the credit losses of RCCs.

The logistic regression analysis model of farmers’ loan default is applied using the historical sample data of RCCs, to assess the farmers’ loan default predicted probability. Then the profiles of RCCs’ loan clients are set up, providing a quantifiable forecasting basis for the loan default of RCCs.

#### **3.3.3.2 Enterprise operation failure default evaluation index system**

The loan loss possibility of RCCs is evaluated according to such indicators as company scale, solvency, operational capability, profitability and development. Through the above evaluation index system, the default model for corporate clients is established to evaluate the default probability of new clients, thereby controlling the operational loss of RCCs.



Table 3-1 Bank regulatory indicator system

Regulatory indicator		Definition	Target
<b>Asset quality indicator</b>	Non-performing loan ratio	The ratio of non-performing loans to the total loan balance	Lower than 5%
	Provision coverage ratio	The ratio of loan loss provisions to non-performing loans	No lower than 150%
	Loan provision ratio	Ratio of loan loss provision to loan balance	No less than 2.5%
<b>Liquidity indicator</b>	Deposit-loan ratio	Loan-to-deposit ratio	Lower than 75%
	Current ratio	The ratio of current assets to current liabilities	No lower than 25%
	RMB excess reserve ratio	The ratio of the sum of excess reserve deposits and cash on hand of the People's Bank of China to the ending balance of various RMB deposits	No lower than 2.5%
	Liquidity coverage	High-quality liquidity assets meet the liquidity needs in the next 30 days	No lower than 100%
	Net stable financing ratio	The amount of stable financing available to the necessary stable financing amount	No lower than 100%
<b>Benefit indicator</b>	Cost to income ratio	The ratio of operating cost to operating income	Lower than 45%
<b>Capital adequacy index</b>	Capital adequacy ratio	The ratio of total assets to risk-weighted assets	No lower than 8%
	Core capital adequacy ratio	The ratio of core assets to risk-weighted assets	No lower than 6%
	Ordinary share capital adequacy ratio	Ratio of common stock to weighted assets	No lower than 5%
	Capital retention buffer	Aimed at ensuring that banks hold buffer funds to absorb losses during financial and economic crises	Request to establish a 2.5% capital retention buffer
	Countercyclical capital buffer	Protect the banking system from the surge in credit, with GDP ratio as a reference	Countercyclical capital buffer is 0-2.5%
<b>Systemically important bank additional capital</b>	Supplementary capital regulatory requirements for systemically important banks	Set as 1%	
<b>Leverage</b>	Core capital to adjusted balance of in-and-off-balance assets	No lower than 4%	

Source: Chen (2011)

The logistic regression analysis model or the BP (back propagation) neural network model of enterprise loan default is established according to the historical sample data of RCCs, as shown in Table 3-3. On this basis, the enterprise loan default probability prediction model is established to provide a quantifiable prediction basis for relevant default predictions.

Table 3-2 Farmers' default evaluation index system

	<b>Index</b>	<b>Definition</b>
<b>Individual characteristics</b>	Age	$\geq 50$ years old=1, 50-40 years old=2, 40-30 years old=3, $\leq 30$ years old=4
	Educational attainment	Elementary school=1, junior high school=2, high school=3, university and above=4
	Labor force population	The sum of the number of people with work ability
	Family support factor	Old people, children, students
	Working population	Number of migrant workers
	Main income channels	Planting = 1, farming = 2, salary = 3, business service = 4
	Grain farmers or not	Crops as the main food = 0, income from planting economic crops and breeding etc. = 1
<b>economic structure</b>	Total household income	$>100000=1, 5-10$ million=2, 2-5 million=3, $\leq 20000=4$
	Have loan(s) or not	Yes=1, No=0
	Maximum expenditure use	Agricultural investment = 1, housing = 2, education = 3, medical = 4, non-agricultural = 5
<b>Loan trait</b>	Loan balance	$\leq 10000=1, 10000-20000=2, 20000-50000=3, > 50000=4$
	Loan rates	Effective interest rate at the time of loan
	Loan term	$\leq 6$ months=1, 6 months-1 years=2, 2-3 years=3, 3 years and above=4
	Loan method	Mortgage = 1, guarantee = 2, credit = 3

Source: Hainan Province Rural Credit Cooperatives (2007-2018)

Table 3-3 Enterprise default evaluation index system

	<b>Index</b>	<b>Definition</b>
<b>Solvency indices</b>	Asset-liability ratio	Total liabilities to total assets
	Current ratio	Current liabilities to current assets
	Cash current debt ratio	Net cash flow from operating activities to current liabilities
	Interest coverage ratio	EBIT margin to interest expense
<b>Operating capacity</b>	Total asset turnover	Net sales income to the average balance of assets
	Accounts receivable turnover	Net sales revenue to average accounts receivable
	Inventory turnover	Cost of sales to average inventory
<b>Profitability</b>	EBITDA	EBIT + depreciation expense + amortization expense
	Net profit margin on sales	Net profit / Sales income
	Return on total assets	EBIT to the average balance of assets
	Return on net assets	Net profit to average net assets
<b>Development ability</b>	Sales revenue growth rate	(annual sales - sales revenue of the previous year) / sales revenue of the previous year
	Capital accumulation rate	Increase in owner's equity this year / owner's equity at the beginning of the year

Source: Hainan Province Rural Credit Cooperatives (2007-2018)

### 3.4 Chapter summary

Taking RCCs as an example, this chapter first gives a detailed introduction to microcredit risks, including credit risk, interest rate risk, legal risk, operational risk, management risk, adverse selection risk and moral hazard. Then, by introducing the relevant contents of the microcredit interest rate risk management of RCCs, this chapter describes the existing management model of farmers' microcredit in China. Finally, this chapter analyzes the microcredit risk index systems of RCCs, including the macroeconomic environment index system, the bank regulatory indicator system, and farmers' default evaluation index system. In this way, it describes the main risk types, risk sources and risk indicator systems of farmers' microcredit in China at present, laying a theoretical foundation for building a new microcredit risk management system.

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## **Chapter 4: Establishment of the Continuous Improvement System of Microcredit Risk Management of Rural Credit Cooperatives**

The management of farmers' microcredit process improvement has its special aspects different from traditional process management. The key is the ability to effectively cope with the work and organization complexity in the continuous improvement process and reasonably decompose them. This can be summarized as the process from "differentiation" to "simplification" and then to "standardization" (Feng & Lv, 2013).

The premise of IDEAL process improvement is the maturity and stability of the project execution process and key technical links. For the continuous improvement of microcredit risk management in the context of interest rate liberalization, the continuous improvement of farmers' microcredit management is made possible exactly because it meets this requirement.

At present, farmers' microcredit management is cumbersome, very costly and highly risky. Therefore, loan "management right" is handed over to the system. Developing special technical system has become an inevitable choice for addressing the current dilemma. In this chapter, the author proceeds from his own work experience, adopts the method of software engineering, and analyzes the business requirements, functional requirements, performance requirements and environmental needs based on the project management theory of continuous improvement of the IDEAL model. A continuous capability improvement system of microcredit risk control is presented that covers such contents as interests of loan farmers, loan approval process, later-stage management and risk early warning system.

## 4.1 Business requirements analysis

In recent years, China's economic capabilities have been increasing continuously, and the application of computer technology has been maturing (Zhu, 2010). Microcredit has abandoned the original business model and improved its process through software. Microcredit management standards have been institutionalized and the implementation standards for microcredit risk management have been established. The goal of microcredit management is to combine composition and decomposition to complete digital storage and document management in the lending process (Xu, James, & Peng, 2016). The gradual improvement of computer technology has enabled microcredit to establish the activities of people and organizations in an orderly work process. The steps in the process improvement are completed through the mining of stored data.

### 4.1.1 Microcredit risk management model

The models considered here, designated as Models A, B and C, include quantitative and qualitative variables and indicators and combine features of the main types of models currently available for credit risk analysis. These are statistical models, such as logistic regression or discriminant analysis, theoretical (structural or reduced form) models, and data mining and artificial intelligence models (Celik, 2013; Zamore, Djan, Alon, & Hobdari, 2018; Soui, Gasmi, Smiti, & Ghédira, 2019).

Statistical models are generally considered to be less effective in the long run than theoretical models, which allow for better introduction to organizational dynamics (Wang, 2014). The newer models of artificial intelligence still need to reinforce their basic theoretical framework.

**Model A** - It is a causal relationship model, which is composed of multiple structural variables, and the quantitative relationship is calculated by computer economic models of multiple equations (Li, 2011).

There are in total six structural variables in the operation of Model A. The credit risk is

the variable of expected quality, credit quality, credit value, and the final target variable is the credit risk. The outcome variables of credit risk are customer loyalty and dissatisfaction (He & Yang, 2011). The reason for the selection of the six structural variables in the model is based on the credit customer behavior theory.

**Model B** - It is an important factor derivation model, also known as quadrant model, which is a diagnostic model focusing on qualitative research.

It can first list all performance indicators of credit products and services through big data mining + sample actual credit, and set two attributes for each performance indicator, namely, importance and satisfaction, according to credit customers' scores of importance and satisfaction of the performance indicators. The factors affecting microcredit are included into four quadrants, and enterprises can deal with these factors separately according to the classification results. If necessary, you can also aggregate the overall credit risk value.

**Model C** - It defines three levels of credit customer needs: basic demand, expected demand and excitatory demand (Hu & Luo, 2016).

These three needs can be divided into basic factors, performance factors and incentives based on performance indicators. The model is a typical qualitative analysis model, which is often used to classify performance indicators, help enterprises understand the needs of different levels of credit customers, find out contact points between credit customers and enterprises, and identify the key factors of credit.

#### **4.1.2 Basic functions through microcredit risk management software**

The implementation of an efficient concept of credit risk management based on information systems that optimize the information flow of internal as well as external data is a very relevant success factor.

Among the available software offerings on the market, with their different analytical and reporting capabilities, the software that was deemed most appropriate to meet the project's objectives and conditions was selected.

The development and design of computer software is based on a detailed analysis of the above three models (Hartungi, 2007).

First, identify the influencing factors of microcredit clients through the application of Model A.

According to the relevant data of Model A, the six variables are mutually constrained and interact with each other. In order to obtain accurate data to determine the final level of microcredit, the other five aspects can be compared to find out the most important factor affecting microcredit risk level. In the software, the sample customer research amount of big data mining is combined, and the variables are numerically refined by the value-based weighting model.

In the clients' investment, each problem is expected to meet the highest expectations, and then the customer credit and customer value are counted through the credit risk assessment model to determine the highest level of customer satisfaction (Wu, 2013).

At the same time, the software can flexibly apply, merge and decompose relevant data, finalize the main factors affecting the performance of microcredit in the current credit cycle, obtain the corresponding microcredit risk management results and improvement suggestions, improve the microcredit platform, and finally choose a reasonable way to improve, thereby increasing the amount of microcredit loans.

Second, help credit objects find the corresponding improvement direction through Model B.

Through the four-quadrant model, we can compare the level of microcredit risk within a certain range according to the comparative analysis function provided by the software, and can get the following contents:

- Distribution of each type of microcredit in specific regions;
- Distribution of ordinary microcredit;
- Distribution of different types of clients;

The above content specifies that Model B helps the credit objects find the



corresponding improvement policy. Through detailed analysis of various types of data, the credit level of specific credit objects can be quickly analyzed and located to find out the influencing factors of the problematic microcredit, and identify the factors that need attention in the work of microcredit performance and quality improvement as well as the improvement direction.

Third, help credit objects find out customers' expectations and excitement through Model C.

Using Model C is a key technology of fintech. Data accumulation and analysis can help identify customers' need. And the individual linear analysis provided by the software can be used to calculate the overall level of microcredit after credit objects change in one aspect. Through the positioning of the desired point, the improvement focus of microcredit risk management and control will be found.

#### **4.1.3 Microcredit risk management platform based on process improvement model**

Based on the IDEAL model's framework and process improvement capability factors, the process capability factors, human resource capability factors, process support capability factors, risk management capability factors, quality assurance capability factors and program management capability factors of professional banking organizations are realized through the microcredit risk management software platform and organically integrated into banks' microcredit risk management data. Continuous collection, sorting, analysis and monitoring are carried out to provide banks with dynamic management and analysis of microcredit risks, improve service level, service process management capabilities, and product quality improvements.

With regard to different microcredit risk management of bank clients, focus on establishing a target system and indicator system, freely set different levels and different types of credit lines, and use various flexible credit methods to collect relevant credit data through such tools as the Internet and mobile terminals. Effectively use the latest mobile 3G/4G technology, use microcredit risk management models A, B and C, combine the

actual needs of service objects, analyze the credit risk indicators affecting the financial industry, establish corresponding quality control model, identify problems in the service process, and provide corresponding data support for decision-making. Provide information, consulting, analysis and decision-making services for the development of microcredit and new product markets in the financial industry.

The microcredit risk management platform has the following characteristics:

First, as a technical foundation supporting software, it establishes a data service operation platform, providing unified, comprehensive and complete information, consulting, analysis and decision-making services for banks, while creating a professional, authentic and constructive innovation-driven process consulting services model.

Second, it provides custom support of flexible data credit rules. In other words, based on the screening factors and by screening the credit data that meet the elements, formulate “personalized” credit rules for different credit data results to ensure the reliability and validity in the microcredit risk management process and provide clients with the necessary continuous improvement support.

Third, it exercises real-time and end-to-end management and control of data acquisition through mobile terminals.

Fourth, based on WebGIS technology, it dynamically tracks the credit process and carries out regional comparative analysis to improve the integrity and fullness of information, improve data analysis quality, and facilitate client service and product adjustment in the financial industry.

Fifth, it develops the function of comprehensive credit risk analysis based on the combination of models A, B and C.

## **4.2 Functional requirements analysis**

The microcredit risk management analysis software is built as the infrastructure for process improvement. Its functions are designed according to the requirements of process

improvement. It is mainly divided into system management part, authorized institution management part, whole-process node service part, as well as analysis and display part.

#### 4.2.1 System management function

According to the classic model of microcredit risk management and the improved model of microcredit risk management formed through milestones in the process improvement stage, microcredit targets are set by grades, the credit indicator supporting system is established, the corresponding risk control node is generated, and such functions as process monitoring, quality verification, and online collection and verification of microcredit process data are realized, as shown in Table 4-1.

Table 4-1 Functional chart of the management part of bank microcredit risk management system

Subsystem	Module	Features	Description	Remarks
Execution system	System settings	Regional settings	Set areas and regions mainly for dividing the administrative division of each credit object.	
		Institutional setting	Set the organization type, organization level and organization of credit objects mainly for locating the attribution relationship and classification relationship of each microcredit object, so as to compare it with multiple angles and multiple directions.	This function is also provided with the organization level correspondence setting to set the correspondence between different organization levels under different organization categories to increase the horizontal contrast characteristics of credit institutions.
		Operator setting	Set operator, operator grouping, evaluation and risk identification operator permissions.	Operator groupings are divided by region to allow operators to be geographically divided to support operator credit evaluation and risk identification credit tasks.

			<p>The system uniformly authorizes the organization, uniformly sets the authority to the relevant institution category, and then the agency category authorizes itself to its subordinate members. Through the secondary evaluation of authority and risk identification, the authority evaluation and risk identification of the whole system are more reasonable and orderly. It also includes a risk rating setting that allows you to set subordinate sub-questions. Through the continuous refinement of risks, the risks can be more refined and the direction of risk control is clearer.</p>
	Agency authorization	<p>Used to set the organization category to view the organization and view the risk factors and risk dynamic weights. Set the expiration date to view the data.</p>	
	Risk calibration	<p>Set risks, types of risks, and risks related to business.</p>	
Risk system			
	Risk tracking	<p>Based on big data mining + sample user analysis, a service and tracking strategy for personal microcredit is developed for all users.</p>	
Risk Management	Risk identification	<p>The evaluation and risk identification of microcredit users, the evaluation and risk identification process are divided into risk factors and risk dynamic weights. The urban sub-operator group evaluates the credit process and identifies the risks.</p>	<p>The evaluation and risk identification process will evaluate and identify the credits of specific risk factors and risk dynamic weights by the operator group, and specify the corresponding risk factors and the credit duration of the risk dynamic weight. In this way, the operator's credit process is assessed.</p>

<b>Knowle dge base system</b>	Risk control measures	The results of the credit evaluation and risk identification program are guided, reminded and controlled by the practical process, and the guidance, reminder and management process of the substantive process are guided, reminded and controlled by the unified practice process.	
	Credit system	access to customers, each sub-model quota, initial quota, pricing interest rate; access conditions, access model, anti-fraud model. Blacklist in the line, including system identification and manual transfer (except for internal employees)	Period: T+1; prompt object: responsible loan officer
	Credit card	Prompt that both parties have a loan (online).	Period: T+1; prompt object: responsible loan officer
<b>Risk Control AI</b>	Core (whether there is fraud)	The installment repayment plan is adjusted	Period: T+1; prompt object: responsible loan officer
	Core (whether the account is normal)	Delayed period $\geq 2$	Cycle: monthly; prompt object: responsible loan officer
	Core (whether to maintain the card)	On the day of the payment, transfer to another stock loan customer account	Period: T+1; prompt object: responsible loan officer
	Core (transaction)	Multiple stock loan customers, transfer the funds to another same account on the same day	Period: T+1; prompt object: responsible loan officer
	Core (negative list)	Transfer to the additional internal employee account on the day of the payment	Period: T+1; prompt object: responsible loan officer

Social security information	Transfer money to another credit on the same day Blacklist customers (except internal employees)	Period: T+1; prompt object: responsible loan officer
	Stock loan customer repayment account ID: "Payment", "discount", "loss"	Period: T+1; prompt object: responsible loan officer
	Inventory loan customer account ID: "freeze"	Period: T+1; prompt object: responsible loan officer
	Debit card transfer to another person's credit card, the number of sheets exceeds 10	Cycle: Monthly; prompt object: responsible loan officer
	Other credit card debit card, more than 10 sheets	Cycle: Monthly; prompt object: responsible loan officer
	The counterparty belongs to a bad customer (online)	Period: T+1; prompt object: responsible loan officer
	Previously, it was a customer, and there was no effective proxy for two consecutive months.	Period: T+1; prompt object: responsible loan officer
	The stock loan customer account contains negative abstracts: disabled people's fuel subsidy, severe disability, poor disability subsidy, disabled disability, residual car oil supplement, residual care subsidy, poor and poor aid, severe disability subsidy, heavy disability sun, trapped subsidy, severely disabled care, disability subsidy, residual care, exclusive disability, disability association, disability, library disability, poverty support, poverty subsidy, ecological	Period: T+1; prompt object: responsible loan officer

	poverty alleviation, poor support expenses, medical expenses, medical reimbursement, high medical expenses , disaster subsidies, disasters, disasters, special hardships, ailments, sleepiness, sleepiness, Medicaid, unemployment insurance	
Social security system	Suspension of payment	Cycle: Monthly; prompt object: responsible loan officer
	Paying social insurance 130 change 110	Cycle: Monthly; prompt object: responsible loan officer
	Social security payment base reduced (excluding 320)	Cycle: Monthly; prompt object: responsible loan officer
	Arrears>=3	Cycle: Monthly; prompt object: responsible loan officer
	Customer defaults on the month to remind the responsible loan officer	Cycle: Monthly; prompt object: responsible loan officer
	Check customer credit report	

#### 4.2.2 Management function of the authorized organization

Through the authorization function, the function of the microcredit risk management software can be secondarily authorized by the entrusting agency to realize the platform development requirements for the bank microcredit risk management, as shown in Table 4-2.

Table 4-2 Management part functions of the authorized organization of bank microcredit risk management system

Subsystem	Module	Function	Description	Notes
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<b>Authorized organization management</b>	System settings	Member authorization	Used to set up the institutions as well as the risk factors and risk dynamic weights that can be viewed by specific members under the organization category.	The member authorization is mainly to perform secondary authorization under the authority of the authorized organization. Except the authorization data period and the viewable problem, secondary evaluation and risk identification can be performed on the viewable institutions.
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### 4.2.3 Statistical analysis functions

#### 4.2.3.1 Comparative analysis of risk factors and dynamic risk weights

This analysis is mainly used to analyze the scores of a certain risk factor and risk dynamic weight of selected institutions in each comparison period. Given its characteristics, the grouping approach can be adopted to conduct comparison and analysis of the performance of each institution in face of a particular problem in a fairly significant way, so as to find out their strengths and weaknesses in each given institution. The system can not only compare credit objects of the same level from the same city, but also select objects at random and conduct a comprehensive comparison with a variety of approaches (World Bank, 2003). This is conducive to a comprehensive comparative analysis of the institutional risk factors and risk dynamic weights and makes it easier for the analysts to identify the advantages as well as disadvantages that require further attention, so as to adopt effective coping methods on this basis. In addition, the comparison periods are placed in a chronological order, so that the changes in the scores of specific institutions during the overall comparison period become apparent. In this way, the problem can be targeted and exposed in front of the analysts, and the cause of the problem faced by the credit object will be located.

#### 4.2.3.2 Individual linear analysis

With an emphasis on specific risk factors and dynamic risk weights, specific problem categories and specific problems, this analysis intuitively presents the linear changes of the scores of specific institutions in these problems at different times. Through the chart,



analysts can clearly observe the changes of the scores of the institution in a specific problem over time, understand how the situation changes at any given time and make improvements in response, and inform the credit object of the changes that are in need of attention during this period and the root cause of the problem.

#### **4.2.3.3 Sample statistics**

The sample sizes are analyzed under various scenarios, such as the sample sizes in different cities and sample changes among credit subjects and relevant competitive institutions. The statistics equip analysts with a more comprehensive and objective judgment of the sampling situation, based on which they can determine the proportions of subjects and contrast samples, whether they are reasonable, and whether the results of correlation analysis are objective and universal (Zhang, 2012). The statistics are mainly used to calculate the total sample coverage rate, and, with the coverage rate of competitive samples as a reference, assist the related staff in conducting a comprehensive analysis of the sample coverage rate, analyzing whether the sample cover range is extensive and complete, and verifying the analysis data, so as to determine whether the sample is implementable.

#### **4.2.3.4 Satisfaction factor/dissatisfaction factor analysis**

The analysis targets the scores of specific risk factors and risk dynamic weights of a particular credit object in a particular time period. By ranking the scores of risk factors and risk dynamic weights, it assists relevant personnel in analyzing and judging the problems of the object, so as to help solve various problems that exists in the field of credit and provide necessary support for enhancing the emphasis of risk factors and risk dynamic weights in the next step and further narrowing the focus of the problem.

#### **4.2.3.5 Analysis of microcredit risk level**

Aimed at calculating the average scores of a credit object in the specified period in terms of specific risk factors and risk dynamic weights, this analysis can help analysts judge the microcredit risk of the credit object, tailor specific strategies and measures to credit risk management, and strengthen risk control ability before and during the process.

#### **4.2.3.6 Analysis of execution details**

This analysis is mainly used to determine the degree of generalization of specific risk factors and risk dynamic weights in a certain time and a certain problem category. All problems will be listed graphically in order to determine the possibility of its generalization. It assists related staff in finding out and assessing the major causes of the problem by carrying out a comprehensive analysis of the problem, while improving the accuracy of the credit object when assessing the risk, and ensure that the direction and size of the risk existing in the credit industry can be controlled to a certain extent.

#### **4.2.3.7 Performance analysis**

This section compares the performance of credit execution, locates and analyzes the major problems in the credit field, and identifies and probes into the main reasons for the problems, with finding a solution to these problem as the primary task, so to assist relevant personnel in developing a more effective credit management plan.

#### **4.2.3.8 Analysis of the level of execution in each institution at each link**

Based on a comprehensive analysis of multiple links including specific risk factors and risk dynamic weights, the analysis will assist relevant personnel in identifying the main factors that contribute to the problems, analyzing them in a comprehensive way, and cracking the major causes of each problem, in order to solve various problems that have occurred in the credit field recently and reduce the adverse effects of the problems in the field of credit while solving the problems.

#### **4.2.4 Management function of credit data collection**

In the process of microcredit risk management, it is necessary to manage credit development, credit data collection and data quality from the process, practice process guidance, reminders and management and results, as described in Table 4-3.

Table 4-3 Functional chart of management part of the credit data collection process of bank microcredit risk management system

Subsystem	Module	Function	Description	Remarks
<b>Credit officer mobile terminal part</b>		Credit task reception	The credit task issued by the loan managers is accepted by the mobile terminal, and the credit task can be issued to the same group member by SMS according to the authority.	
<b>New credit officer mobile terminal part</b>		Risk factors and risk dynamic weights are filled in	Report and modify risk factors and risk dynamic weight credit results through mobile terminals.	The results can be temporarily stored locally and synchronized with the central server when synchronization is required.

### 4.3 Performance requirements analysis

Based on the technical foundation supporting software, a data service operation platform is established to provide unified, comprehensive and complete information, consulting, analysis and decision-making services for financial institutions. Besides, an innovative, authentic, constructive and innovative process consulting service model is created to meet the time response performance of credit data collection (Yao & Hou, 2013).

Based on WebGIS technology, the credit process is dynamically tracked, and regional comparative analysis is carried out to improve the integrity and fullness of information and improve the quality of data analysis, which will facilitate customer service and product adjustment in the financial industry, and meet relevant data storage performance and the access performance of GIS data.

The comprehensive analysis function of credit risk based on the combination of models A, B and C meets the data mining performance requirements.

In Annex I the system environment configuration and the network topology of the system operation are presented.

## **4.4 Use case modeling of the risk management system of farmers' microcredit**

### **4.4.1 Case modeling**

Based on the extraction of business functions, the use case modeling of the bank microcredit risk management system is shown in Figure 4-1.

The figure shows that traffic risk, construction risk, market risk, credit and financials risk, environmental risk and operational risks may influence the financial model. The level of each risk has impact on the factors in the model. The model outputs will vary for different levels of risks. On the other hand, the uses of the model will reflect the utility of the financial model.

The system participants can be generalized into four categories, namely, loan managers, data analysts, terminal implementers and clients based on their roles and tasks.

Use cases for interaction with loan managers include member authorization, basic parameter settings, risk factor and risk dynamic weight setting and generation, credit task evaluation and risk identification and practice process guidance, reminders and management and statistical analysis.

Use cases for interacting with data analysts involves statistical analysis.

Use cases for interaction with terminal credit officers include: risk factor and risk dynamic weight distribution, risk factor and risk dynamic weight filling, risk factors and risk dynamic weight submission.

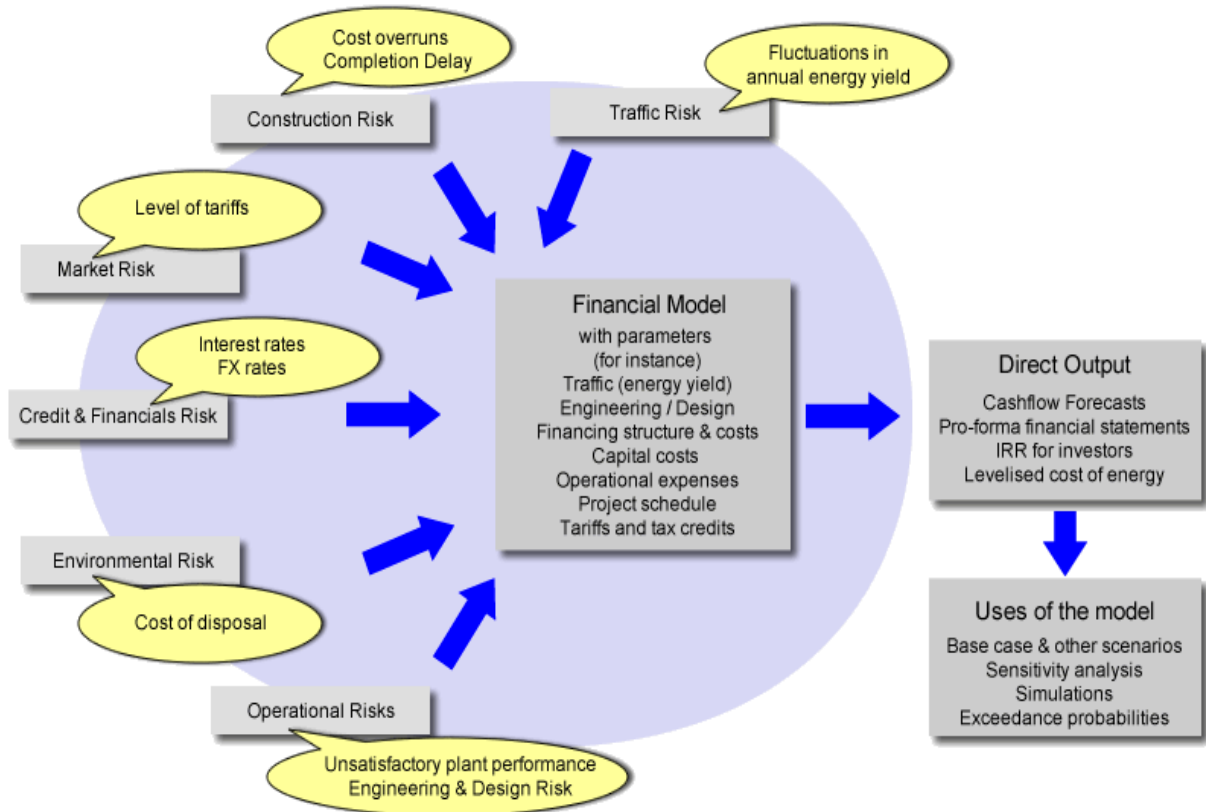


Figure 4-1 Use case diagram of bank microcredit risk management system

One use case may contain/uses another use case. In the “Statistical Analysis Use Case”, on the one hand, managers and analysts can directly use the services provided in “WebGIS Map Pattern Management and Analysis”; on the other hand, through the data query and selection operations of the map mode, “WebGIS map mode” Management and Analysis provides input data for analysis for each extended use case of other analysis cases (comparative analysis cases, individual analysis cases, sample statistical analysis, satisfaction analysis, execution analysis), and other analysis cases include/use “extend” /“include” “WebGIS map mode management and analysis”.

Among them, loan managers interact with use cases such as credit task assignment, network information editing, network information selection, network map display and network information query (Wu & Jiao, 2011). The analyst does not participate in the interaction with the two use cases of credit task assignment and site information editing.

#### 4.4.2 Description of some use cases

A simple use case description of some of the above use cases is shown in Table 4-4.

Table 4-4 Description of the use cases of bank microcredit risk management

Serial number	Method Name	Method Description
1	Authorization limit	Authorize this feature, which is to authorize the results data of microcredit.
2	Authorization Method	The method of searching is to authorize the employees of the company, or to entrust the organization to perform unified authorization. The authorized institution may also perform individual user authorization according to the reasons of the user.
3	Microcredit user	The microcredit users can be set up by themselves; the credit problems can be combined and decomposed without disturbing the original data; and the risk status of different weights can be evaluated.
4	Risk identification and effective evaluation of credit tasks	A unified evaluation of credit officers based on different regions to identify credit-related risks. The credit team leader can conduct task evaluation and risk identification for subordinates.
5	Credit officer management	The credit team can be guided, reminded and controlled by the unified practice process according to the completion of the credit task. The guidance of the practical process, the internal and external control plan, and the two aspects are completed, and the guidance, reminder and control of the actual process are carried out separately.
6	Risk factor and risk dynamic weight	The risk dynamic weight and risk factor credit result can be submitted through equipment, etc., and the mobile terminal can also temporarily store the data according to the internal storage capacity for one-time submission to the server.
7	Statistical Analysis	According to the relevant micro-credit users, the sample comprehensive quantity, sample coverage rate, satisfaction level, satisfaction factor, support rate, etc. can be analyzed, and the corresponding credit objects can be compared and analyzed accordingly.

Source: China Financial Bank Journal (2013)

## **4.5 Chapter summary**

This chapter introduces the new system of microcredit risk management based on software engineering combined with the long-term experience of farmers' microcredit management and analyzes farmers' microcredit risk management software. According to practical application, aimed at continuous improvement of the microcredit risk management by the IDEAL model, and proceeding from the demand for software and the trend of demand, business requirements analysis, function analysis and performance analysis are described. Finally, the OOA method is used to model relevant microcredit businesses of the software. Use case analysis modeling is also described.

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## **Chapter 5: Design and Implementation of the Platform for the New Microcredit Risk Management System**

After completing software requirement analysis to ensure the continuous improvement of the microcredit risk management system, the microcredit risk management software was designed in a systematic way using the OOD (Object-Oriented Design) method and its functions implemented through the techniques of rapid prototyping.

### **5.1 Structural design of the microcredit risk management system**

The microcredit risk management system chart is shown in Figure 5-1.

Based on the type of users, the functional structure of functional modules that users can use in various fields can be designed and divided as follows:

1. Authorized agency: the usable function module of the agent, including the function that authorizes system access to “institutional users” and the corresponding usable analysis report.

2. Functional modules that can be used by analysts, managers, terminal personnel and other internal business personnel, including the function that sets system parameters (administrative region, user, authorization mechanism), the function of index system establishment, credit business implementation (task allocation, task implementation tracking response) and data statistical analysis and response.

3. Functions used by credit officers and credit applicants, including corresponding functions of credit service (credit service personnel) and the function of credit consultation application (credit applicants).

Please refer to Section 4.2 of Chapter 4 for a detailed discussion.

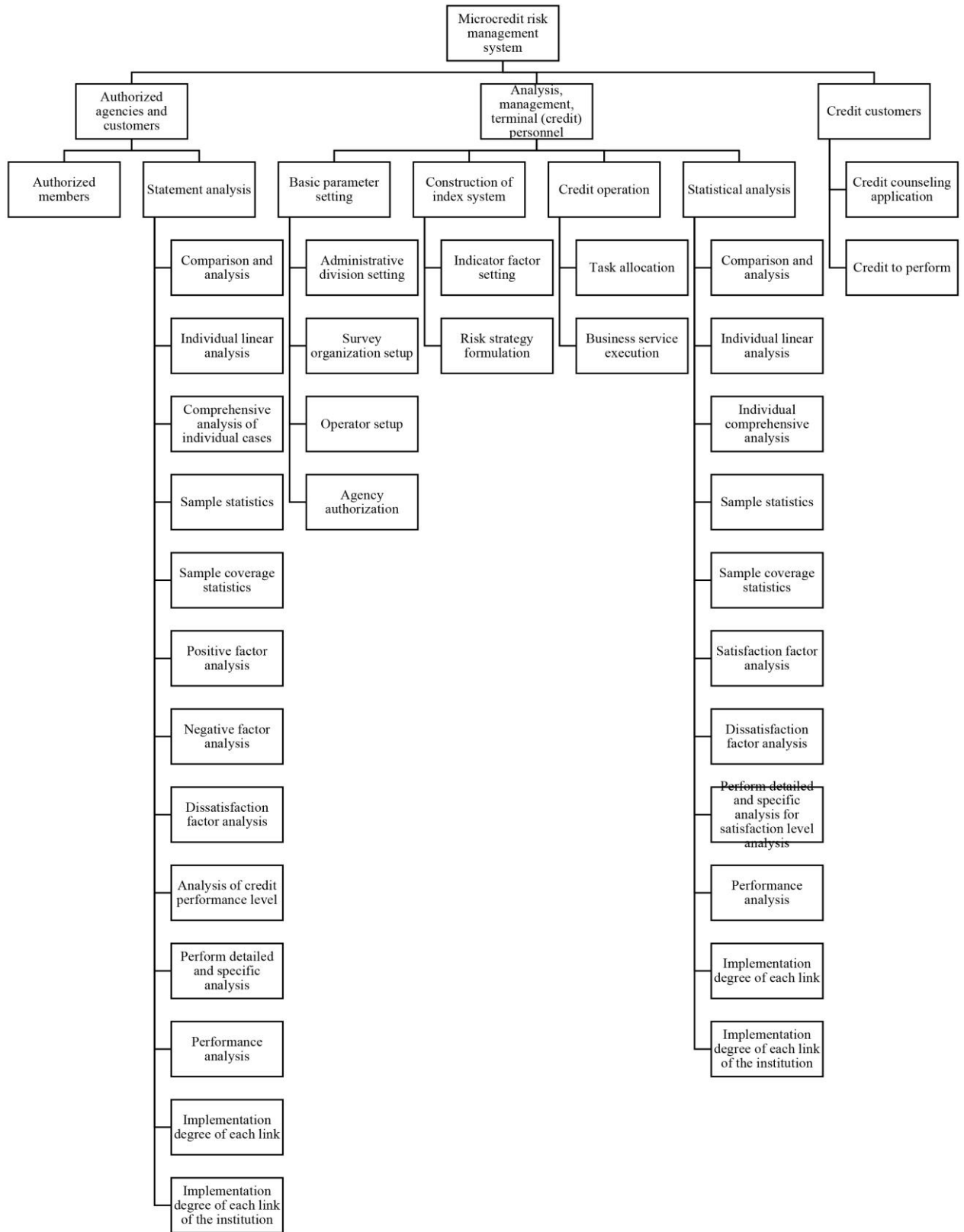


Figure 5-1 Software function module diagram

## 5.2 Object-oriented design of the microcredit risk management system

### 5.2.1 Object-oriented static design

Based on the use case modeling and its description, the modeling of different “design classes” is shown in Figure 5-2. Given the limited space available, the attributes and methods of each class are not listed.

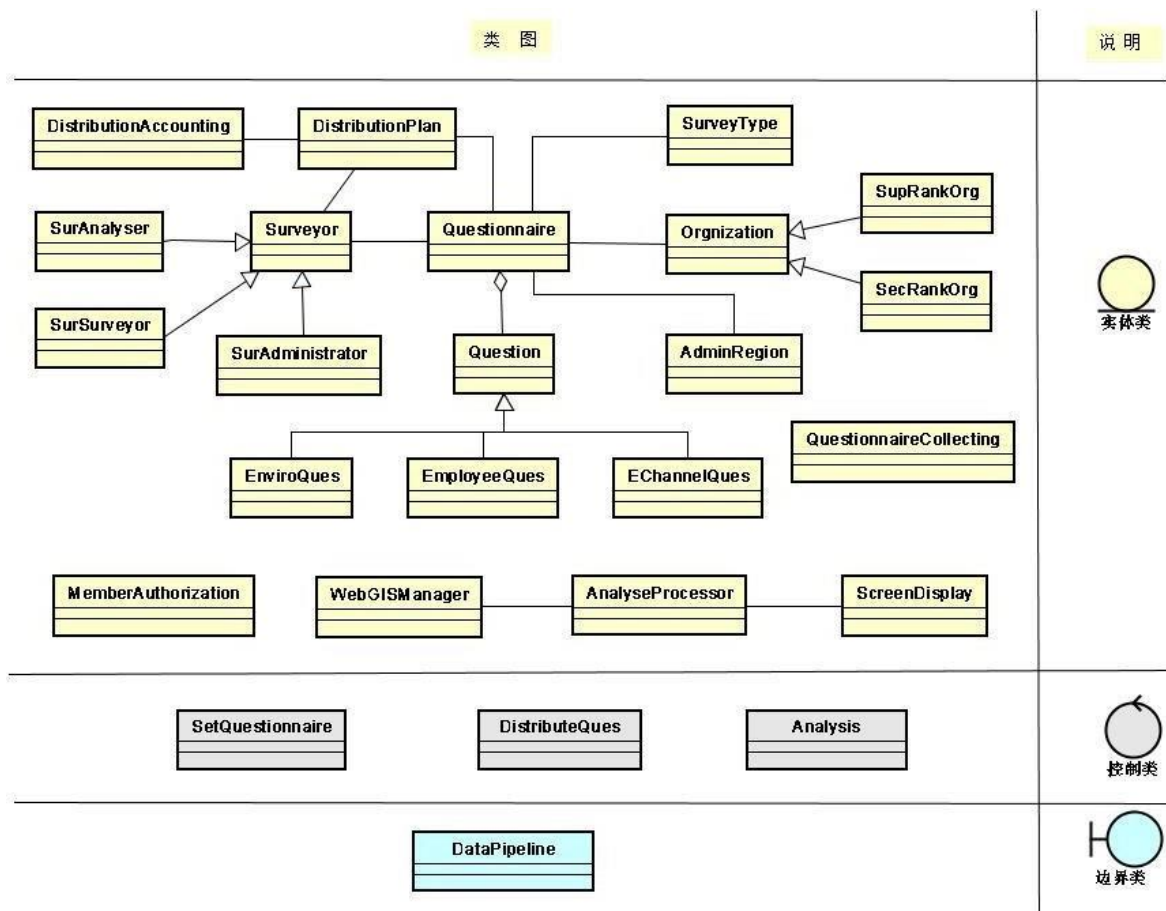


Figure 5-2 Static design class diagram of customer microcredit risk management system

The major classes included in the entity class are: Surveyor (extended in the forms of SurAnalyser, SurSurveyor and SurAdministrator), risk factors and risk dynamic weights (Questionnaire), types of risk factor and risk dynamic weight (SurveyType), Organization (with SuperRankOrg and SecRankOrg as its extensions), administrative region (AdminRegion), Question (whose extensions include EnviroQues, EmployeeQues and EChannelQues), credit task evaluation and risk identification (DistributionPlan), credit task

accounting (DistributionAccounting), WebGISManager map management (WebGISManager) and statistical analysis algorithm (AnalyseProcessor).

The major classes under the control class include: risk factor and risk dynamic weight setting (SetQuestionnaire), risk factors and risk dynamic weights of task evaluation and risk identification (DistributeQues) and statistical analysis (Analysis). The message control mechanism between the control class and the entity class is described in the sequence diagrams of “dynamic design”.

The boundary class is mainly used for the connection and access of the database/data warehouse, and its basic operations are encapsulated in the DataPipeline class.

### **5.2.2 Object-oriented dynamic design**

The design of the sequence diagram for setting risk factors and risk dynamic weights as well as generating use cases can be seen in Figure 5-3.

The survey administrator logs in to the module for setting risk factors and risk dynamic weights. After authentication (authenticate), the first step is to set basic parameters (setBasicParameter) such as credit type, administrative region, organization and operator, followed by the parameters of questions concerning the risk factors and risk dynamic weights, including the type of question, time period, target product and service (setQuestionParameter). The survey administrator then adds other questions (addQuestion), and finally calls the generateQuestionnaire method to generate risk factors and risk dynamic weights.

The design of the sequence diagram of credit task evaluation and risk identification is shown in Figure 5-4.

Evaluation and risk identification are completed by the survey administrator. After logging into the task evaluation and risk identification module and being authenticated, the administrator first appoints the operator/operator group of the task execution through the appointSurveyor method, designates the administrative region of the task execution using the appointAdmReg method, assigns the organization of the task execution by the

appointOrg method, and specifies the time period of the task execution via the appointTimeP method. Next, the association between the task and the risk factors and the risk dynamic weights is completed using the appointQues method. Finally, the task is published by calling the publish method.

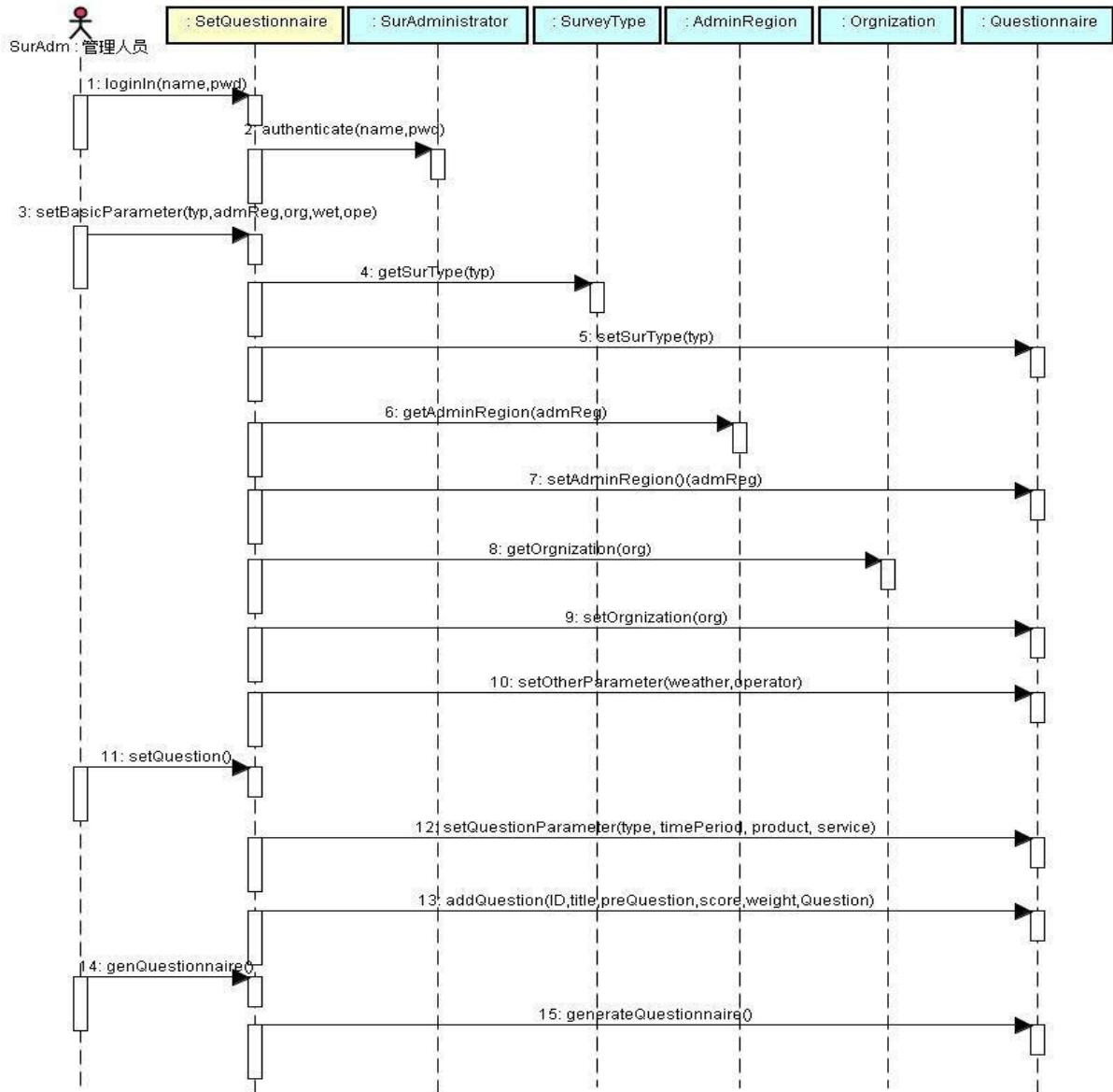


Figure 5-3 Sequence diagram of the setting and generation of risk factors and risk dynamic weights

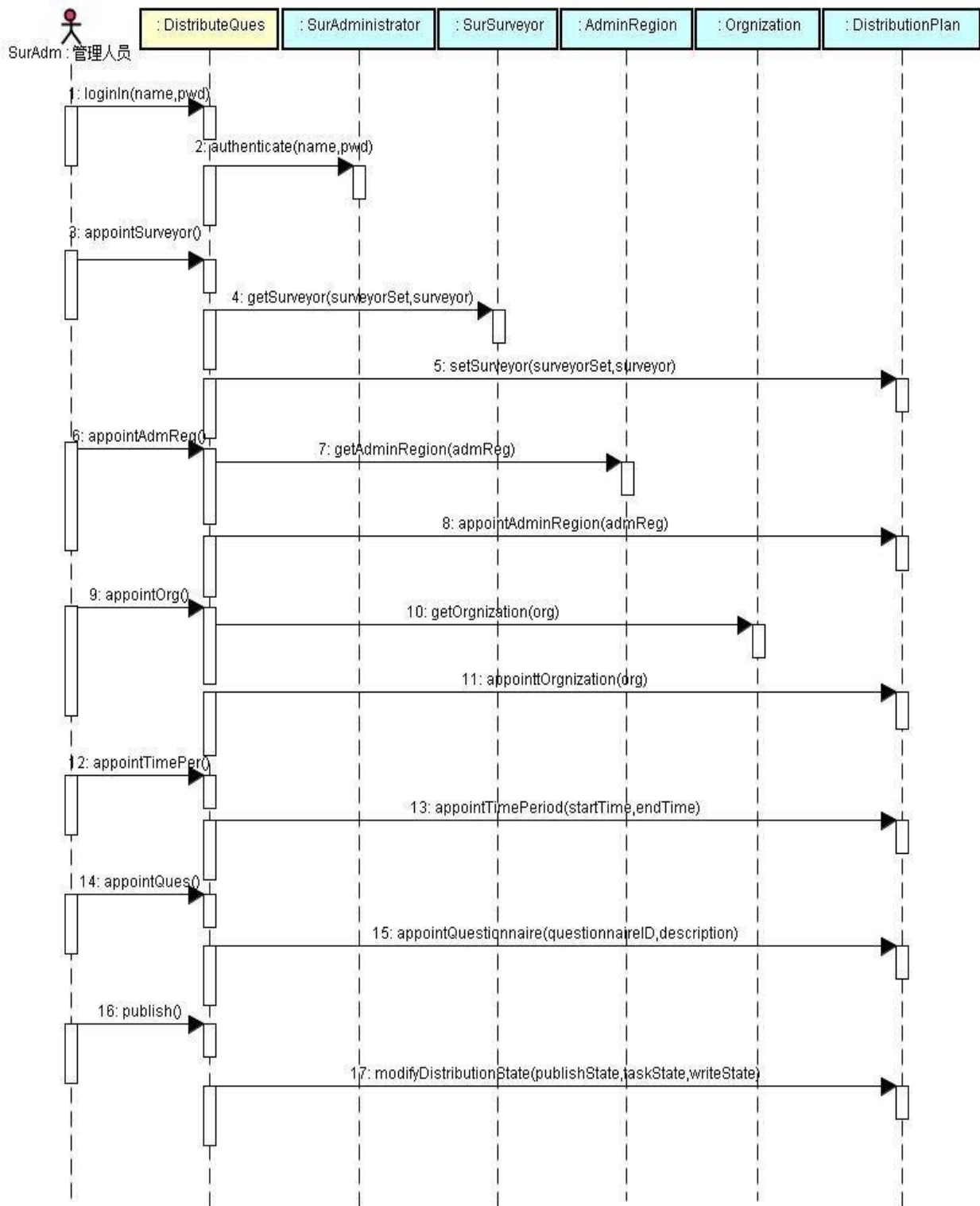


Figure 5-4 Sequence diagram of credit task evaluation and risk identification

The statistical analysis process of the credit data by the statistical analyst is illustrated in the sequence diagram as shown in Figure 5-5.

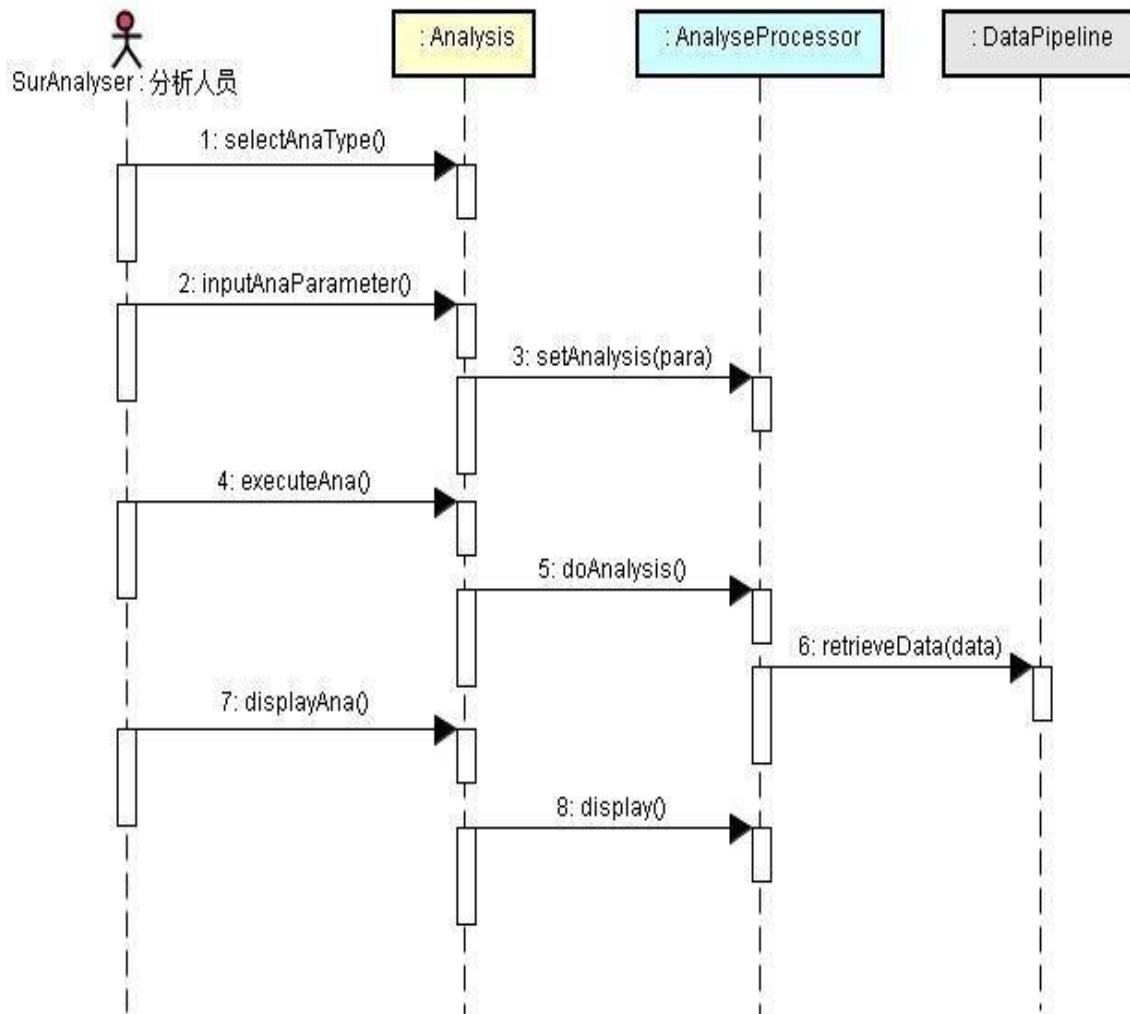


Figure 5-5 Sequence diagram of statistical analysis

The analyst selects an analytic method (`selectAnaType`), inputs the raw data required for analysis (`inputAnaParameter`), performs analysis (`executeAna`), computes the data in the background (`doAnalysis`), and displays the result to the user through the `displayAna` method.

The above is the sequence diagram modeling of main use cases such as the setting and generation of risk factors and risk dynamic weights, credit task evaluation and risk identification, and statistical analysis. Other use cases are carried out in the same way.

Figure 5-6 is a status diagram corresponding to the use case of the “setting and generation of risk factors and risk dynamic weights”. After logging in, the administrator enters the “authentication status”, completes authentication and goes into the status of “risk factor and risk dynamic weight setting”. Failure to pass authentication will cause the

administrator to exit the use case directly. The risk factor and the risk dynamic weight setting will be carried out repeatedly. When there are no more risk factors and the risk dynamic weights left to be set, the administrator enters the status of “risk factor and risk dynamic weight setup complete” and exit the use case after the “risk factor and risk dynamic weight generation” is executed.

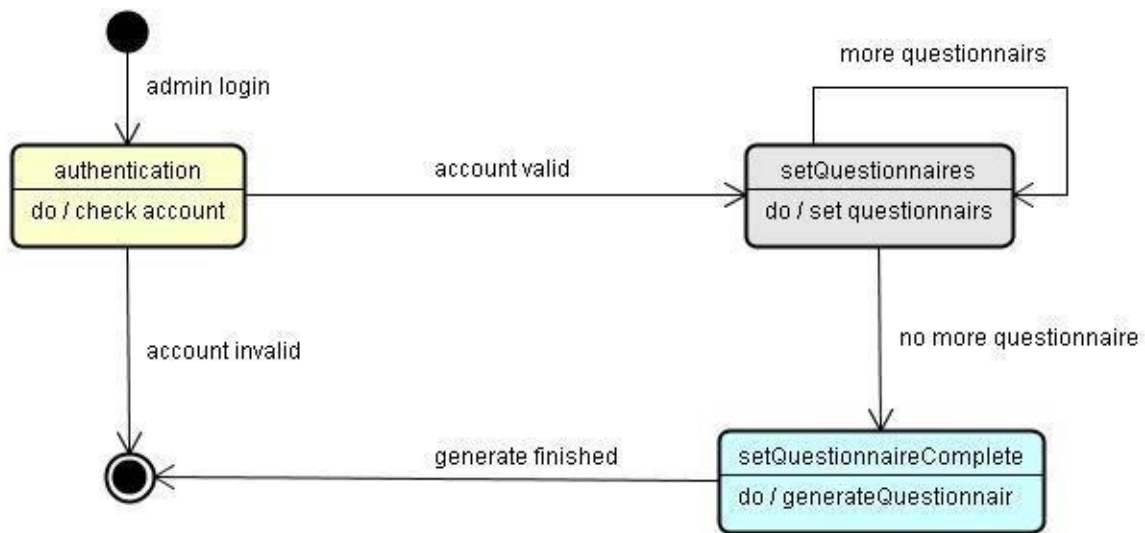


Figure 5-6 Status diagram of risk factor and risk dynamic weight setting and generation

Figure 5-7 demonstrates the status transition relationship in the use case of “credit task evaluation and risk identification”. The details are as follows: After the administrator logs in, he enters the “authentication status” and passes the authentication to enter the “task evaluation and risk identification” status. If you fail to pass the authentication, you will directly exit the use case. The task evaluation and risk identification will be carried out in cycles. When there is no new task to be evaluated and no risk to be identified, the administrator enters the status of “modifying task evaluation and risk identification”, and then goes into the status of “credit task evaluation and risk identification setup complete” after “modifying task evaluation and risk identification”, and finally exits the use case.



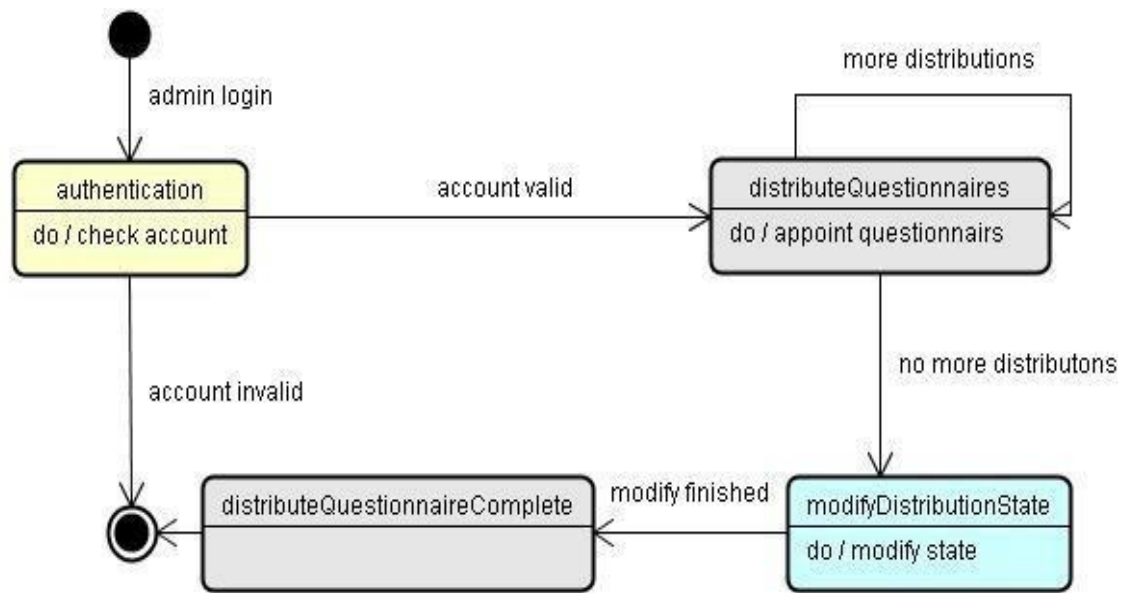


Figure 5-7 Status diagram of credit task evaluation and risk identification

In Appendix 2 some functional implementation screenshots and descriptions are presented.

### 5.3 Chapter summary

Affected by different economic backgrounds and production environments, farmers will vary in terms of their production and operation needs, as well as the scale and conditions of their capital demand, eventually leading to significant changes in the farmers structure of the capital demand for small loan and the risks caused by it. In this case, how do we control the law of change in real time and effectively adjust and guide our risk control and the release of credit resources?

This chapter designs and implements the software by using the OOD (Object-oriented Design) method and the UML(Unified Modeling Language): describing the loan and corresponding risk assessment business process with use case diagrams; establishing a compliance model for software coding with class diagrams and status diagrams; describing scenarios of loan application, the risk assessment process and information interaction with sequence diagrams of human-computer interaction when using corresponding software. The continuous improvement of software research and development follows the route of OOD

technical solution, combined with the evolution model and carried out under the specific evolution model of the rapid prototyping method. Further optimization and adjustment will need to be made in the small loan management system for farmers through iteration, by combining the changes in such aspects as the capital demand, income level, service demand and risk preference of farmers, so as to better meet the differentiated capital demands of farmers while controlling the risks.

## **Chapter 6: Empirical Contribution for the Improvement of Microcredit Service for Farmers and the Risk Management System**

Financial projects with a high degree of inclusion are characterized by the rational use of costs and sustainable development. Due to the particularity of microcredit financial projects for farmers, farmers need to continuously improve their repayment ability, and the credit sector must constantly provide better services and guarantees to farmers to ensure that more farmers can obtain small loans (Guo, 2012). It is also important to ensure that microcredit financial institutions operate at a reasonable cost and achieve sustainable development. To this end, with HN Province as the research object, this study has created a selection mechanism for loan farmers, determined a reasonable scale of microcredit joint guarantee for farmers, and established different microcredit service systems for farmers, so as to promote the rapid development of farmers themselves and the rural economy.

### **6.1 Characteristics analysis of farmers in the microcredit system in HN Province**

As pointed out in the report delivered at the 18<sup>th</sup> National Congress of the Communist Party of China, our nation needs to “attain the goal of completing the building of a moderately prosperous society in all respects by 2020 (Zhao, 2012).” In order to see the early realization of the goal of building a moderately prosperous society and narrowing the gap between the rich and the poor (Berger & Frame, 2007), HN Province has been vigorously developing the economy, improving the living standards and quality of farmers, and increasing their disposable income. However, the inability to obtain effective financial support has been a major bottleneck restricting the expansion of production and acceleration of poverty alleviation for farmers in HN Province.

### **6.1.1 A large agricultural population**

Agriculture plays an important role in the economic development of HN Province, whose agricultural population is large and accounts for a relatively high proportion of the total employed population. In 2016, the regional output value of HN Province reached 40.4451 billion yuan, an increase of 7.5% over the previous year. The largest industrial added value came from the tertiary industry, followed by the secondary industry and the primary industry. The added value created by the three industries made up 22.3%, 24.0% and 53.7% respectively in the regional GDP. As can be seen from Table 6-1, although the employment ratio in the primary industry was decreasing year by year, the number of employed people was on the rise, reaching 2,311,400 in 2014. The continuous growth of the agricultural population has unintentionally sped up the development of the microcredit sector in HN Province, potentially creating broader space for its future development.

### **6.1.2 Basic characteristics of farmers**

To better understand the basic situation of the peasant economy in HN Province, the author randomly selected 10,528 loan applicants from the employed people of HN Province and conducted a survey on related projects. In order to ensure the accuracy of the survey data, all the loan applicants were selected based on the distribution principle of farmers in the microcredit system of RCCs. Among them, 466 farmers were selected from the western region, accounting for the smallest proportion of the total number of people selected (4.43%); A total of 2,038 farmers were selected from the central region, accounting for 19.36%; 3,821 were selected from the eastern region, accounting for 36.29% of the total number of people selected (see Table 6-2).

In terms of age distribution, among the people selected for the survey, most of the candidates were loan applicants between the ages of 31 and 40, followed by 41-to 50-year-olds, accounting for 9.97%, and elderly people, most of whom were between the ages of 61 and 65, making up only 0.48%.

Table 6-1 Historical employment figures in the three industries: number (in ten-thousands) and proportion (%) of employed people

<b>Year</b>	<b>Primary industry</b>	<b>Secondary industry</b>	<b>Tertiary industry</b>
<b>1987</b>	201.8/71.95	26.44/9.43	52.23/18.62
<b>1990</b>	212.81/69.93	28.77/9.45	62.74/20.62
<b>1995</b>	203.92/60.96	39.06/11.68	91.51/27.36
<b>2000</b>	203.93/60.84	31.41/9.37	99.83/29.79
<b>2001</b>	203.73/60.84	31.74/9.38	102.92/30.42
<b>2002</b>	205.59/60.21	33.24/9.50	111.06/31.74
<b>2003</b>	210.71/58.76	35.42/9.83	114.21/31.70
<b>2004</b>	212.47/57.78	37.11/10.09	118.16/32.13
<b>2005</b>	215.10/56.67	39.34/10.37	125.11/32.96
<b>2006</b>	218.76/56.23	41.04/10.55	129.23/33.22
<b>2007</b>	221.43/55.71	43.11/10.85	132.92/33.44
<b>2008</b>	221.24/54.18	45.82/11.22	141.30/34.60
<b>2009</b>	225.59/53.14	48.24/11.36	150.73/35.50
<b>2010</b>	221.45/50.37	52.33/11.90	165.87/37.73
<b>2011</b>	224.98/48.99	54.73/11.92	179.51/39.09
<b>2012</b>	230.79/47.69	59.20/12.24	193.91/40.07
<b>2013</b>	222.45/43.23	65.25/12.68	226.86/44.09
<b>2014</b>	231.14/42.56	68.68/12.65	243.28/44.79

Source: Hainan Provincial Bureau of Statistics (2015)

From the perspective of educational background, in the sampling survey, the number of applicants with primary school education and below accounted for 16.05%; the number of applicants with junior high school education occupied 62.47%; the number of applicants with high school education made up 17.51%; the number of applicants with a college degree and above accounted for the smallest proportion (3.97%). From the perspective of family composition, the survey data shows that the number of family members of applicants exceeded the number of people employed in their families in most cases. The average family employment rate was 68.9% and the average number of employees per household was 1.5. As indicated by the results of the living conditions survey, the housing structure of

the loan applicants mainly include self-built single-story houses and self-built houses with two stories and above, and the family housing area of 47.21% of the loan applicants fell between 100 and 200 square meters (see Table 6-3).

Table 6-2 Sample distribution of loan applicants in different cities and counties

<b>City/County</b>	<b>Survey sample ratio (%)</b>	<b>City/County</b>	<b>Survey sample ratio (%)</b>
<b>Haikou City</b>	8.92	Lingao County	5.18
<b>Sanya City</b>	4.64	Zhazhou City	13.26
<b>Wuzhishan City</b>	1.41	Dongfang City	11.81
<b>Wenchang City</b>	7.13	Ledong City	4.81
<b>Qionghai City</b>	3.68	Qiongzong County	3.46
<b>Wanning City</b>	6.66	Baoting County	0.008
<b>Anding County</b>	5.09	Lingshui County	5.25
<b>Dunchang County</b>	3.20	Baisha County	3.13
<b>Chengmai County</b>	5.48	Changjiang County	3.81

In terms of household income sources, as the income of loan applicants stabilizes, their income sources are also increasingly diversified. According to the survey data, the main sources of income for farmers in HN Province are crops farming and animal husbandry. Meanwhile, with the continuous economic development of China, self-employment has gradually become one of the main sources of income for farmers. The sources of agricultural income consist mainly of daily necessities (grains), melons, rubber, betel nuts and tropical fruits; poultry farming depends primarily on three kinds of birds (chicken, ducks, geese) as well as pigs (see Table 6-4).

## **6.2 Selection of farmers in microcredit service**

According to the above comprehensive analysis, the farmers that apply for microcredit loans in HN Province are characterized by a low education level and living in a wide range

of areas. However, due to the limited amount of funds available to relevant credit institutions, they are not able to grant more loans, thus reducing the likelihood of farmers obtaining a loan to a certain extent. Therefore, credit institutions should continuously improve their service quality and management system, reduce credit risk, and pay more attention to their repayment ability when selecting service objects, while constantly striving to increase the amount of funds available for borrowing, so as to reduce the possibility of farmers turning to usurious loans due to their inability to borrow from banks. As the first province in China to carry out microcredit service, HN Province has established a relatively sound credit management system by drawing upon the practical reference provided by long-term accumulated experience for creating a microcredit management system. This section focuses on the effective selection of loan users to ensure a high loan acquisition rate and a high repayment rate, which is, in other words, how microcredit services effectively satisfy the needs of farmers in a scientific way.

Table 6-3 Housing structure and housing area of farmers that apply for loans

<b>Housing structure</b>	<b>Proportion of the selected farmers in all the respondents (%)</b>	<b>Family housing area</b>	<b>Proportion of the selected farmers in all the respondents (%)</b>
<b>Self-built houses with two stories and above</b>	36.18	100-200 m <sup>2</sup>	47.21
<b>Self-built one-story houses</b>	35.50	50-100 m <sup>2</sup>	30.57
<b>Old tile-roofed houses</b>	17.67	200-300 m <sup>2</sup>	14.51
<b>New tile-roofed houses</b>	7.81	300m <sup>2</sup> and above	5.79
<b>Commercial residential buildings</b>	1.20	50m <sup>2</sup> and below	1.92
<b>Rented houses</b>	0.84		
<b>Others (thatched cottages, for instance)</b>	0.80		

Source: Hainan Provincial Bureau of Statistics (2015)

Table 6-4 Production and operation status of farmers that apply for loans

<b>Staple crops</b>	<b>Proportion of the selected farmers in all the respondents</b>	<b>Main species of livestock farming</b>	<b>Proportion of the selected farmers in all the respondents</b>	<b>Aquaculture species</b>	<b>Proportion of the selected farmers in all the respondents</b>	<b>Other types</b>	<b>Proportion of the selected farmers in all the respondents</b>	
<b>Rice &amp; corn</b>	44.41%	Three kinds of birds (chicken, ducks, geese)	48.38%	Freshwater fish, shrimps, shellfish, crabs	6.87%	Self-employment	22.64%	
<b>Vegetable</b>	38.72%							
<b>Rubber</b>	33.09%							
<b>Betel nuts</b>	30.86%							
<b>Tropical Fruits</b>	15.88%	Pigs	28.79%			Seawater fishing	1.46%	
<b>Timber forest</b>	7.86%							
<b>Pepper</b>	7.40%	Cattle	5.43%					
<b>Sugar cane</b>	1.90%				4.63%	Betel nuts processing	0.94%	
<b>Flowers</b>	1.00%							
<b>Commercial medicinal herbs</b>	0.87%	Sheep	2.18%			Vegetable purchasing	0.20%	
<b>Others</b>	0.73%							

Source: Hainan Provincial Bureau of Statistics (2015)

### 6.2.1 Design and data description of the Logistic model

Logistic regression (Song, 2009) is mainly used to analyze the relationship between categorical variables and a set of independent variables, and applicable to a wide range of areas, primarily the military and medical fields. The basic structure of the Logistic regression model is derived from multivariable linear regression models. The following is a standard linear regression model:



$$\hat{Y} = \alpha + \beta_1 \chi_1 + \dots + \beta_m \chi_m \quad (6.1)$$

In the above model,  $Y$  is the dependent variable and  $x_1$  to  $x_m$  are independent variables, while  $\mu$  is the stochastic error term. In real-life operations, it is often the case that the dependent variable is a categorical variable. Therefore, the relationship between the two should be thoroughly analyzed. With a linear regression model as the reference model, the fitting is continuously performed to derive the following regression model:

$$\hat{P} = \alpha + \beta_1 \chi_1 + \dots + \beta_m \chi_m \quad (6.2)$$

This model presents the transformation process between each independent variable and the dependent variable, which greatly reduces the difficulty of requirement analysis. Scholars have long been researching and discussing the problem and predicting the various problems that will arise. To date, the model has been applicable to multiple areas. Nevertheless, there are still two intractable problems in the model. (1) Range of values: The set of real numbers falls into the entire range of values on the right side of the model. It can be concluded from the range of values of the model that the numerical ranges of the two models are not consistent. Therefore, the various problems that appear in the model above are the main factors leading to the incorrect conclusion. (2) Curvilinear correlation: After careful observation, it is found that there is no effective correlation between the dependent variable  $P$  and the independent variables. The two are not presented in a linear relationship, but in a sigmoidal relationship. Therefore, in the above two models, the assumption does not hold.

The logit transformation proposed by British scholars in the 20<sup>th</sup> century has commendably solved the above problem, converting the dependent variable to the probability ratio of a specific result occurring to the probability of it not occurring:  $odds = P / (1 - P)$ . Taking its logarithm, we have  $\lambda = Ln(odds) = Ln[P / (1 - P)]$ . Therefore,  $logit(P)$  can be used as a dependent variable to construct a Logistic regression model containing  $p$  independent variables, as follows:

$$\mathbf{Logit(P)} = \beta_0 + \beta_1 \chi_1 + \dots + \beta_p \chi_p \quad (6.3)$$

The above formula can be further converted to:

$$P = \frac{\exp(\beta_0 + \beta_1\chi_1 + \dots + \beta_p\chi_p)}{1 + \exp(\beta_0 + \beta_1\chi_1 + \dots + \beta_p\chi_p)} \quad (6.4)$$

$$1 - P = \frac{1}{1 + \exp(\beta_0 + \beta_1\chi_1 + \dots + \beta_p\chi_p)} \quad (6.5)$$

This section uses the Logistic regression model to empirically analyze the factors affecting the loan acquisition rate and loan repayment rate of farmers in the microcredit system. The research data was derived from the RCCs of HN Province, with a total of 4,000 borrowers selected from the eastern, western and central regions of HN Province for empirical research. 434 pieces of unqualified data were excluded, leaving 3,566 pieces of data that met the research requirements, which was then standardized. Based on the data characteristics, 12 characteristic variables of borrowing farmers were selected as explanatory variables of the regression model, specifically fixed residence ( $x_1$ ), marital status ( $x_2$ ), repayment willingness ( $x_3$ ), labor capacity ( $x_4$ ), poor credit record ( $x_5$ ), bad habits ( $x_6$ ), educational background ( $x_7$ ), illegal and criminal activities ( $x_8$ ), age ( $x_9$ ), presence of other loans ( $x_{10}$ ), explicit use of the loan ( $x_{11}$ ), and gender ( $x_{12}$ ). The Logistic regression model is shown in Equation (6-6), where  $P$  represents the loan acquisition rate or loan repayment rate, and  $\mu$  stands for the stochastic error term.

$$\text{Logit}(P) = \beta_0 + \beta_1\chi_1 + \dots + \beta_{12}\chi_{12} + \mu \quad (6.6)$$

### 6.2.2 Analysis of factors influencing the loan acquisition rate

Table 6-5 shows the Logistic regression results of the loan acquisition rate. It can be seen that fixed residence, labor capacity and explicit use of loan have a significantly positive impact on the loan acquisition rate. The regression coefficients are 0.878, 1.054 and 0.901, with a significance level of no less than 5%, suggesting that farmers with a fixed residence, stronger labor capacity and explicit use of the loan are more likely to obtain small loans from RCCs. Meanwhile, poor credit record, bad habits and age have a significantly negative impact on loan acquisition rates, with regression coefficients of -1.783, -2.514 and

-0.676 respectively and a significance level of no less than 10%. This indicates that farmers with a poor credit record and bad habits, as well as older farmers, are less likely to obtain loans. In addition, marital status, repayment willingness, educational background and gender have a positive impact on the loan acquisition rate of farmers, while illegal and criminal activities, and the presence of other loans have a negative impact.

Table 6-5 Logistic regression results of loan acquisition rates

Explanatory variables	Regression coefficients	Standard error	Z statistics	P value
<b>Fixed residence</b>	0.878**	0.421	2.086	0.037
<b>Marital status</b>	0.437	0.337	1.297	0.195
<b>Repayment willingness</b>	0.021	0.362	0.058	0.954
<b>Labor capacity</b>	1.054***	0.309	3.411	0.001
<b>Poor credit record</b>	-1.783***	0.479	-3.722	0.000
<b>Bad habits</b>	-2.514***	0.821	-3.062	0.002
<b>Educational background</b>	0.185	0.733	0.252	0.801
<b>Illegal and criminal activities</b>	-1.045	1.276	-0.819	0.413
<b>Age</b>	-0.676*	0.401	-1.686	0.092
<b>Presence of other loans</b>	-0.554	0.347	-1.597	0.110
<b>Explicit use of the loan</b>	0.901**	0.404	2.230	0.026
<b>Gender</b>	0.199	0.299	0.666	0.505
<b>Constant term</b>	0.005	0.517	0.010	0.992

Source: RCCs in HN Province (2016)

### 6.2.3 Analysis of factors influencing the loan repayment rate

Taking a step further 7 variables were selected from the 12 characteristic variables, and a regression analysis of their influence on the microcredit loan repayment rate of farmers was conducted. The results, shown in Table 6-6, suggest that labor capacity, fixed residence, and explicit use of the loan have a significantly positive impact on the loan repayment rate. The regression coefficients are 0.977, 0.804 and 0.779 respectively, with a significance level of at least 5%, which means farmers with a fixed residence, stronger labor capacity and explicit use of the loan are more likely to repay the small loans from RCCs on schedule.

On the other hand, poor credit record and bad habits have a significantly negative impact on the loan repayment rate. The regression coefficients are -1.219 and -1.167 respectively, with a significance level of 5%, indicating that farmers with a poor credit record and bad habits are less likely to repay the loan on time.

Table 6-6 Logistic regression results of loan repayment rate

<b>Explanatory variables</b>	<b>Regression coefficients</b>	<b>Standard error</b>	<b>Z statistics</b>	<b>P value</b>
<b>Labor capacity</b>	0.977***	0.369	2.648	0.008
<b>Fixed residence</b>	0.804**	0.381	2.110	0.035
<b>Poor credit record</b>	-1.219**	0.499	2.443	0.015
<b>Repayment willingness</b>	0.021	0.402	0.052	0.959
<b>Explicit use of the loan</b>	0.779**	0.378	2.061	0.039
<b>Bad habits</b>	-1.167**	0.602	1.939	0.053
<b>Illegal and criminal activities</b>	-0.923	0.899	1.027	0.304
<b>Constant term</b>	0.287	0.404	0.710	0.478

Source: RCCs in HN Province (2011)

## 6.2.4 Analysis of the importance of variables

In order to dig deeper into whether there is a certain correlation between the seven variables, the classification tree model and CRT algorithm were used to analyze the variables affecting the microcredit repayment rate.

### 6.2.4.1 Principle of the tree model

The model divides the research objects into several homogenous subgroups based on their characteristics, so as to discuss and explore them. In this model tree group, since the values of the dependent variables are absolutely equal, and the variations/impurities are distributed as much as possible among the various subgroups, the model must be computed under this rule, with certain differences among the definition, nature and connotation.

Examples include variance, entropy, Gini index, deviation and other indicators to be measured.

#### 6.2.4.2 Tree model algorithm

Based on their characteristics, arrays can be divided into two categories: classification tree and regression tree. The focus of this section is to find out whether there is a correlation between the main factors affecting the repayment rate, namely, whether the indicators are mutually restrained, while analyzing the above problems in combination with the model. Its formula is as follows:

$$g(t) = \sum_{j \neq i} p(j/t)p(i/t) \quad (6.7)$$

In the above formula,  $i$  and  $j$  represent the two categories of the target variables.

$$\begin{aligned} p(j/t) &= \frac{p(j, t)}{p(t)} \\ p(j, t) &= \frac{\pi(j)N_j(t)}{N_j} \\ p(t) &= \sum_j p(j, t) \end{aligned} \quad (6.8)$$

If anyone wants to split a node using the difference value of the independent variable, there are several ways to do so. It can split the node, with the change of the Gini index represented as:

$$\Phi(s,t)=g(t) - P_Lg(t_L) - P_Rg(t_R) \quad (6.9)$$

When the Gini index change reaches the maximum value, the ratio of the right child node is the best segmentation method.

$$\Phi(s * t) = \max_{s \in \Omega} \Phi(s, t) \quad (6.10)$$

The above set contains all possible branches. If the independent variables of the model meet the following two conditions, the range of values can be differentiated; In the disordered independent variables, each combinatorial method is used for splitting.

From the analysis of the results of the classification tree model analysis it can be

concluded that there are interactions among the four impact indicators—labor capacity, fixed residence, explicit use of the loan, poor credit record and bad habits—but this interaction does not affect the ability to repay of the borrower.

The most influential factors are labor capacity, fixed residence, bad habits, explicit use of the loan and poor credit record (see Table 6-7) which is consistent with the conclusion of the research and analysis of the Logit model regression. However, the microcredit repayment rate is affected by the repayment willingness of the borrower, which is influenced by the fact that the microcredit institution in HN Province requires the borrower to take part in a five-day loan education program before asking for a loan. Besides, RCCs in HN Province have implemented user repayment incentives. In the gold system, the actual repayment rate of loan users is related to their integrity. In practice, RCCs in HN Province have actively implemented the above two measures to instill a strong sense of repayment in the borrowers, which has greatly improved the repayment rate.

Table 6-7 The importance of explanatory variables

<b>Explanatory variables</b>	<b>Importance</b>	<b>Standardized importance (%)</b>
<b>Labor capacity</b>	0.030	100.00
<b>Fixed residence</b>	0.029	97.90
<b>Bad habits</b>	0.018	58.80
<b>Explicit use of the loan</b>	0.014	47.70
<b>Poor credit record</b>	0.008	26.60
<b>Presence of other loans</b>	0.006	21.20
<b>Marital status</b>	0.003	14.10
<b>Gender</b>	0.002	10.60
<b>Repayment</b>	0.000	0.00

Source: RCCs in HN Province (2016)

### **6.3 Determination of the number of microcredit joint guarantors**

However, the farmers that meet the above key conditions cannot guarantee repayment on schedule, and they need joint guarantees from other farmers. If the number of joint guarantors is too small, the on-time repayment rate will decrease; if there are too many joint guarantors, the interest rate of the loan will be affected. To this end, it is necessary to scientifically and reasonably determine the number of joint guarantors. Using the panel data of the RCCs in HN Province and the curvilinear regression method, the optimal number of joint guarantors can be determined under the premise of ensuring a high loan acquisition rate and a high repayment rate.

#### **6.3.1 Analysis of repayment without joint guarantees**

Can the borrowers with the above relevant indicators guarantee the repayment of the loan amount on time? Research was carried out based on the statistics of 3,566 samples collected by the author between 2014 and 2015. Using these samples as research objects, five indicators were studied and analyzed, including labor capacity, explicit use of the loan, fixed residence, no poor credit record, and no bad habits.

#### **6.3.2 Relationship between the rate of repayment on schedule, the loan acquisition rate and the number of joint guarantors**

Table 6-8 provides the parameter estimation results of the repayment rate on schedule and the number of joint guarantors. Figure 6-1 shows the relationship between frequency and repayment rate, while Figure 6-2 shows the corresponding curve-fitting results. It can be inferred from the curve shape that there is a positive correlation between the repayment rate on schedule and the number of joint guarantors, and the increase in the number of joint guarantors effectively raises the loan repayment rate. Based on the parameter estimated value, the functional relationship between the repayment rate on schedule and the number of joint guarantors can be presented as:

$$Y_1=60.352+14.071t-1.489t^2+0.045t^3 \quad (6.11)$$

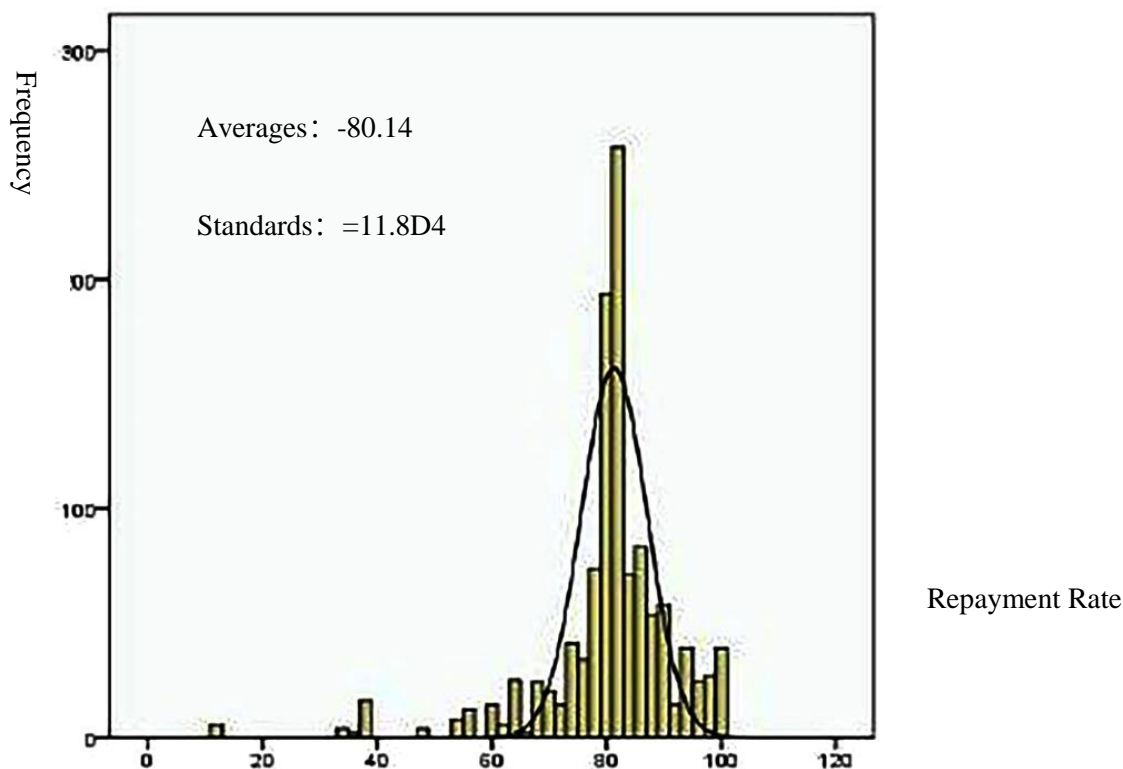


Figure 6-1 Histogram of on-schedule loan repayment rate

Among them,  $Y_1$  is the repayment rate on schedule, and  $t$  is the number of joint guarantors.

Table 6-8 Model summary and parameter estimation

Equation	Model summary					Parameter estimation			
	R <sup>2</sup>	F	df1	df2	Sig	constant	b1	b2	b3
Cubic	0.966	105.71	3	11	0	60.352	14.071	-1.489	0.045

Note: The dependent variable is  $Y_1$ , the on-time repayment rate, and the independent variable is  $t$ , the number of joint guarantors.

Table 6-9 presents the estimated results of the loan acquisition rate and the number of joint guarantors. According to the parameter estimated value, the relationship between the loan acquisition rate of users and the number of joint guarantors can be expressed as:

$$Y_2=98.632-1.052t-0.424t^2+0.059t^3 \quad (6.12)$$



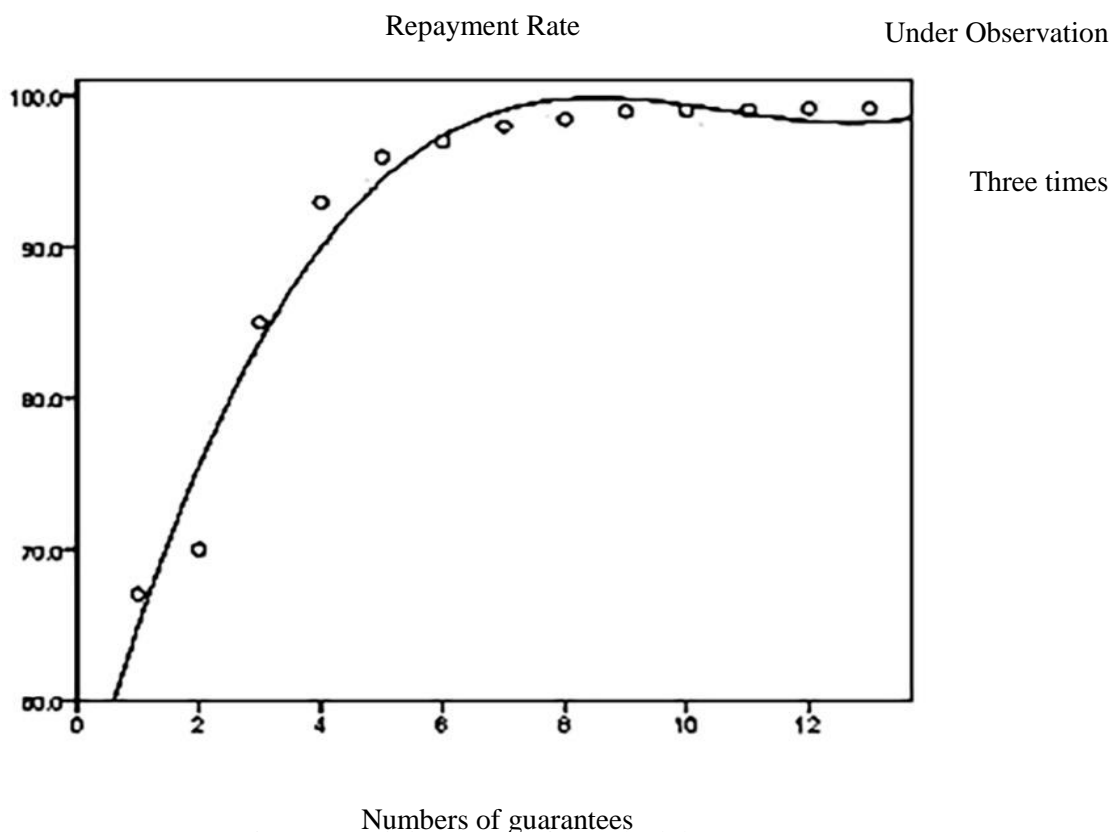


Figure 6-2 Fitting graph of on-schedule repayment rate

In the above formula,  $Y_2$  is the loan acquisition rate, while  $t$  stands for the number of joint guarantors.

Table 6-9 Model summary and parameter estimation

Equation	Model summary					Parameter estimation			
	R <sup>2</sup>	F	df1	df2	Sig	constant	b1	b2	b3
<b>Cubic</b>	0.992	612.969	3	14	0	98.632	-1.052	-0.424	0.059

Note: The dependent variable is  $Y_2$ , the loan acquisition rate, and the independent variable is  $t$ , the number of joint guarantors.

### 6.3.3 Determination of the number of joint guarantors

In the above sections, the relationship between  $Y_1$ , the microcredit repayment rate on schedule, and  $t$ , the number of joint guarantors was derived [see formula (6-14)], and the relationship between  $Y_2$ , the loan acquisition rate, and  $t$ , the number of joint guarantors [see formula (6-15)]. According to the development requirements of financial institutions, the

repayment rate of microcredit is generally no less than 95% (Peng, 2001). Meanwhile, in accordance with the national requirements for inclusive financial development, microcredit institutions should gradually increase the level of user loan acquisition (Peng, 2001). In combination with the development of microcredit it was determined that  $Y_1$ , the repayment rate of microcredit, is no less than 95%, and  $Y_2$ , the user loan acquisition rate, is no less than 90% (Huang, 2010). In other words, the following conditions should be met:

$$\begin{aligned} 60.352+14.071t-1.489t^2+0.045t^3 &\geq 95\% \\ 98.632-1.052t-0.424t^2+0.059t^3 &\geq 90\% \end{aligned} \quad (6.13)$$

The optimal number of joint guarantors, while ensuring a high loan repayment rate and a high user loan acquisition rate, is calculated by solving the nonlinear problem with an implicit software. The calculated result of the  $t$  value is  $t \in [3.87, 5.12]$ , which means when the number of joint guarantors is 4 or 5, the repayment rate and loan acquisition rate of microcredit can reach 95% and 90% respectively (see Figure 6-3).

## 6.4 Chapter summary

Taking the historical microcredit data of RCCs in HN province as the research sample, this chapter first analyzes the characteristics of farmers in the microcredit system, concluding that the applicants of RCC microcredit are primarily 31-40 years old, with junior high school or even lower education; the farmers applying for microcredit come from families whose average employment rate is 68.9% and mostly live in self-built houses, with diversified income sources dominated by crops farming and animal husbandry.

Secondly, this chapter uses the Logistic regression model to empirically analyze the influencing factors of the microcredit loan acquisition rate and loan repayment rate of farmers. The result shows that labor capacity, fixed residence, and explicit use of the loan have a significantly positive impact on the loan acquisition rate and repayment rate, whereas a poor credit record and bad habits exert a significantly negative impact.

Finally, this chapter probes into the relationship between the loan acquisition rate and loan repayment rate of microcredit and the number of joint guarantors, and determines the optimal number of joint guarantors while ensuring a high loan acquisition rate and a high

loan repayment rate. It is concluded that when there are 4 or 5 joint guarantors, the repayment rate and loan acquisition rate of microcredit can reach 95% and 90% respectively. Furthermore, it shows the effectiveness of the use of the characteristic analysis of farmers, the microcredit client selection and the determination the optimal number of join guarantors for the risk management model of microcredit service for farmers.

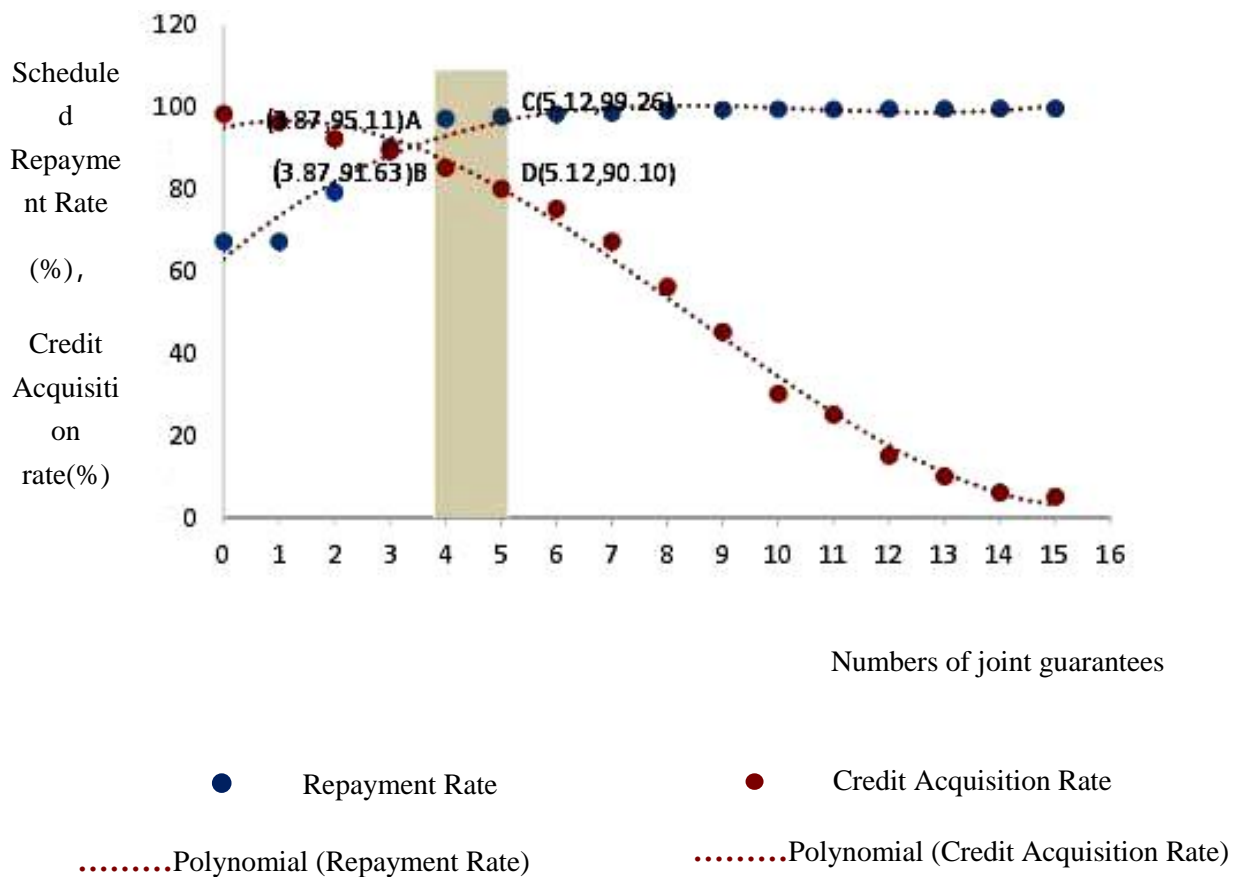


Figure 6-3 Diagram of the number of joint guarantees

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## **Chapter 7: Institutional Mechanisms and Procedures for the Improvement of Microcredit Service for Farmers and the Risk Management System**

Although traditional microcredit has a variety of different service models, each of which has its own advantages and disadvantages. It is difficult for a single microcredit model to develop healthily and stably in the long term. Although financial institutions with microcredit as the basic business have optimized their main models of service, they have only improved external services and have mobilized neither farmers' initiative to use microcredit well nor their willingness to pay on time.

Efforts should be made to strengthen the quality of internal and external services, actively innovate, improve the overall system of credit services, effectively improve the risk prevention and control capabilities, and accelerate the development of microcredit. Credit is the foundation of financial activities. All practices have proved that, in regions or cities with better social environment, whether it is enterprise development needs or individual entrepreneurial needs, it is less difficult to obtain funds, and the financing cost is relatively lower; on the contrary, cities and regions with relatively poor social conditions in all aspects have to not only face the dilemma of "financial difficulties", but also bear many potential financial risks. In this context, in order to maximize the service value of rural financial institutions, it is necessary to reform and innovate relevant institutional mechanisms and build a sound credit system as soon as possible.

### **7.1 Farmers' microcredit integrity cultivation function system**

In order to ensure more healthy development of microcredit, drawing on the advantages of traditional service model and in light of the characteristics of microcredit

development practices in RCCs, survey results and also the author's work experience farmers should be encouraged to adhere to the bottom line of honesty and credibility and credibility level should be linked with loan interest rates. Thus, the self-pricing loan interest rate of the microcredit two-way service model would be further explored, based on microcredit financial institutions and farmers' external services (namely, incentives for changes in loan interest rates, internal service system).

What does the farmers' integrity system cultivate? Specifically, it aims to emphasize farmers integrity, value their own credibility, and popularize financial knowledge in the necessary process. Farmers who borrow money from credit unions for the first time must receive a five-day training on the financial knowledge system from the loan officer so as to understand the differences between financial institution loans and government aids, learn to use loan procedures, such as the ways to calculate interest rates and understanding the benefits of repaying loans on time. Moreover, in order to make it more convenient for the broad masses of peasants to learn financial knowledge, it is necessary to develop easy-to-understand training content for them. It is relevant to disseminate credit culture in the daily life of farmers and let integrity become the principle of every farmer. Farmers' understanding of honesty also needs to be deepened, which can, on the one hand, greatly reduce the credit risk faced by RCCs, and on the other hand, fully stimulate the enthusiasm of other financial institutions to disburse small loans to farmers, thereby significantly improving the status of farmers' microcredit.

HN Province is an underdeveloped area with a large number of poor people in rural areas and a high incidence of poverty. From 1988 to 1998, the average annual growth rate of per-capita net income of farmers in HN province was 12.43%, which was not only 2.6% lower than the disposable income of urban residents in the province, but also 2.4% lower than the per-capita net income of rural residents; from 1999 to 2008, the per-capita net income of farmers in HN Province increased by 8.43% annually, which was 1.59% lower than the per-capita disposable income of urban residents in the province, and 0.5% lower than the per-capita net income of rural residents (Hainan Provincial Bureau of Statistics,

2015). From 2000 to 2007, the income gap between urban and rural residents in HN Province increased from 2.4:1 to 2.9:1.

Formal financial institutions continue to provide inclusive financial services to poor farmers, and informal financial institutions have become the main financing channel for farmers. According to a survey conducted by the Haikou Center Sub-branch of the People's Bank of China, 71.1% of farmers in the HN Province never borrowed from formal financial institutions in 2007 (People's Bank of China, 2010).

As formal financial institutions are unable to meet the financial needs of farmers, usury and other informal financial institutions already occupy rural financial markets.

According to a survey of 518 heads of financial institutions of county-level banks in HN in 2007, 85.3% of the respondents believed that there was private lending with higher interest rates in the HN county, and 33.6% of the respondents considered private lending to be more active. According to the survey, the total amount of private loans in HN Province in 2007 was 15.59 billion yuan, which was 5.09 billion yuan higher than the new loans of financial institutions in the province. Farmers' lack of credit knowledge has led to higher financing costs.

## **7.2 Farmers' microcredit interest rate incentive system**

Strengthening the repayment mechanism of microcredit farmers will help increase the repayment rate of loans, reduce the risk of repayment, perfect the microcredit service system and improve their overall service level and ability. Based on this and on practices of RCCs, this section will focus on the innovation of the microcredit system, connect the actual loan interest rate with the credit farmers' degree of emphasis on integrity, and identify the actual loan rate in the next step in combination with the real situation of the farmers' loan repayment, namely, handing over the "power of pricing" loans to farmers. Thus, we can use interest rate changes to encourage credit farmers to repay loans, improve service quality, and avoid unnecessary credit risks. Why should we give the farmers the

“power of pricing” interest rates? The establishment of a credibility system requires all-round advancement in a gradual and progressive manner, which is an arduous project. Thus, it is necessary to strengthen education and training, do top-level design well, and increase the intensity of system development. This requires financial institutions and customers to actively participate and the government to vigorously promote. Giving the interest rate pricing power to the farmers themselves not only makes it more simplified for farmer to understand financial knowledge, but also makes it easier for farmers to understand the importance of repaying loans on time.

The incentive mechanism associated with it is mainly as follows. Loan customers should pay interest and margin on a monthly basis. If the customer can meet this requirement, the deposit that has been paid can be refunded when the loan is settled. On the contrary, the monthly payment of the deposit is taken as interest. In simple words, farmers' loan interest rate = loan interest rate + integrity reward rate. Integrity reward refers to the fund that farmers need to pay to the financial institution before signing a loan agreement. The true purpose of the incentive mechanism is to let farmers discipline their credit behavior and enable them to price their own loan interest rates based on their own credit. In this way, the loan pricing power is truly in their own hands. As long as farmers fulfill their own loan repayment responsibility in accordance with the agreement, they will enjoy relatively lower loan interest rates. If the interest rates are high, some microcredit users may not be able to repay the loans within the required time. This mechanism can also be used to discipline farmers' repayment behavior, thus cultivating farmers' repayment awareness and optimizing the credit environment. Besides, this mechanism not only improves farmers' sense of integrity, but also reduces farmers' burden of interests, enabling honest farmers to gain real benefits.

Seen from the perspective of microcredit business at home and abroad, the important guarantee for effective risk prevention lies in improving the positive incentive mechanism. On the one hand, efforts should be made to mobilize farmers' initiative to repay their debts on time. On the other hand, measures should be taken to encourage grassroots loan officers



to abide by the rules and prevent moral hazards. Interest rate incentives are fundamental to the interest mechanism.

Farmers with the ability to repay tend to weigh the advantages and disadvantages of whether they repay loans in time or not. In other words, both timely repayment of principal and interest and default on loans have their advantages and disadvantages. If the advantages of repaying the principal and interest in time are far outweigh the disadvantages, then farmers will choose to pay back the principal and interest in a timely manner.

Four possible situations or scenarios of farmers' microcredit repayment are considered:

(1) During the loan period, the borrower will pay interest on a monthly basis and repay the loan within the required time limit;

(2) During the loan period, the borrower defaults on interest or principal;

(3) During the loan period, the borrower did not pay interest on a monthly basis;

(4) The borrower repays the principal and interest in accordance with the contract or agreement.

In combination with the above four situations, a reasonable incentive mechanism is selected for microcredit farmers, based on which the loan interest rate is determined.

First scenario - The borrower only needs to deposit the interest  $X$  yuan into the designated RCC loan account before the specified date of each month to obtain the reward  $Y$  yuan in that month. In other words, the actual monthly interest is  $(X-Y)$  yuan.

Second scenario - If the borrower delays the repayment for a few days, but the corresponding amount is deposited before the end of the month, which means repayment is not delayed to the next month, then the borrower will be rewarded with  $Y_1$  ( $Y > Y_1$ ) yuan. In other words, the actual interest for each month is  $(X-Y_1)$  yuan.

Third scenario - When the loan principal is due and the borrower does not have enough money to repay the principal, the borrower can choose to repay the monthly interest  $X$  on time, in which case he/she will be rewarded  $Y_1$  yuan when the loan is fully repaid. In other words, the actual monthly interest is  $(X-Y_1)$  yuan. If the payment of the interest for this

month is delayed to the next month, then the actual interest for each month will be increased to X yuan.

Fourth scenario - After the funds are repaid, the funds will be deposited in the HN Provincial RCC, which will reduce their monthly loan interest. If the deposit amount is equal to the loan amount, then the monthly reward is  $Y^*(Y^*>Y)$ , making the actual interest  $(X-Y^*)$ .

It should be noted that the parameters X, Y, Y1, and  $Y^*$  need to be measured according to the loan amount and operating cost. The profit target of the financial institution, the asset profit rate (net profit/average daily loan amount), “when the average daily loan amount reaches 2 billion yuan and the task of newly added loan amount is 500 million yuan should be no less than 1%”. When the average daily loan amount reaches 2 billion yuan, the various cost ratios of loans are calculated as follows:

- (1) Labor cost ratio: 4.57% (the employee's salary divided by the average daily loan amount);
- (2) Loan provision rate reserve: 0.63 (the loss caused by the loan impairment divided by the daily average loan amount);
- (3) Cost of capital: 3% (the interest expense divided by the average daily loan amount);
- (4) Tax: 0.15% (the sum of corporate income tax and value added tax divided by the average daily loan amount);
- (5) Other operating costs: 0.5% (operating expenses divided by average daily loan amount)

Thus, the loan cost rate is equal to the sum of the above four cost ratios, namely, 8.85%. in general, considering the scale effect of loans, when an enterprise's interest income increases, the basic salary of employees will not increase accordingly. Therefore, when the average daily loan amount exceeds 2 billion yuan, the maximum loan cost rate is 8.85%.

The drive of incentives not only enhances the sense of responsibility of the loan

officers, but also effectively cultivates and enhances the level of regional integrity. By maintaining integrity and effectively optimizing the service quality of loan officers, a good social image for financial institutions can be established, a positive work atmosphere fostered, and borrowers' awareness of active repayment strengthened. With the increase in the number of loans from farmers and under the support of the provincial government's discounted funds, the final loan cost of honest farmers is very low. For farmers who have been affected by natural disasters, RCCs provide financial support for post-disaster recovery, while guide them to resume production and management and rebuild their homes, thereby winning the heartfelt thanks and long-term support of local farmers and the government. According to the production and operation status of the farmers, the annual review-based loan process and advance approval of renewal are implemented, providing long-term liquidity support to customers, and renewing loans for qualified customers, so as to protect them from high interest loans.

### **7.3 Integrity reward system for farmers' loans**

Farmers are born kind and subjectively honest and credible. Despite so, it is also important to cultivate farmers' awareness of financial integrity and encourage farmers to constantly emphasize their "integrity" and guide them to fully realize the value of "integrity".

The integrity reward system for farmers' loans is about giving a certain amount of reward to the customers who repay loans on schedule. Farmers cannot have a comprehensive and profound understanding of financial knowledge. Giving farmers actual rewards can not only reduce their burden of interest, but also bring real benefits to farmers. Besides, collective integrity rewards should be set up. Collective farmers who act as joint guarantees should also be given a certain amount of reward according to the different loan amount.

The realization of integrity is inseparable from scientific guidance and a reasonable incentive mechanism. Advocating honesty and integrity needs to reflect in deeds rather than

just words. For most loan farmers, microcredit institutions need to integrate honesty into the development of social integrity, set up a matching incentive mechanism, and use economic means to improve the honesty and integrity of the broad masses of farmers. The concept of honesty is to let farmers benefit from honesty. Incentives to foster farmers' integrity can make families, neighbors and even the entire village honest. For small-scale joint guarantee loans of farmers, this kind of integrity will bring more benefits, the impact will be more extensive, and the driving effect will be more obvious. Through long-term active and orderly guidance, the optimization and upgrading of the financial environment and promote the long-term stable development of the microcredit industry and rural economy will be promoted.

Take the Indonesian Financial Bank as an example. The Indonesian Financial Bank provides bank products and services to retail, commercial and SME customers in Indonesia. The bank's financial accounting guidance to corporate loan clients is not an actual bonus incentive, but customers do recognize the importance of timely repayment and credit from it. This aspect has, on the one hand, enabled customers to establish long-term and stable cooperative relations with the bank and, on the other hand, ensured the timely recovery of bank loans and reduced credit risk. In the cooperative training with enterprises, the inspections mentioned before, during and after the loan process, greatly reduce the risk of lending and enable the bank to identify the risks and difficulties facing enterprises in time.

Based on the idea that farmers honor credibility, efforts should be made to promote the innovation of the financial system, establish the integrity incentive system for farmers' microcredit, and include the financial awareness training of farmers in the necessary process of loans. The role of the interest induction mechanism should be given full play so as to increase farmers' enthusiasm for pricing and fundamentally improve the loan users' internal motivation to repay.

The farmers' loan interest rate includes the basic interest rate and the integrity reward rate. The latter varies according to the borrower's specific repayment situation. If the borrower repays on time, he/she will obtain the full integrity reward. Therefore, the loan

interest rate of the borrower will be calculated with reference to the basic interest rate, which will also reduce part of the financing cost; if the borrower cannot repay the loan within the stipulated time, the integrity reward cannot be obtained, and the loan interest rate will be charged in accordance with the contract, thus significantly increasing farmers' loan cost. In addition, it is necessary to further increase government support, build a sound financial subsidy system as soon as possible, and provide a certain proportion of economic subsidies to farmers who repay loans on schedule, thus benefiting honest farmers. In summary, the establishment of a microcredit incentive mechanism for farmers can greatly reduce farmers' loan cost, strengthen their sense of integrity, integrate the concept of integrity and its related culture into the daily life of farmers, and root this sense into the hearts of farmers, thus creating a beautiful society that is honest and trustworthy. The development of "agriculture, rural areas and farmers" has formed positive interactions with a credible society, which has not only improved the service level of microcredit institutions, but also established a mechanism of protection and trust to reduce the economic losses of both parties.

Integrity is the condition for obtaining the integrity reward. The integrity reward takes up 30% of the loan interest farmers pay to RCCs according to the annual loan interest rate. If loan farmers can pay interest on a monthly basis, they will also receive the full integrity reward; on the contrary, if farmers fail to pay interest on time but manage to pay it before the end of the month, then they still have the willingness to repay instead of malicious default. In this case, they will not obtain the integrity reward for that month and the integrity reward for other months of on-time repayment will be calculated as 15% of the interest for the specific month. If the loan farmers delay the repayment of interest to the next month, then the monthly integrity reward will be reduced to zero in the loan period.

Integrity is also the condition for obtaining the financial discounts issued by the government. An interpretation of the policies promulgated by HN Province shows that when farmers apply for small loans, the government should provide a discount rate of no less than 5%. Some cities and counties even apply full discounts to small loans. Once

interest is arrears, it is difficult to apply for financial discount from the government.

Finally, integrity is the condition for obtaining the disability mutual help guarantee. According to the management regulations on disability mutual aid of HN Province, if a borrower encounters a major family accident during the loan period, such as death from serious illness, sudden physical accident, death of spouse, etc., the borrower is entitled to applying for disability mutual aid to reduce or exempt partial loan. And if the borrower's children are admitted to a key university, they are also entitled to a certain amount of scholarship. To obtain these guarantees, the premise is that the borrower pays interest on time and has a good record of integrity.

Integrity is the condition for applying for renewal. During the period of social production and operation, it is hard for farmers to avoid uncontrollable disasters or risks. Therefore, if they delay on the repayment of principal, it is not necessarily a deliberate action. Forcing them to repay their loans will inevitably increase their anxiety to the extent of choosing usury. If farmers can pay interest on a monthly basis during the loan period, but are not able to repay the principal due to financial market fluctuations or natural disasters, they may be allowed to continue to apply for a loan, and RCCs may provide necessary financial support. However, farmers that delay on the payment of interest during the loan period are not eligible to apply for renewal.

Trusting farmers by "putting ourselves into their shoes" will contribute to win farmers' trust, decrease RCCs' non-performing rate of micro loans, and greatly improve the rural financial environment.

#### **7.4 Improvement of the loan compensation reserve and reward and punishment system for microcredit financial institutions**

As a major breakthrough for solving the issues of agriculture, rural areas and farmers, microcredit financial institutions must not only provide strong financial support for the development of these areas, but also include poverty alleviation as a major mission of their

development. Farmers' microcredit is mainly targeted at rural areas. The quality of service microcredit loan officers provide to farmers will have an intuitive impact on the social image of microcredit financial institutions. Integrity is like a weathervane. Financial institutions are willing to provide credit loans to farmers with integrity under the premise that they must be honest and credible. Farmers' microcredit technicians should further strengthen the service concept, improve the quality of service, avoid "taking others' things or asking others for things without doing anything in return" before the loan, increase service efficiency during and after the loan process, and serve the farmers well and gain their trust through practical actions.

Most microcredit technicians have experience resisting the temptation of "red packets". Hainan Rural Credit Cooperatives require every microcredit technician to sign a letter of honesty and self-discipline, making a solemn commitment to strengthen the study of clean government education, adhere to the "three don'ts" code of conduct, stick to clean government and self-discipline, and voluntarily accept supervision.

First, microcredit technicians issue loans and supervise other microcredit technicians. For each loan, the loan officer, supervisor and branch manager shall assume responsibility and share a certain percentage of the proceeds.

Second, each loan is managed by a computer system, which is transparent and mechanism-based in process control, ensuring that the loan is well documented, and that the rights and responsibilities are clear. Once the customer defaults on interest, the system automatically prompts the loan officer to conduct a risk warning. When the microcredit technician's non-performing rate reaches 2%, the system automatically locks up its loan disbursement authority, and the loan officer automatically leaves the post to collect the loan.

Such a reward and punishment system not only effectively controls the risk of loans, but also increases the approval rate of loans. Microcredit technicians supervise each other and borrow money directly to simplify the loan process and provide convenience for farmers.

The approval of traditional bank loans is carried out by the loan review meeting, and

the risks are collectively taken. However, if there are non-performing loans, there will be no one to undertake the economic losses caused thereby. Therefore, it is important to set up a credit incentive mechanism based on the level of integrity of financial practitioners. It is explicitly required that the microcredit officers must pay a certain percentage of the loan compensation reserve to the financial institution in which he/she works for and the percentage shall be determined according to the amount of loan disbursed and the asset quality. If a non-performing loan occurs, not only those who have performed their duties will be exempt from liability, the pre-paid compensation reserve can be used to complement for the loss. In the meantime, farmers' microcredit officers with excellent performance should be given corresponding rewards and provided with a considerable proportion of loan interest income. In the event of a delay in loan repayment, the technician shall take appropriate measures, such as starting a deferred payment system. This system aims to strengthen the sense of responsibility of farmers' microcredit officers, make their behavior more self-disciplined, and fundamentally reduce the internal corruption problem of "taking others' things or asking others for things without doing anything in return". Besides, the implementation of this mechanism can also improve the ability and quality of financial services to a certain extent, further improve the financial common sense of farmers and their initiative to repay loans.

In terms of age structure, most microcredit technicians are young people, with an average age of 26 years old. They are not only vigorous, but also able to integrate into the microcredit corporate culture and withstand the harsh work environment in rural areas. In terms of academic structure, most microcredit technicians are fresh college graduates, of which graduates with a bachelor's degree or above account for nearly 60%. A higher level of literacy not only facilitates the development of microcredit work, but also enables the team to form its own team culture and belief through learning. In terms of professional structure, the loan officers recruited by traditional commercial banks are mainly financial professionals, whereas the loan officers recruited by RCCs pay more attention to moral quality and are required to not only have the corresponding financial and accounting knowledge, but also understand the rural areas, farmers and agriculture.



## **7.5 Creation of a proprietary model for microcredit in rural areas**

The core of the exploration of inclusive finance lies in the institutional innovation. With the goal of creating “farmers’ own bank” and under the problem-oriented approach, it is necessary to identify a series of root causes of microcredit illness and suit the remedy to the case, so as to form a professional institutional mechanism and create a new path that is both inclusive and sustainable. The specific contents include: Set up specialized institutions, form professional teams, create special cultures, formulate special procedures, develop patented products, implement special interest subsidies, establish specialized systems, hire expert teams, and set up special funds.

1. Set up specialized institutions - Before the establishment of the microcredit headquarters, RCCs mainly rely on grassroots organizations to disburse micro loans. These grassroots organizations operate both micro loans and large loans. The trend of “large loans crowding out micro loans and the deviation from farmers and micro loans” was obvious. After the reform of RCCs, a special organization was set up for the microcredit headquarters to provide more opportunities for microcredit. Since provincial associations cannot directly operate deposit and loan business, they set up a headquarter for microcredit financial institutions and adopted the management model of business units. HN Province has now equipped 2-3 professional microcredit officers for each credit service station, and the service organizations covering the whole province have become more and more perfect.

2. Organize and set up professional teams - In order to effectively provide inclusive financial resources to farmers, it is necessary to recruit a group of fresh graduates who have never done credit business to be dedicated to a team of microcredit technicians rooted in rural areas and providing loans to agriculture.

3. Create special cultures - In the traditional financial cognition system, farmers are believed to have “a low education level and poor credit”. Thus, farmers’ microcredit is characterized by “high risks, high cost and low profits”. This concept has restricted the development of microcredit for a long time. Proceeding from the idea that “farmers are the

most honest”, efforts should be made to explore micro loans suitable for farmers' characteristics and foster a complete microcredit corporate culture that is different from traditional finance.

4. Formulate special procedures - The original loan process mostly relies on standardized materials. In comparison, microcredit does not have a set of standardized process or standards because it is small and dispersed. Instead, it relies on the non-standardized information collected from comprehensive analysis. In order to simplify the loan procedures and increase loan efficiency, a specialized microcredit operation process should be established. This could consider a five-day pre-lending training, when loan officers train loan applicants borrowing knowledge, repayment rules, liability for breach of contract and relevant agricultural technologies and also supervision of loan review and disbursement. Loan applicants should have first loans disbursed in seven days, and second loans in one day; they should also obtain customer guarantees. The loan management practices follow the principle of “four guarantees and four linkages”. Four guarantees refer to guaranteed disbursement, guaranteed management, guaranteed collection and guaranteed compensation, whereas four linkages refer to their linkages to wages, share capital, risk compensation for non-performing loans, and job promotion.

5. Develop patented products - In order to meet the funding needs of different levels of customers, under the original microcredit model, new credit products will be further introduced to ensure that each farmer can find loan products that meet their needs.

6. Implement special interest subsidies - In order to alleviate farmers' burden of interests and encourage agricultural financial institutions to actively disburse small loans, HN Provincial Government has formulated and implemented a special interest subsidy policy to provide farmers with a discount of no less than 5%. In 2010, the provincial government passed the “Interim Measures for the Administration of Farmers' Subsidized Loans in HN Province”, continued to improve in practice and formed an institutionalized financial subsidy management system. Although HN is not the first province to implement political subsidies, HN is one of the provinces that best implement the subsidy policy as

well as promote standardization and institutionalization.

7. Establish specialized systems - According to the classic model of microcredit risk management and the milestone results during process improvement stage, the improvement model for microcredit risk management will realize such functions as the grading of microcredit targets, establishment of the credit indicator supporting system, generation of the corresponding risk control nodes, process monitoring and quality verification, as well as online collection and verification of microcredit process data. In this way, the technology-based management will be realized.

Based on the historical sample loan data, a logistic regression analysis model or BP neural network model for corporate loan default may be established to set up the forecast model of corporate loan default probability, providing a quantifiable prediction basis for loan default in financial institutions.

The new system will effectively improve the level of informatization and technology of inclusive financial services, providing efficient financial services for farmers, allowing farmers to “borrow loans without leaving the town and repaying loans without leaving the village”, delivering the “last mile” of inclusive finance.

8. Hire expert teams - The intrinsic reasons for the high risk of farmers' microcredit are farmers' lack of understanding of the agricultural market and poor agricultural management. These problems directly lead to their insufficient repayment ability.

Hire technical experts in “three rural issues” to provide such services as agricultural guidance and information consulting is aimed at addressing farmers' poor repayment ability. For a long time, by forming high-quality expert teams to help farmers accurately select agricultural projects that meet the market needs, guide farmers to effectively improve agricultural development, establish agricultural product sales channels, provide risk warning for rural financial institutions, and adjust industry structure, the objective of “all-win” for multiple parties has been realized.

9. Set up special funds - Due to the risks of agricultural production, the availability of

small loans is extremely important for farmers. Microinsurance is no exception. These can effectively strengthen farmers' risk resistance ability and awareness. Yunus and Jolis (2008) set up a deposit insurance plan in the microcredit exploration process. Drawing on this practice, a mutual fund will be set up for disabled farmers, and farmers who meet the application conditions will be able to use resources according to the proportion of the loan amount. Some of these funds need to be repaid by the Disability Fund and provide a certain amount of pension for disabled farmers. For example, if borrowers' children are admitted to a key university, they can receive a scholarship ranging from 2,000-5,000 yuan.

The reason why traditional financial institutions are reluctant to develop microcredit business is information asymmetry. To be specific, lenders and borrowers cannot use a standard way to assess the loan risk. Besides, because of the continuous expansion of the commercial financial system, loan officers' ability to make decisions and interfere with microcredit is too large, and credit directors have too much discretion over the income level of each loan officer under his management. This not only makes it harder for farmers to obtain loans in time, but also produces certain rent-seeking space. In response to this problem, it is necessary to establish a complete set of loan approval procedures as soon as possible to ensure that rights and responsibilities are balanced, open and fair, so as to form the following five special mechanisms.

1. Give farmers the "approval right" for loans - This is because microcredit loans require loan review and approval. Microcredit technicians are the first-level loan approval officers and have rent-seeking options. Farmers will not receive loans without giving benefits. The terms of the microcredit collateral must be clearly defined. As long as they have a fixed residence, a clear purpose, the willingness to repay and the ability to repay, while having no poor credit history, no criminal records of pornography, gambling or drug abuse, they can voluntarily form joint guarantee of 3-5 households. After the five-day training, the loan officer must issue a certain amount of credit loan to them.

2. Transfer the "pricing power" of loan interest rate to the farmers - Most of the farmers in China are honest and trustworthy. But because the traditional mechanism does

not reflect the importance of good faith, honest farmers have not received the rewards they deserve due to good faith. Therefore, it is necessary to establish a positive incentive mechanism. Innovatively launching the microcredit “integrity reward” system directly links the interests of farmers with the integrity of farmers: Honesty brings benefits and interests; Dishonesty invites losses. This measure can significantly improve the integrity of farmers.

3. Transfer the “allocation right” of the microcredit employees' salary to themselves - In view of the fact that microcredit belongs to the labor-intensive business category, a mechanism to separate deposits from loans and large loans from small ones should be designed. Besides, a payable and testable salary payment system should also be designed to include such indicators as the number of loan households, amount, non-performing rate into the comprehensive assessment. Under this mechanism, the income of microcredit technicians depends not on the superiors, but themselves. Their income can be calculated according to their performance. Supporting and benefiting the farmers and increased income for employees form a new pattern of “interest compatibility”.

4. Give the “control” of loan risk to loan officers - After giving the loan authority to the microcredit technicians, in order to prevent possible risks and reduce the non-performing rate, a complete set of risk prevention mechanisms needs to be established. The first is mutual restraint and mutual supervision. For example, one branch has four microcredit technicians ABCD, B is responsible for supervising the loans disbursed by A, C is responsible for supervising the loans disbursed by B, D is responsible for supervising the loans disbursed by C, and D provides loans to A. The branch manager re-supervises the loan officers under his management, forming a cyclical risk monitoring mechanism. The second is to implement the apprenticeship system. Microcredit technicians are apprentices during the internship and probationary periods. Apprentices can train up to 30 clients to apply for loans from the branch within 6 months. Upon leaving the branch, the branch head must sign a joint and several liability guarantee and bear joint and several liability for violations and illegal acts during their employment.

5. Give the loan “management rights” to the computer - At present, rural households

account for 95.3% of the total number of households in HN Province (1.193 million), and service households account for 59.7% of the total number of households in HN Province. It is managed by more than 500 microcredit technicians, with a heavy workload, high costs and high risks. Therefore, it is necessary to develop a special technical system, which includes such content as basic information of loan farmers, approval procedures for loans, post-management and risk warning. This not only effectively manages farmers' loans, reduces labor management costs, but also plays a role in effectively preventing and controlling loan risks. At present, the economic situation at home and abroad is changing rapidly. Therefore, in the study of the microcredit service system for farmers, in addition to the successful cases of foreign developed countries, it is necessary to proceed from China's reality, comply with the principles and rules of economic development, facilitate the development of microcredit for farmers, continuously improve the interest rate pricing and risk control of small mortgage farmers, in order to better guide the healthy, orderly and sustainable development of China's rural microcredit, and strive to achieve the "two century" goals.

## **7.6 Chapter summary**

Cultivation of an integrity system is a strong support for the scientific and sustainable development of the microcredit service system. The problem-oriented approach should be adhered to. In order to effectively address such prominent problems as low on-schedule repayment rate, cumbersome procedures, and a long loan period, the loan interest rate pricing system for farmers' microcredit is regarded as the core "baton" to give full play to the role of financial institutions as market players, reform, innovation and pilot demonstrations strengthened. The "five-transfers" service model is also critical, characterized by transferring the powers of review & approval, pricing, and risk control to the loan applicants, transferring the salary payment right to loan officers, and transferring the "management rights" of loans to the computer information system. The management model featured by "nine specialties" has been formed. The system of social integrity

cultivation has been created. And a unique financial institution service system for farmers' microcredit has been set up. These efforts will improve the quality and efficiency of microcredit services on the whole, reduced microcredit risks, and enhanced the profitability and operational management capabilities of rural microcredit financial institutions, thereby accumulating new experience and exploring new paths for the development of microcredit in China.

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## **Chapter 8: Conclusions and Research Prospects**

### **8.1 Research conclusions**

Through the analysis of the current situation of farmers in HN area and the problems faced by financial institutions, this study presents an insight into the theoretical and practical issues of microcredit loans for farmers in HN area. The reasons are attributable to the poor role financial institutions play in market leadership and the imperfect risk control mechanism of financial institutions themselves.

In the process of China's market economy development, interest rates need to be gradually liberalized. After interest rates are liberalized, if financial institutions fail to improve their management and service quality, they will suffer from lower profits and be rendered at a disadvantageous position in the financial market. Besides, the competition among various financial institutions can also allow the majority of credit customers to get more quality services and more favorable prices.

In this context, this study presents a multi-dimensional dynamic risk control mechanism to scientifically price the microcredit for farmers in the context of interest rate liberalization and seeks to address the practical difficulties and institutional problems for developing microcredit in rural areas at an affordable cost, so as to provide farmers with appropriate and effective financial services and explore new ways to promote the sustainable development of microcredit in rural areas.

Benefiting from the long-term experience of the author in rural finance and with the support of the research methods of iterative model establishment and statistical analysis, this study analyzed the current situation of microcredit in rural areas and proposed a set of microcredit mechanisms for farmers from two dimension, namely, scientific pricing and risk management.

### **8.1.1 Microcredit interest rate pricing system for farmers**

In order to give full play to the role of the farmers' microcredit financial institutions as the main market players and effectively break the theoretical and practical dilemma of farmers' microcredit, focus must be on the microcredit for farmers. There have been some outstanding problems, such as low repayment rates, complicated procedures, and long-term loans. Driven by reform and innovation, the major role of the market has been given full play and institutional innovation has been adopted to design a set of effective methods to "give farmers the right to review loan applications", provide loan farmers with the "pricing power", and give loan officers "the right of salary payment". The "risk prevention and control right" of loans is transferred to credit technicians. The core of setting up the microcredit interest rate pricing system for farmers is to hand over the "pricing power" of loan interest rates to the farmers and unfold by focusing on three core factors, namely, the outstanding characteristics and problems of microcredit in rural areas, interest rate liberalization, and cost affordability. These efforts have effectively removed such constraints as low on-time repayment rate of farmers' microcredit loans, long loan period and cumbersome procedures, achieved the goal of giving full play to the role of microcredit financial institutions for rural households as the main market players, and found a farmers' microcredit development path that is in line with the conditions and reality of China's rural areas.

### **8.1.2 Farmers' microcredit risk management system**

The research carried out shows how the microcredit risk management mechanisms for farmers, through the two dimensions of scientific pricing and risk management, can effectively play the role of microcredit financial institutions for farmers as the main market player after interest rates are liberalized, and effectively break the theoretical and practical dilemma of microcredit for farmers, providing a guarantee for financial institutions to achieve risk-controllable and cost-effective sustainable development. The microcredit risk management system for farmers is built centering on farmers' microcredit interest rate

incentive mechanism, farmers' microcredit integrity reward system, and farmers' microcredit integrity cultivation function system.

In this way, a successful path suitable for the development of microcredit for farmers can be explored in line with China's national conditions. Advanced experience can be developed, replicated and popularized to promote the rapid and healthy development of farmers and the rural economy, and realize the ambitious goal of building a well-off society as soon as possible.

## **8.2 Research prospects**

The farmers' microcredit management mechanisms proposed in this thesis are based on the development background of farmers' microcredit at present and its stage as well as farmers' loan demand. The "three rural issues", namely, agriculture, rural areas and farmers, will continue to arouse social attention, reform and to provide innovation. With the constant change of the external environment, the following key factors will certainly affect the development of microcredit for farmers:

### **1. Development and improvement of land ownership**

In China's rural areas, most peasant households have no fixed assets, but they have the land resources that have been cultivated for generations. In China's rural areas, farmers' lack of collateral and inability to find a guarantor have become the main difficulties for them to obtain loans from financial institutions. With the continuous development and improvement of land ownership in China, the history where farmers cannot borrow loans from financial institutions through such forms as land realization and land mortgage will be changed (Yang, 2010).

Reform and innovation in the "three rural aspects", especially the deepened reform in rural land system has liberalized land management rights. Under the premise of protecting the collective ownership and farmers' right to contract in accordance with the law, the land management right acquired by the operating entity in accordance with the circulation

contract is equally protected to guarantee its stable business expectations, realizing the separation of rural land ownership rights, contract rights and management rights, making the value of land measurable, property rights clearer, and land tradable and liberalized. This will bring tremendous help and guarantee for the development of rural credit.

## 2. Coordination between financial institutions, governments and society

Farmers' microcredit has strongly mobilized the initiative of the broad masses of farmers to apply for micro loans and also promoted the vigorous development of relevant financial institutions. However, the existing credit institutions are in need of optimization and improvement in the later period in both service level and the regulatory system. In the meantime, farmers' agricultural production and management skills should be strengthened to help them reduce the potential risks during production and operation. In the process of carrying out microcredit work in the future, it is necessary to guide farmers to master good agricultural technologies, actively build a sales system of agricultural products, effectively improve farmers' fund use efficiency, improve farmers' production and operation level, bring more economic benefits to farmers, and form a "station" service system. For this to happen there must be good coordination between financial institutions, governments and society.

## 3. Integration of finance and technology

It turns out that decisions in the financial industry, especially lending, are made by people, and data are just a reference. Now, on the basis of a large number of live data, this work can be done with artificial intelligence. The financial industry is engaged in credit business and the original form and function of these financial institutions may be overturned or restructured.

In the near future, there will be an ideal trend in China, namely, "cooperation model", where technology is used to help financial enterprises. Because technology enterprises are born with strong access ability, they have low customer acquisition cost, large service coverage and strong data precipitation ability. By marrying technology enterprises, financial institutions are able to access a broader scope of corporate information faster and cheaper.

In addition to operating profit, there are more detailed data on taxes, turnover, rent and utilities. These data can help us identify the most efficient production and operation conditions of farmers, lower the cost of collecting information, and reduce the risk of granting loans.

#### 4. Improvement of information data and enrichment of trading scenarios

With the combination of finance and technology, this study applies the farmers' microcredit risk iteration IDEAL model with microcredit as a theoretical basis. Thus, the original production model and microcredit database is continuously screened and optimized, before, during and after the loan process. The risk of rural microcredit is controlled and prevented in real time, and this effectively helps financial institutions to accurately and timely identify risks in credit activities, and make timely interventions to minimize losses. With the continuous iteration of the process of farmers' microcredit and the continuous enrichment of transaction scenarios, this model will be able to further promote the healthy development of rural financial environment. IDEAL model needs a lot of data to improve and optimize, so this study also hopes to provide information that may contribute to theoretical and empirical work of future researchers.

Nowadays, farmers' microcredit has been widely popularized and practiced, and the scale of loans has been gradually expanded. In the future, the development focus of farmers' microcredit will turn to commercialization, relevant financial institutions will also gain more prominent profitability and the goal of sustainable development will be gradually incorporated. This will give full play to the main role of the market and reduce administrative intervention. Gradually, the focus will be shifted from the establishment of subsidy system for farmers' loans and incentive system for microcredit financial institutions to the guidance of microcredit plans for farmers, so as to realize the sustainable development of both sides.

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## Appendices

### Appendix 1 Environmental requirements analysis

#### I. System environment configuration

The platform support system software and development tools used by this software are as follows:

1. Persistence layer (data layer)

Application server: MSSQLServer2005/2008 or MYSQL5.0

2. Application service layer (business logic layer)

Application server: ApacheTomcat6.20 JavaSESDK: SunJava6.0

Application middleware: TOMEE

3. Presentation layer (customer operation layer)

Front Desk SDK: HTML

Front-end browser: master browser above

IE6.0/Chrome/Safari/Firefox3/Netscape/Opera

4. Support tools for credit big data processing and analysis

ETL (data mining, Extract-Transform-Load) tool: Talend

Data Warehouse Engine: Mondrian

OLAP (Online Analytical Processing) report presentation tool: Jpivot

The system architecture is shown in Table 1.

Internal operation platform	Authorized agency application	Digital collection mobile terminal PPCI
	Browser	Android
OLAP Report display tag library	FlashPlayer BlazeDS	Data Collection WebService
	application server (Tomcat)	
Data warehouse engine (Mondrian)	Database (MS SQL Server MySQL)	
ELT tools(Talend)		

Table 1 System architecture diagram

## II. Network topology of system operation

The system runs in a network environment and supports various workstations and handheld terminals. It is a typical WEB application, and its network structure is shown in Figure 1.

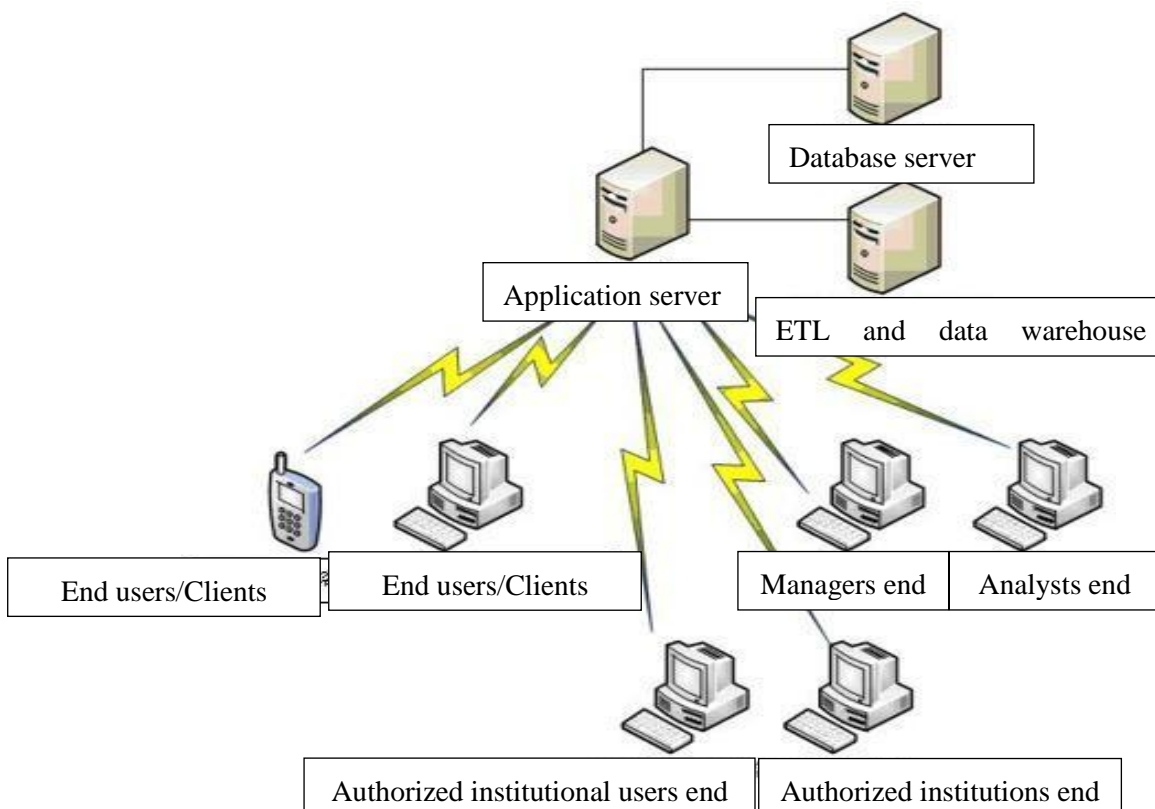


Figure 1 System network structure

Source: Tao (2003)

1. Database server, application server, ETL and data warehouse server:

The platform support system software and development tools used by this software are as follows:

The system support software that run the “microcredit lending risk management system” on such professional servers as local area network (LAN) and wide area network (WAN) (internet, intranet):

(1) Persistence layer (data layer)

Application server: MSSQLServer2005/2008 or MYSQL5.0

(2) Application service layer (business logic layer)

Application server: ApacheTomcat6.20 JavaSESDK: SunJava6.0

Application middleware: TOMEE

(3) Presentation layer (customer operation layer)

Front Desk SDK: HTML

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(4) Support tools for credit big data processing and analysis

ETL (data mining, Extract-Transform-Load) tool: Talend

Data Warehouse Engine: Mondrian

OLAP (Online Analytical Processing) report presentation tool: Jpivot

2. Managers' end and analysts' end

Managers and risk evaluation professionals of “microcredit lending risk management system” using browsers (master browsers above

IE6.0/Chrome/Safari/Firefox3/Netscape/Opera) on PC or computers

3. Authorized institution user terminal and authorized institution terminal

Other institutional users using browsers (master browsers above IE6.0/Chrome/Safari/Firefox3/Netscape/Opera) on PC or computers, such as employees of other banks or credit agencies

4. End users/customers (PC/Mobile)

Other businesspeople of our institution using browsers (master browsers above IE6.0/Chrome/Safari/Firefox3/Netscape/Opera) or mobile terminals on PC or computers, such as loan officers/loan customers etc.

## Appendix 2 Implementation of software functions

Using HTML5 as a development tool for quick page display and MYSQL as a database server, the development of various functions was completed. Due to the limited length of this thesis, a brief list of some functional implementation screenshots and descriptions are given below (Figures 1, 2 and 3).

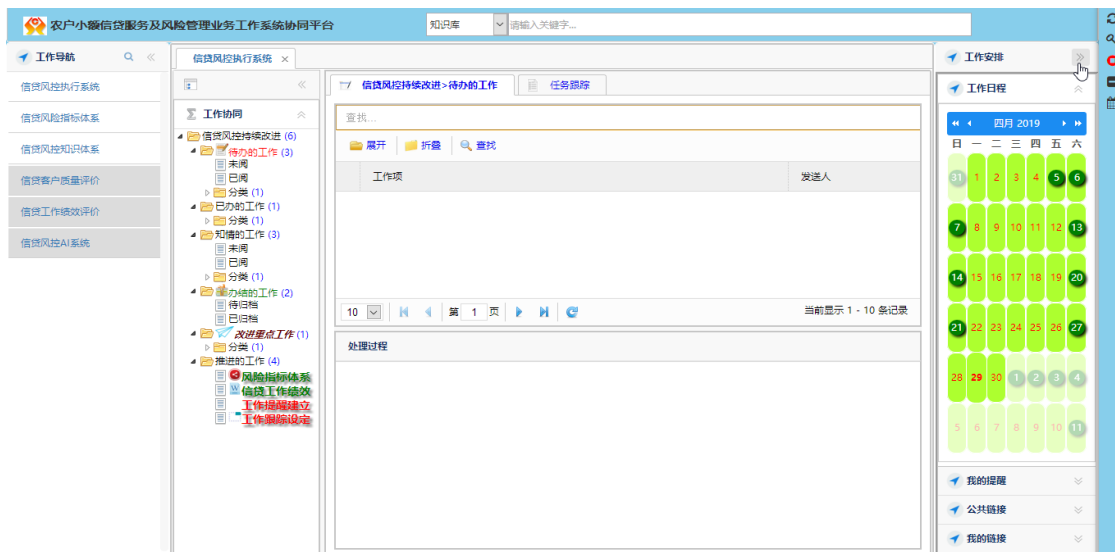


Figure 1 Working interface of the definition layer of the risk control system model



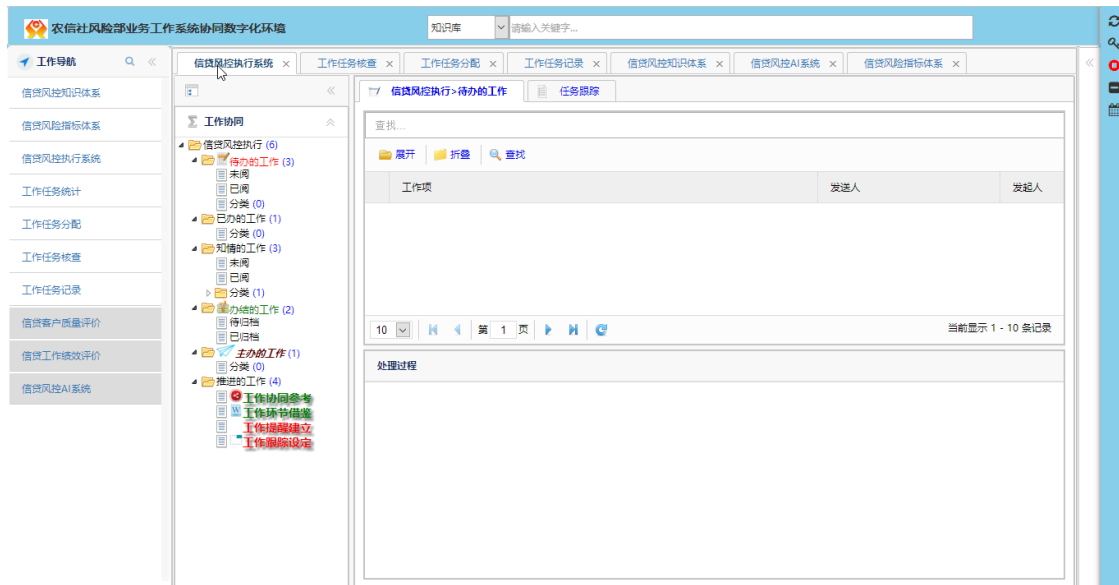


Figure 2 Working interface of the risk control execution system

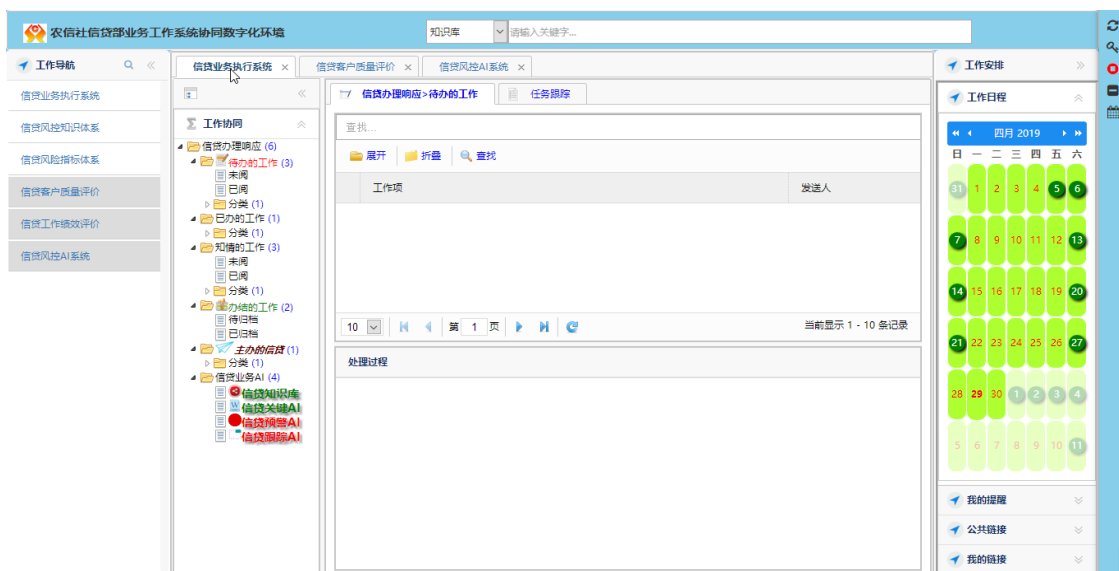


Figure 3 Working interface of the credit execution operation system

## I. Risk factor and risk dynamic weight setting function

This function realizes the target objects of the current credit and completes the risk identification and weight setting of related micro-credit users, as shown in Figure 4.

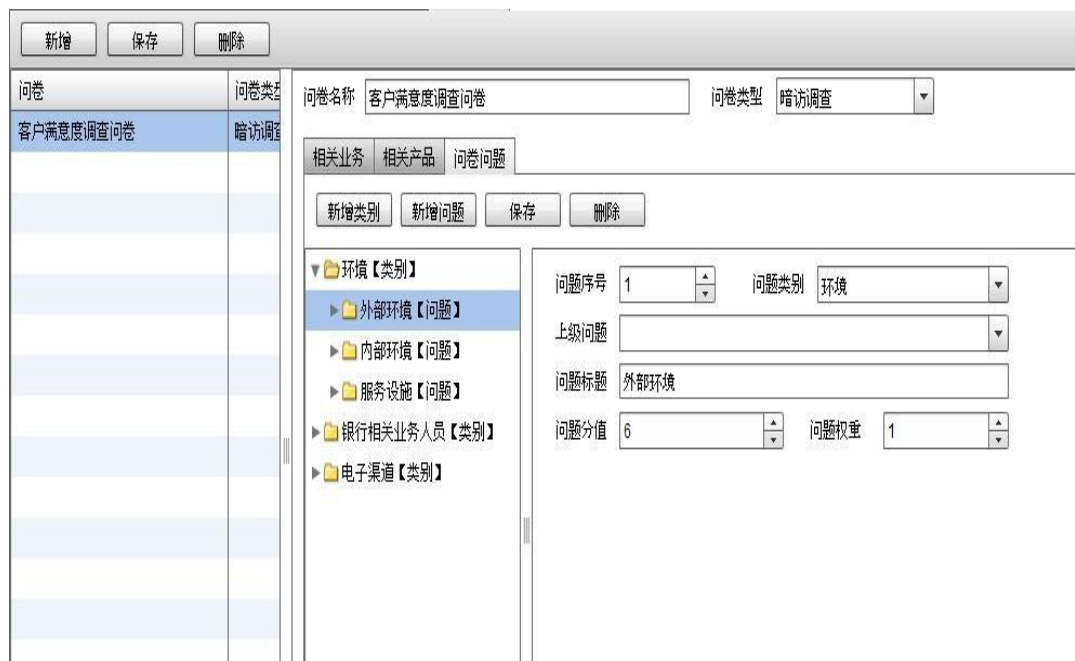


Figure 4 Software function implementation diagram of risk factor and risk dynamic weight setting

## II. Risk factors and risk dynamic weight filling function

Credit data entry and processing are carried out according to data collection methods and sources of micro-credit users, which support online and offline data entry via mobile phones, the Internet and other handheld devices, as shown in Figure 5.



Figure 5 Software function implementation diagram of risk factor and risk dynamic weight filling

### III. Report function of individual linear analysis

Focusing on a specific risk factor and risk dynamic weight, this function analyzes different scores and distribution ratios and lists the top ten problems, so as to help the institution personnel conduct a detailed analysis, thus helping the credit object determine the cause and scope of the problem, as shown in Figure 6.



Figure 6 Software function implementation diagram of individual linear analysis

### IV. Trend chart of estimated parameters of the rate of repayment on schedule and number of joint guarantors

This analysis is primarily used to assist analysts in identifying the parts that surface in the process of credit execution and that enjoy advantages over other links, as well as the weaknesses in each link. A detailed comparison of the execution of the competitive object and the credit object in each link of the particular risk factor and risk dynamic weight. See Figure 7.

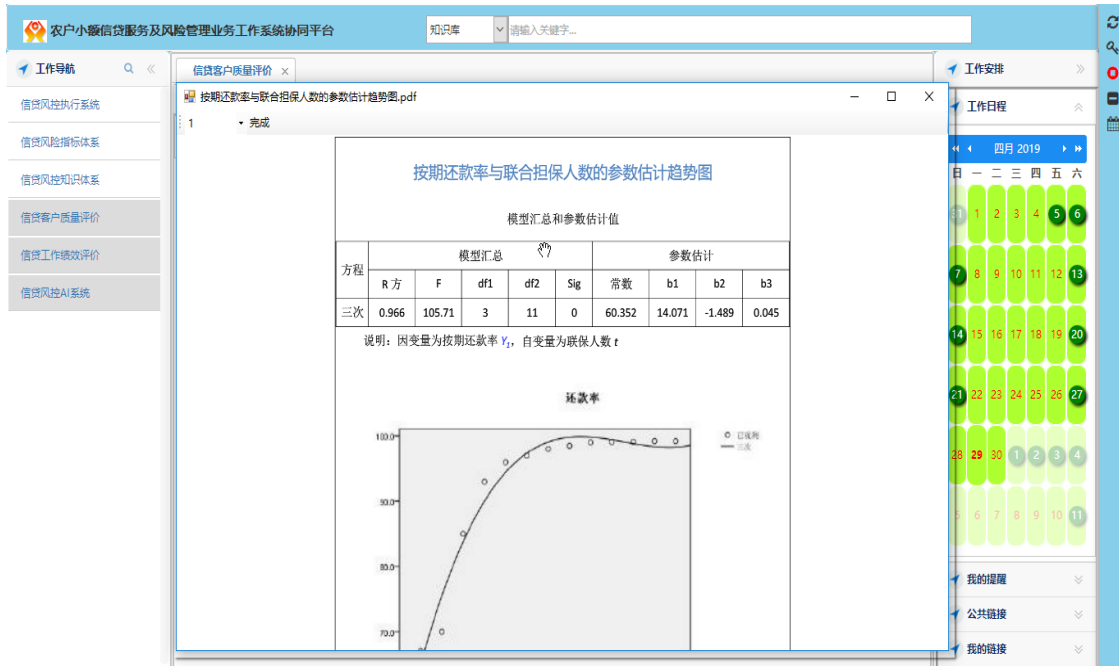


Figure 7 Software function implementation diagram of estimated parameters of the rate of repayment on schedule and number of joint guarantors