Disaster Risk Management in Agricultural Sectors of China with Focus on Complementarity between Revised Institutions and Traditional Functions

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Abstract

In the agricultural communities of China, production is largely affected by natural hazards, yet disaster-mitigation infrastructures and disaster risk transfer are undeveloped. This greatly increases exposure of the agricultural sectors of China to damage and suffering from disasters. To improve rural disaster risk management, governments at all levels are required to improve community-based disaster prevention and mitigation in rural areas. Many relevant studies have been completed at the community level; however, the current research contains a vast lack of concrete and mathematical research regarding methods for the improvement of disaster risk transfer and the development of disaster-mitigation infrastructures in rural China based on the traditional functions and revised institutions of local communities. Therefore, this thesis investigated how new institutions and conventional mechanisms that are provided by local communities and traders in a regional economy can be effectively combined to cope with disasters in Chinese agricultural sectors. Considering the limitations of normal commercial insurance in terms of disaster risk financing in rural China, risk management models for Chinese agricultural communities have been developed to examine that the liquidation of the farmland management right and the microcredit system (Rural Credit Cooperatives, RCCs) that leaves some roles for informal financial sectors complementarily work in rural disaster risk transfer. Based on the model formulation and numerical analysis focusing on the institutional reformation of RCCs, this study has proved that the efficient participation by farmers in RCCs' management can increase farmers' disaster mitigation efforts and make RCCs efficiently finance disaster risk through the capital market. This will improve RCCs' commercial sustainability and the long-term welfare of farmers. To improve the development of disaster-mitigation infrastructures in rural China, the collaborative development of the disaster-mitigation infrastructure based on the group loan supplied by RCCs has been proposed. The application of group loans can expand the possibility for the development of the disaster-mitigation infrastructure and for the sustainable agricultural community by relaxing the subsistence constraint and motivating Pareto improvement. Moreover, adequate attention should be given to the improvement and extension of the local culture or conventional functions when applying some innovative ideas to improve rural disaster mitigation.

Contents

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Chapter 1 Introduction

1.1 Background

Communities worldwide have been facing an increasing frequency and variety of disasters, which have had a number of direct and indirect causes as well as effects (Srinivas and Nakagawa, 2007). Over the period 1984–2003, more than 4 billion people were affected by natural disasters, and between 1990 and 1999 the costs of disasters (in constant dollars) were more than 15 times higher than during the period 1950–1959 (World Bank, 2006).

In agricultural communities of China, production is largely affected by natural hazards while the infrastructure, such as communication and transportation systems, is yet undeveloped, farmers' habitation is obscure and in-concentrated, villages are located in vulnerable areas, residents' awareness and ability to prevent and mitigate disasters is poor, and there is no early warning system. All the things make agricultural sectors of China suffer very much from disasters. Since 2000, in each year, the area of the farmland affected by natural disasters is more than 500 thousand sq. km. and decreased agricultural production due to natural disasters is about 23 million tons (Chen, 2007). Each year, more than 80% of the casualties in all of China and most of the building collapses caused by natural disasters happen in rural China (Qin, 2006).

The rapid increase and growing seriousness of disaster-caused losses in rural China means that more and more attention needs to be paid to disaster prevention and mitigation in agricultural communities of China. Until now, the following disaster prevention approaches have been carried out in agricultural sectors of China:

(1) Improve monitoring and early warning systems for disasters (the General Office of the State Council, 2007; Chen, 2007; Li et al., 2006).
(2) Improve the disaster-mitigation infrastructure (the General Office of the State Council, 2007; Wang, 2008; Qin, 2006).
(3) Increase residents' awareness of disaster prevention and mitigation (Fan, 2008; BLnews.com.cn, 2006; Duan, 2008).
(4) Improve households' ability to prevent and mitigate disasters through training, drilling and reinforcing houses (the General Office of the State Council, 2007; Liu et al., 2007; Huang 2007).

(5) Encourage cooperative insurance (the People's Government of Zhejiang Province, 2008).

On the International Disaster Mitigation Day, 2005, the Ministry of Civil Affairs started the campaign of community-based disaster prevention and mitigation in both urban and rural areas (Duan 2006). Additionally, in the Outline of China's Eleventh Five-year Plan for National Integrated Disaster Mitigation, the General Office of the State Council requires governments at all levels to improve the disaster prevention and mitigation ability of communities in both urban and rural areas (the General Office of the State Council, 2007). Under the guidance of these principles, besides practicing the above approaches at community-level, the following additional methods are being carried out:

(1) Train information tellers to be in charge of collecting information about hidden dangers and promulgating it among community residents (the General Office of the State Council, 2007).
(2) Train community-based volunteer teams for disaster mitigation and relief (the General Office of the State Council, 2007).
(3) Organize community-based mutual aid after disasters (Li, 2006; Chen, 2007).
(4) Install a coordination mechanism among communities (Li, 2006; Chen, 2007).

Although the above policies and practices have contributed to the improvement of rural disaster risk management compared with before, many problems still remain (Chen, 2007). In this study, focus is placed on disaster risk financing, such as disaster mitigation financing and disaster risk transfer.

As farmers have a limited ability to resist natural disasters, once natural disasters come, in the absence of risk transfer, farmers will bear most of the loss by themselves. As most farmers have a low income, if they do not receive financial compensation in a timely manner after the disaster, their lives and production will be significantly affected (Gong and Zhang, 2007). In general, natural disasters are accompanied by poverty and there is a positive correlation (Wang, 2005). And whether the rural areas can become rich or not is not only related to the improvement of living standards of farmers but also to China's reform, opening-up, and modernization (Deng Xiaoping, 1993). Therefore, the necessity of researching on ways of improving rural disaster mitigation and disaster risk transfer is self-evident.

To improve rural disaster mitigation, governments at all levels are required to improve the development of community-based disaster-mitigation infrastructures, such as early warning systems, shelters, emergency preplans, disaster-mitigation facilities, and residents' awareness of disaster prevention and mitigation (the General Office of the State Council, 2007). Unfortunately, farmers do not have enough motivation to develop community-based disaster-mitigation infrastructures for the following reasons (Chen, 2008):

(1) Farmers are too poor to be involved in developing the infrastructures. Because post-disaster harvest is very small (even not enough for subsistence), farmers will face a subsistence problem if they spend money and labor developing the infrastructure which takes time.

(2) Even if some farmers have enough money to develop the disaster-mitigation infrastructure, it is not economical or efficient because their production scale is always very small.

Additionally, more and more farmers have to move to urban areas because of the subsistence constraint (because of poverty induced by natural disasters) and an increase in income in urban areas (Zhou, 2006). This damages the sustainability of agricultural communities and makes the development of the community-based disaster-mitigation infrastructure lack a solid foundation.

In general, the probability of disaster is low while its potential damage is prodigious. Covering the loss induced by disaster is a great burden for individual persons, enterprises and even the government. One active and efficient way is to pool and diversify disaster risk in a certain region. In this sense, insurance can and should play a very important role in preventing disaster, mitigating losses, protecting people's lives and property and improving the post-disaster living level. With this in mind, since 1998 the government has been encouraging and improving agricultural insurance for disaster risk financing in rural China (the State Council of the People's Republic of China, 1998). Unfortunately, rural disaster insurance is not developed and popular (Xiong, 2005; Yu et al., 2006). Without policy support and a reinsurance mechanism, commercial insurance companies only insure flood risk through special additive insurance. Considering the commercial steadiness, insurers exclude insurance related to earthquakes and tsunamis that also affect farmers very much. The design and variety of agricultural insurance cannot match the demand of farmers for insurance because the agricultural insurance is not created according to farmers' realities. At the same time, farmers lack the incentive to get insurance because of poverty (Finance Time,

2004; Yu, 2006). In January of 2008, there was a serious snow and ice disaster in the south of China. The post-disaster insurance payment in rural China equaled less than 1% of the total losses (Gao, 2008).

Based on the historical changes in the policies and practices of disaster risk management in rural China, it has been found that community-based disaster prevention and mitigation is becoming more and more important in the agricultural sectors of China. This requires us to improve rural disaster risk financing at community level. At the same time, in Chinese agricultural communities some changes relevant to the everyday lives and production of farmers were made (such as liquid transaction of farmland management right), and are happening (such as institutional reformation of Rural Credit Cooperatives (RCCs)) or coming (such as regenerating informal financial sectors). The circulation of farmland management right is supposed to have the implicit function of diversifying disaster risk among farmers. RCC is the only formal institution that supplies farmers with the necessary funds for everyday production and post-disaster subsistence, reconstruction, and production restoration. This means RCCs can finance farmers' disaster risk and relax farmers' subsistence constraints for developing the disaster-mitigation infrastructures. As a meaningful complement to formal financial institutions, informal financial sectors can supply farmers with financial service (including disaster risk financing) through interlinked transactions. An interlinked transaction is one in which the two parties trade in at least two markets on the condition that the terms of all such trades are jointly determined (Bell, 1988). The market inter-linkage generally provides a way of partially circumventing incomplete or non-existent markets in developing societies (Bardhan and Udry, 1999). Contractual inter-linkages in the rural communities of developing countries may be a key element of informal insurance when information is incomplete, and may influence the evolution of the distribution of resources (Ligon, 2005).

To improve community-based disaster mitigation financing and disaster risk transfer in agricultural communities, conventional institutions and mechanisms should be improved and expanded with considering and involving local revolutions that are happening or coming.

1.2 Objective of the study

The main objective of this study is to figure out how new institutions and conventional

mechanisms provided by the community and local traders in a regional economy can be effectively combined to cope with disasters. The following problems will be studied:

(1) Why normal commercial insurance does not work in Chinese agricultural communities.
(2) How to finance disaster risk and increase farmers' welfare by integrating microcredit systems, informal financial sectors, and transaction of farmland management right.
(3) How to improve farmers' awareness, motivation and ability to prevent and mitigate disasters by combining RCCs' institutional reform.
(4) How to improve the sustainability of agricultural communities and increase farmers' welfare through the collaborative development of the disaster-mitigation infrastructure based on group loans.

1.3 Structure of the thesis

Based on the above discussions, the structure of the thesis is designed to consist of 7 chapters as follows (Fig.1.1):

Chapter 1 provides an overview of the background and objective of this study, including this description of the structure of the thesis.

Chapter 2 reviews the current research works regarding disaster risk management in Chinese agricultural communities. It specifically underlines the need to study this area, and thus gives an overview of related realities in rural China such as the circulation of the management right of farmland, the development of informal financial sectors, and RCCs' realities and institutional reformation (based on the survey of RCCs in Zhejiang Province, China). After considering and modeling the above facts, mathematical analyses is made to investigate the problems mentioned in section 1.2 and give corresponding conclusions and policy advice.

Chapter 3 investigates the barriers to insuring against disaster in rural China with conventional commercial insurance. By focusing on the micro-structure of households' insurance behaviors, conventional commercial insurance's insufficiencies in economic availability for farmers is modeled and studied. Because of the subsistence problem, liquidity constraint and the insurance's indivisibility, farmers prefer savings to insurance for disaster risk financing. This proves the necessity of innovative disaster

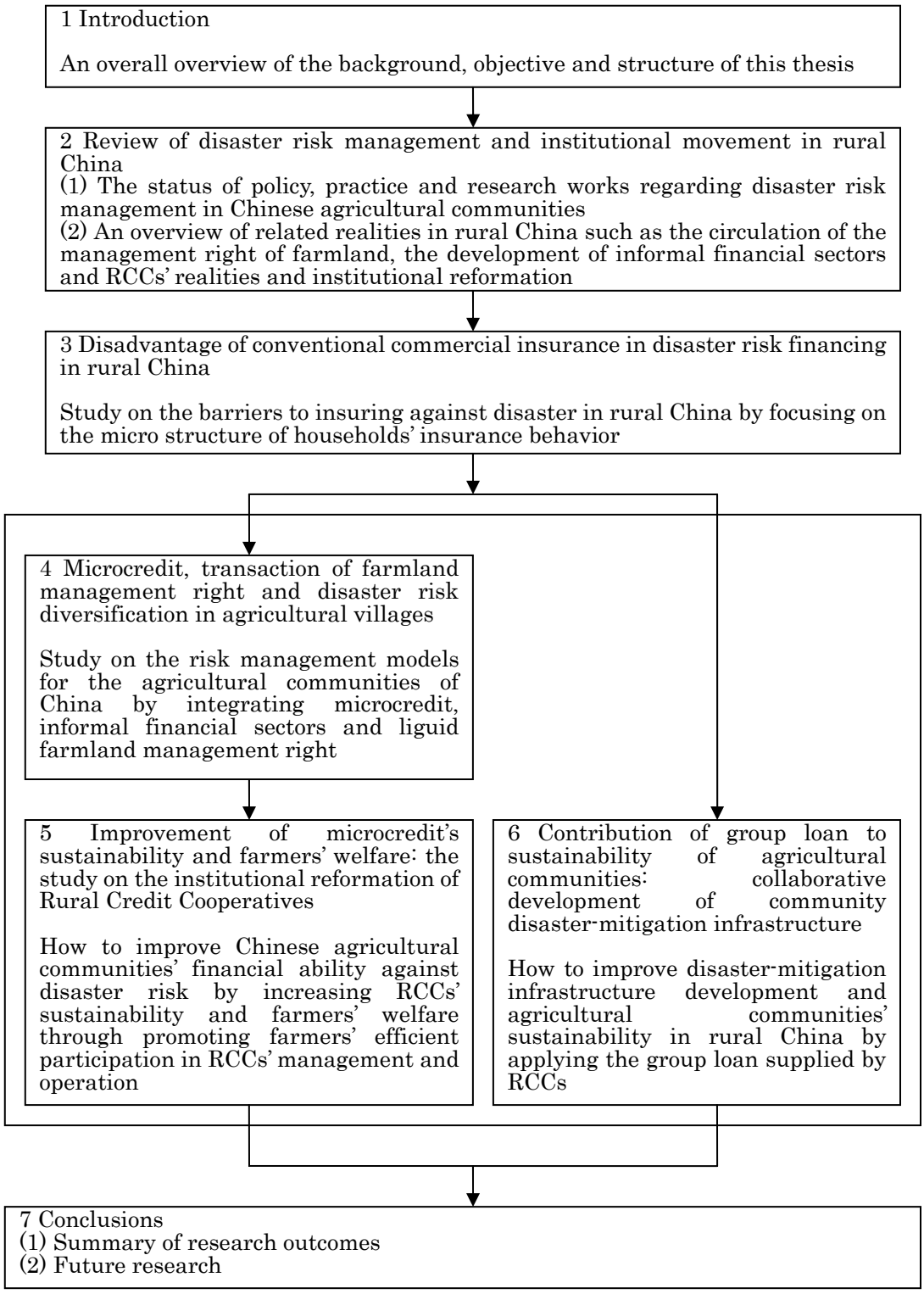

Fig.1.1: Framework of this study

risk financing methods such as relaxing the liquidity constraint and accelerating the

evaluation and transaction of pledges such as household assets, expanding "Market Inter-linkage" where landlord, entrepreneur and trader take multiple roles and applying the idea of the "Microcredit System" to group risk financing.

Chapter 4 develops the risk management models for the agricultural villages of China to investigate the effective coordination between the RCC and the informal financial sectors in the liquid market on the farmland management right. It is proved that the microcredit system that leaves some roles for informal financial sectors and the liquidation of the farmland management right complementarily work in rural disaster risk financing through diversifying disaster risk among farmers, increasing the ability of RCCs as well as that of the informal financial sectors to pool risk, decreasing the risk premium included in the interest of the loan and reducing farmers' motivation to induce the moral hazard in disaster risk mitigation.

Chapter 5 develops a model to investigate how to increase RCCs' post-disaster sustainability as well as farmers' long-term welfare. When farmers make decisions about both disaster mitigation and RCCs' financial risk management, both RCCs' post-disaster sustainability and farmers' long-term benefits are improved. Additionally, the government's supervision and encouragement of RCCs to introduce the decision making system in which farmers can represent and practice their opinions is the key point of RCCs' institutional reformation.

Chapter 6 develops a model for group loans and the collaborative development of the disaster-mitigation infrastructure. This chapter studies how to relax the subsistence constraint and motivate the collaborative development of the infrastructure in Chinese agricultural communities by making use of group loans. When the local agricultural production level is relatively low, the application of the group loan can expand the possibilities for the development of the disaster-mitigation infrastructure, and for Pareto improvement and the sustainable agricultural communities. The utility-rise induced by the community culture (social capital at the community level) which is derived from collaborative work and enjoyed by farmers together is very important to reduce the welfare difference between rural and urban areas and give farmers enough motivation to be involved in the collaborative development of the disaster-mitigation infrastructure. In general, this kind of community culture is based on local interpersonal relationships or traditional functions. This requires people to pay attention to improving and extending local culture or conventional functions when

applying some innovative ideas to improve the community-based disaster-mitigation infrastructure. In other words, the complementary relationship between revised institutions and traditional functions is important and meaningful for disaster risk management in agricultural sectors of China.

Chapter 7 summarizes the main contributions of the study and discusses the needs for further extensions of this research.

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Chapter 2 Review of Disaster Risk Management and Institutional Movement in Rural China

2.1 Introduction

As mentioned in Chapter 1, there has been an increasing need for managing disaster risks in rural China in a community-based way. For community-level disaster risk management, special consideration should be given to both the traditional functions and revised institutions of local communities. This chapter focuses on the review of the status of the disaster risk management at the community level and related institutional movement in rural China.

2.2 Disaster risk management in rural China

In 1998, the State Council of the People's Republic of China published the "Plan for National Disaster Mitigation (1998-2010)" (the State Council of the People's Republic of China, 1998). Since then, the following actions have been carried out in rural China:

(1) Construct an integrated agricultural disaster mitigation system to improve integrated disaster mitigation ability for agriculture and rural areas.
(2) Focus on farm water conservancy construction during the construction of the agricultural infrastructure.
(3) Install and improve a national disaster early warning system.
(4) Develop agricultural insurance for disaster risk financing in rural China.

Since 2006, the construction of the agricultural infrastructure has been focusing on small-scale farm water conservancy construction to improve disaster mitigation in rural China (Xinhua News Agency, 2006). The subsidy system for victims of disasters has been installed and improved in agricultural sectors (Xinhua News Agency, 2006; www.news.cn, 2006). Additionally, disaster prevention design and the reinforcing of houses in rural China have attracted more and more attention from governments at all levels (www.news.cn, 2006).

In 2007, to replace the "Plan for National Disaster Mitigation (1998-2010)," the General Office of the State Council issued "The Outline of China's Eleventh Five-year Plan for National Integrated Disaster Mitigation" (the General Office of the State Council, 2007).

Governments at all levels are required to improve disaster prevention in rural China in the following aspects:

(1) Improve community-based integrated disaster prevention ability.
(2) Improve the construction of community-based early warning systems.
(3) Install shelters in vulnerable agricultural communities.
(4) Organize a disaster prevention and mitigation volunteer team in each agricultural community.
(5) For each agricultural community, train one information teller to be in charge of collecting the information about hidden dangers and promulgating it among community residents.
(6) Set and improve community-based emergency preplans.
(7) Increase community residents' awareness of disaster prevention and mitigation, public security and social responsibility.
(8) Improve community residents' ability to prevent and mitigate disasters through training and drills.
(9) Improve the construction of disaster-mitigation infrastructures.
(10) Reinforce community residents' houses.
(11) Improve the ability of individual families to prevent and mitigate disasters.
(12) Install protection systems for disadvantaged groups in emergency situations.

On International Disaster Mitigation Day, 2005, the Ministry of Civil Affairs started the campaign of community-based disaster prevention and mitigation in both urban and rural areas (Duan 2006).

2.3 Review of literature

2.3.1 Studies on disaster risk management in rural China

Based on the above policies and practices, researchers have completed many studies on disaster risk management in rural China as discussed below.

(1) Increase the initiative of disaster prevention and mitigation by improving disaster monitoring and early warning systems through developing weather information service mechanisms (Chen, 2007; Wang, 2008; Keji Luntan, 2007; Li and Zhang, 2006) and applying GIS and GPS technology (Li et al., 2006; Fu and Xu, 2005).

(2) Increase the ability to mitigate agricultural disasters by improving the construction of agricultural infrastructures such as community-based farm water conservancy (Chen, 2007; Wang, 2008; Li et al., 2006; Hu, 2007).
(3) Improve the reinforcement and location-planning of rural houses to increase individual ability to prevent disaster (Liu et al., 2007; Xu, 2004; Shen, 2004; Huang 2006).
(4) Encourage the surplus rural work force to undertake ecological environment construction by applying contract responsibility systems and issuing some long-term preferential policies (Ma, 2000; Hu, 2007).
(5) Improve disaster risk financing mechanisms such as mutual financial aid and cooperative insurance (Liu, 1996; the People's Government of Zhejiang Province, 2008).
(6) Improve community residents' awareness of disaster prevention and mitigation through quiz competitions, educational campaigns, special lectures, propaganda materials and so on (Chen, 2007; Li et al., 2006; Shen, 2004).
(7) Motivate the creation of community-based mutual rescue systems such as volunteer teams and protection mechanisms for disadvantaged groups (San, 2005; Liu 2007).

As mentioned in Chapter 1, because of its necessity and significance for mitigating rural poverty induced by natural disasters and promoting China's reform, opening-up, and modernization, this study will focus on rural disaster mitigation financing and disaster risk transfer at the community level. This thesis tries to figure out how to improve disaster risk financing with developing and expanding financial services at the community level. To enrich the reference background, besides the above relevant studies in rural China (Liu, 1996; the People's Government of Zhejiang Province, 2008), the related studies in other countries should be reviewed.

2.3.2 Financial schemes for disaster risk management in other countries

Disasters exacerbate poverty, as victims take out high-interest loans, sell assets and livestock, or engage in low-risk, low-yield farming to lessen exposure to extreme events. Without a post-disaster infusion of capital for reconstruction, disasters can also exacerbate poverty by their long-term adverse effects on economic development (Linnerooth-Bayer, 2007). As a case in point, 4 years after the devastation of Hurricane Mitch in 1998, the GDP of Honduras was 6% below pre-disaster projections (Mechler, 2004), and, according to Honduras' Poverty Reduction Strategy Paper, the disaster resulted in an increase of 165,000 poor people (Government of Honduras, 2001).

Because of that, increased attention has recently been given to the possible role of financial services in the management of natural disaster risk. Local communities have been at the forefront of developing innovative disaster risk finance strategies and implementing risk-oriented incentive programs (Linnerooth-Bayer et al., 2003; UNISDR, 2005; Warner, 2007). Particular financial services at the community level can offer solutions to help communities adapt to and reduce disaster risk (Vellinga et al., 2001; Bouwer and Aerts, 2006; Helmer and Hilhorst, 2006; Warner, 2007; Linnerooth-Bayer, 2007). Here, financial services (products) refers broadly to any financial arrangement involving a party outside of the household or community unit, regardless whether it is being provided by the (formal) private financial services sector, or semi- or non-market institutions, such as other financial institutions, government, non-governmental organizations (NGOs), local civil organizations (Warner, 2007). In general, the financial services at the community level can be carried out through the following ways:

(1) Central government-initiated scheme: Social investment funds (SIFs) provided by the federal government have been used in El Salvador to provide rapid assistance to poor communities (Cruz, 2005). SIFs mobilize and disburse government resources and expand operations rapidly at the local level, maintain direct contact with poor communities, operate in a decentralized manner, and work closely with civil society organizations and local governments. This program is efficient and effective because of clearly defined responsibilities for all parties involved, including a transparent monitoring and reporting system (Ammann, 2003).
(2) Local government-initiated scheme: Risk reduction and risk pooling/insurance scheme at the community level. Since 1999, the city of Manizales, Colombia, has used a risk pool/insurance mechanism to pay for disaster risk reduction (Warner, 2007). The combination of ex-ante risk reduction and an accompanying financial plan, and strong advocacy within the ranks of municipal leadership make this an interesting case.
(3) NGO-initiated scheme: As a local NGO in India, the Development of Humane Action (DHAN) foundation helps disadvantaged people organize community groups for risk management purposes (Warner, 2007). Additionally, the DHAN foundation tries its best to spread information about how micro-insurance schemes help to solve problems related to disaster risk and increase understanding and demand for micro-insurance products for disaster risk management (Karthikeyan, 2005).
(4) Microfinance initiated scheme: MFIs provide a variety of financial services to communities in developing countries. Microfinance clients form groups that share the

responsibility of paying the interest and principle of small loans with other members. For example, the loans from Opportunity International in Malawi are provided with a compulsory insurance component, the premium of which is added to the interest rate of the loan (Mapfumo, 2005).

There is a need to overcome the obstacles to providing affordable and appropriate financial services at the local level, and from actors which are best suited to manage and finance disaster risk and risk reduction. The main challenges in this process are to effectively reach and work with community groups, and to increase private sector participation (Warner, 2007). Recent experience may show that forming partnerships can provide a solution to both challenges. The cooperation of the formal financial services sector with local community networks can bring different competences and different fields of expertise together (Warner, 2007; Linnerooth-Bayer and Mechler, 2007; Kunreuther, 2001). Partnerships offer a way to provide financial services products that suits the beneficiaries, and which are mutually advantageous. Involvement of partners with strong ties to recipient communities helps in mitigating problems of adverse selection and moral hazard, a major obstacle to formal sector products. Community groups for instance raise awareness among potential clients about using insurance products to reduce disaster risk, thereby lowering product marketing costs. These groups aggregate risk and facilitate the administration of services like premium and claims payments. Strong community ties also strengthen the ability of partners to understand product demands of potential clients. Particularly, community-based financial services combined with public–private partnerships can promote incentives for disaster mitigation investment and more effective risk management in the development, disaster and climate-change communities (Warner, 2007; Kunreuther, 2001; Yu et al., 2006).

2.4 Institutional reform and roles of formal and informal sectors in China

Based on the above policies, practice and studies on disaster risk management, it is true that financial services at the community level are very important for disaster risk financing in Chinese agricultural communities. However, there is a big lack of concrete mechanisms and mathematical analysis of how to improve disaster risk transfer and disaster-mitigation infrastructure development with financial services based on the traditional functions and revised institutions of local communities. A review should be made on the current situations of community-based disaster risk management and

on-going institutional development that should be incorporated in community-based disaster risk management in rural China. As mentioned in Chapter 1, a focus is placed on the microcredit system (RCCs), informal financial sectors and the circulation of farmland management rights.

2.4.1 History of RCCs

Rural Credit Cooperatives (RCCs) were founded in the 1950s (Baidu, 2008a). In the beginning, RCCs raised funds from farmers and mainly supplied members with financial service. The initial purpose of RCCs was to support agricultural production through supplying mutual aid among local farmers. After several decades, RCCs became an important part of the main rural financial institutions because they focus on farmers' loan demands and the lending procedure is relatively simple (Park, A. and Ren, C.Q, 2001). In 1996, the reform of rural financial systems made RCCs independent from supervision by the Agricultural Bank of China (Kawahara, 2005a). Namely, RCCs became cooperatives that make their own management decisions. After 1999, national commercial banks (including the Agricultural Bank of China) and post offices canceled their loan businesses at the county level (Yin, 2008). This makes RCCs the only formal financial institutions that supply farmers with loans in rural China. To improve rural loan supply, RCCs put the individual and group-lending microcredit loans (without guarantee requirement) into practice in 1996, and since 2000 these have gradually gained popularity. At the end of 2002, 93% of RCCs were operating the microcredit loan and more than 20% of rural households had made use of it (Kawahara, 2005a). In general, the amount of a microcredit loan does not exceed local farmers' average annual income, and the interest rate is decided by each RCC with considering it should be close to the basic interest rate given by the People's Bank of China. In most cases, the contract term is one year. In cases where bigger loans are demanded, group-lending is available with a loan group consisting of 3-5 rural households who mutually help and monitor each other to repay the loan (the Peoples' Bank of China, 2000; the Peoples' Bank of China, 2001). After developing for more than 50 years, the current objective of RCCs has been enriched to support agriculture, rural development, cooperative economy and members' domestic economy (Baidu, 2008b). During the past 50 years, RCCs have had a positive effect on the development of rural China by supplying farmers with necessary production capital, improving farmers' employment opportunities, increasing farmers' income and completing rural financial systems (Chen and Qiu, 2006). As for disaster risk financing, the microcredit loan from RCCs has been

supplying farmers with the necessary funds for post-disaster reconstruction and restoring production (Chen, 2008; Anhui Rural Credit Cooperative Union, 2007; Zhuang and Wu, 2008). Besides these active efforts for the rural economy, RCCs still have some insufficiencies that motivated one reformation that started in 2000 (Zhang, 2006). The core of the reformation is the reconstruction of the property right system, management system, and operation mechanism under the supervision and direction of the local government. The main purpose is to improve the commercial sustainability of RCCs. During the process of RCCs' institutional reformation, one has to be aware of the effective boundary of RCCs. Research has found that the most effective boundary of RCCs is the local community (such as a village) consisting of people who know each other well. Information asymmetry and credit risk will increase greatly if RCCs' boundaries are beyond the local community (He et al., 2003).

To improve RCCs' sustainability and making their function of disaster risk financing more sustainable, the institutional reformation should be made more practical and efficient based on the traditional functions and revised institutions of local communities. Additionally, to improve agricultural communities' sustainability and farmers' welfare, the group-lending loan can be used to improve the development of disaster mitigation infrastructures (including the facilities, awareness and ability of disaster mitigation) in rural China.

2.4.2 The institutional reform of RCCs in Zhejiang Province, China

Based on the active practices of the reformation about the property right system, management system, and operation mechanism, RCCs in Zhejiang Province have performed well during the institutional reformation process that started in 2000. The total and annual increased amount of deposit has exceeded that of commercial banks (www.cnr.cn, 2008).

To investigate the concrete procedure of reformation and RCCs' current management and operation system and get first-hand data for the formulation and simulation carried out in this study, field surveys were carried out by the author on the RCCs in Zhejiang Province, China through interviews and a questionnaire. On September 4, 2007, I met the vice director of the risk management section of Haining City Rural Credit Cooperative Union, and on September 5, 2007, I interviewed the director of the marketing section of Haiyan County Rural Credit Cooperative Union. For the concrete

questionnaire, please refer to the Appendix. The concrete survey results are as follows:

(1) In Haining City and Haiyan County, after institutional reformation, members of RCCs consist of not only farmers but also private industrialists and businessmen, private enterprises and rural enterprises. The fund sources have been extended to share-selling income, common reserve fund and savings while the main job of RCCs is still to supply members with financial services. Members have priority to get loans with discounted interest rates.

(2) To increase the rate of profit and improve commercial sustainability, besides using agricultural loans to get interest income, RCCs also invest in the capital market, such as loans to rural enterprises with adequate financial risk management.

(3) Since institutional reform, the application of loans has been extended to support infrastructure developments such as the construction of small-scale farm water systems. This improves the production and disaster mitigation abilities of agricultural communities. The repayment rate and RCCs' sustainability increase correspondingly.

(4) Before getting a microcredit loan, on a voluntary basis, farmers are required to buy accidental injury insurance. This benefits farmers and improves the repayment of loans.

(5) To give the staff enough incentive to operate and expand microcredit loans, RCCs make each staff member's salary related to his or her performance on microcredit loan issuing and recalling. This ensures that the scale and coverage of microcredit loans is sufficient.

(6) Through institutional reformation, RCCs' management became more democratic and independent from the government. RCCs' managers are chosen by members via the democratic election system. Top decision-making body is a congress of members. The executive body is a council that in charge of daily management and operation. Each member has an equal right to vote on policies regarding RCCs' management and operation. Furthermore, all staff and members are fully informed about the situations of lending and repaying loans.

(7) To expand business and attract farmers, RCCs supply farmers with extra-intermediary financial services such as buying insurance, collecting water and

electricity bills and issuing salary.

(8) If RCCs make a profit, farmers benefit from profit-sharing according to their deposit in RCCs. This makes farmers care more about RCCs' management and operation.

All the above results compose the foundation of the following study on deepening RCCs' reform and improving community-based disaster risk financing.

2.4.3 Roles and regeneration of informal financial sectors

Informal financial sectors include all financial transactions, including lending and saving, that are independent from the supervision of the People's Bank of China or China Banking Regulatory Commission (Zhang, 2004). In general, based on a community-based relationship, rural informal financial sectors in China consist of rural-based cooperative funds, individual credit between relatives, direct loans between individuals and enterprises, spontaneous informal financial cooperatives, feneration, and old-style Chinese private banks. Informal financial sectors are not real financial institutions. They are some kind of complement of community-based financial systems by promoting the transaction of idle capital in rural China. Until 1996, based on tacit agreement and support of the government, informal financial sectors have been developing very fast and playing an active role in expanding the resources for rural loans, animating the rural financial market, improving financial efficiency and developing individual ownership economy in rural areas (Yin, 2008). Without the interest control of the People's Bank of China, rural-based cooperative funds have more flexible loan interest arrangements and a higher average profit rate than RCCs (Brandt et al., 2001). Until 1996, rural-based cooperative funds' deposit size equaled to one ninth of RCCs', and 45% of their loans were issued to farmers with 24% issued to rural enterprises. After 1996, the reformation of the rural financial system shifted the center of gravity to commercializing formal financial institutions. In case the development and performance of RCCs would be affected by informal financial sectors, the People's Bank of China strengthened its control over informal financial sectors. Rural-based cooperative funds were disbanded in 1999. After that, most informal financial sectors went into an unorganized and underground state. On the other hand, after 1999, commercial banks and post offices stopped supplying loans in rural China. This makes the financial services from formal financial institutions become less and less. Farmers had to turn to informal financial sectors (Wen, 2001). According to the research report of

IFAD (International Fund for Agriculture Development), farmers' loans from informal sectors are about four times as large as those from formal financial institutions (IFAD, 2001). According to a local survey carried out in villages of 24 cities in 15 provinces of China, 95% of surveyed villages have a private loan supply and 85% have feneration (Wen, 2001). According to another survey in certain areas of rural China, the amount of loans from agricultural banks and RCCs almost equals that from private sectors during 2001-2002 (Kawahara, 2005a). In 2003, farmers' loans from formal financial institutions were only 26% (Zhang and Liu, 2007). Based on these realities, many researchers suggest that the government should relax control over informal financial sectors, improve the diversification of rural financial institutions and encourage competition among rural financial institutions (Lin, 2003; Ma and Jiang 2003; He, 2003, Xie, 2001; Committee of Soft Science, Ministry of Agriculture, 2001). Only with the perfect competition among financial institutions can rural financial service (including amount and variety) be improved to match the loan demands of farmers. Involving informal financial sectors in the reformation process of rural financial systems is the best way to bring out the perfect competition in the rural finance market. Additionally, with a suitable corresponding reform policy, developing informal financial sectors will not affect the development and performance of RCCs (Zhang, 2004). Most of the above suggestions are involved in the "Demonstration Program for deepening the Reformation of Rural Credit Cooperatives" (issued by the State Council of the People's Republic of China in 2003) from the aspects of management systems, property systems, operation mechanisms and policy support (the State Council of the People's Republic of China, 2003).

Informal financial sectors are an active complement of RCCs for financial services (including disaster risk financing) supply in rural China. Compared with RCCs, rural informal financial sectors have an information advantage because they are based on community relationships. This requires us to consider RCCs and rural informal financial sectors synthetically during the improvement of disaster risk financing in rural China at the community level.

2.4.4 The circulation of farmland management right

Before the 1980s, the main land utilization system in rural China was agricultural cooperation and land communization. Since 1978, the state has been encouraging and popularizing the contractual management system in respect to land in the rural areas.

Under the contractual management system, farmers get the farmland management right while the collective still owns the farmland. Farmers can make their own decisions about agricultural production and marketing. Since the 1990s, the government has been encouraging the circulation of the right to the farmland contractual management, which is effected according to the law, on a voluntary basis and with compensation (Kawahara, 2005b; the 29th Meeting of the Standing Committee of the Ninth National People's Congress, 2002; Baidu, 2007). The "Law of the People's Republic of China on Land Contract in Rural Areas" was adopted at the 29th Meeting of the Standing Committee of the Ninth National People's Congress of the People's Republic of China on August 29, 2002 for the purposes of stabilizing and improving the two-tier management system that combines centralized and decentralized management on the basis of household contractual management, granting the long-term and guaranteed land-use right to peasants, safeguarding farmers' legitimate rights and interests which is related to farmland contracts, and promoting the development of agriculture, the rural economy, and social stability in the countryside. The law went into effect on March 1, 2003 (the 29th Meeting of the Standing Committee of the Ninth National People's Congress, 2002).

Liquid circulation of farmland management right in the local community supplies farmers with one implicit mechanism to diversify disaster risk at the community level. At the same time, the circulation depends on the status of RCCs and informal financial sectors because they supply farmers with the necessary loans for cultivating. Therefore, to bring out the potential disaster risk financing function and make it more efficient, RCCs and informal financial sectors should be involved additionally.

2.5 Conclusions

The status of the practices and studies on disaster risk management in rural China has been reviewed with a focus on community-based disaster risk financing. And an overview of local traditional functions and institutional movements (happening or coming) that should be considered in this study has been provided.

Finally, the following points have been made to improve the current situations:

(1) Community-based disaster risk financing should be improved by combining RCCs, informal financial sectors and the circulation of farmland management right.

(2) Disaster risk financing function of RCCs should be made more sustainable by deepening the institutional reformation based on the traditional functions and revised institutions of local communities.
(3) The development of the community-based disaster-mitigation infrastructure (including facilities, awareness and ability) should be promoted by making use of the group-lending loan.

In the following parts of the thesis, each of these points will be addressed respectively in Chapters 4, 5 and 6.

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Chapter 3 Disadvantage of Conventional Commercial Insurance in Disaster Risk Financing in Rural China

3.1 Introduction

The natural disasters such as tsunami, earthquake, typhoon, flood and drought happen more and more frequently and the threat from this change is becoming larger and larger. More than 40% of farmers in developing countries face threats to their livelihoods from adverse weather, which destabilizes households and creates food insecurity (World Bank, 2005). Governments and donors react to these shocks in a reactionary manner rather than proactively managing the risks. These emergency reactions have been criticized for being ad hoc, sometimes untimely and destabilizing local food markets (Hess and Syroka, 2005). The alternative includes measures to prevent the risks and insurance instruments for decreasing farmer vulnerability. However, agricultural insurance is undeveloped in developing countries (Carter, 2007; Raschky and Weck-Hannemann, 2007; Anbarci et al., 2005; Yu et al., 2006). Often receiving only minimal support from insurance companies, disaster victims in developing countries rely extensively on ex-post household disaster finances (such as the consumption of available resources or savings, and sharing risks with extended family or neighbors) that is considered the most costly and least efficient means of paying for disaster losses (Linnerooth-Bayer and Mechler, 2007; Warner et al., 2005; Linnerooth-Bayer et al., 2007). One such developing country, China, has a similar problem and embarrassment. As mentioned in Chapter 1, Chinese agricultural communities suffer greatly from natural disasters, while rural disaster insurance coverage is very low. Farmers prefer saving and borrowing to obtaining agricultural insurance. As the motivation for the study of innovative mechanisms and methods of disaster risk financing in rural China, this chapter investigates into existing barriers to insuring against disaster in rural China by focusing on the micro-structure of households' insurance behaviors.

3.2 Barriers of insurance behavior in the rural areas of developing countries

Before starting concrete modeling and formulation, the relevant theories and research on barriers of insurance behavior in the rural areas of developing countries is reviewed as below.

In general, there are the following rational reasons for farmers in developing countries

not to purchase insurance:

(1) If they spend money on insurance, they cannot buy enough food and will surely die from hunger (Yokomatsu, 2006; Linnerooth-Bayer and Mechler, 2007). In general, disaster insurance is indivisible and the premium is not affordable for farmers.
(2) If disaster occurs, an entire family may die from the destruction of their house, hence insurance money has no value for them (Yokomatsu, 2006).
(3) People face not only disaster risk but other risks such as disease, famine, traffic accidents and so on. Disaster insurance is not attractive because it only insures disaster risk, coping with which is not prioritized by most people (Yokomatsu, 2006; Linnerooth-Bayer and Mechler, 2007).
(4) Direct disaster payments, such as diversions from the budget, already allocated loans and donations from the international community, give little incentive for farmers to pay for crop insurance coverage (Yu et al., 2006; Mechler, 2004; Hochrainer et al., 2003).

Sometimes, it is also likely that farmers do not buy insurance because of the following irrational reasons:

(1) Their perception of risk is incomplete. In some cases they reject to learn disaster risks faced by them (Yokomatsu, 2006; Yu et al., 2006). Correspondingly, farmers often lack an awareness and understanding of the concept of insurance (Linnerooth-Bayer and Mechler, 2007).
(2) They are myopic and do not consider how long it takes to reconstruct their own livelihood after disaster (Yokomatsu, 2006). Because of poverty and subsistence constraint, farmers always prefer the short-term income from cultivation to long-run utility-rise induced by relatively stable income stream based on disaster insurance.

From the aspect of insurers, the following barriers stop them from supplying farmers with adequate and efficient disaster insurance:

(1) Insurers are not likely to target areas prone to frequent and severe disasters, such as floods, without governmental support and re-insurance (Yu et al., 2006; Linnerooth-Bayer and Mechler, 2007; Hansson et al., 2008). Without re-insurance, it will be a difficult situation since premiums probably would not be affordable for property owners and if premiums are lowered, insurance companies will experience

insolvency.

(2) It is difficult for insurers to design suitable disaster insurance and calculate adequate premium rates because they lack the knowledge and data regarding the vulnerable groups, the areas at risk and also the driving forces that influence and generate risk and vulnerability (Yu et al., 2006; Linnerooth-Bayer et al., 2007; Linnerooth-Bayer and Mechler, 2007).

(3) In general, because of imperfect information, insurers set down the premium rate at the county level. This means the premium rate cannot classify concrete risks related to individual farmers. That would induce adverse selection and keep the disaster insurance market from becoming large enough to pool disaster risk efficiently (Goodwin and Smith, 1995; Yu, et al., 2006; Linnerooth-Bayer et al., 2007).

3.3 The model

In rural China, the subsistence problem and liquidity constraint is the biggest barrier discouraging farmers from doing disaster risk financing, such as getting themselves insurance (Yu et al., 2006). In order to explain the principal motion for this entire thesis, a fundamental analysis is conducted to examine the effect of farmers' subsistence and liquidity constraint, and conventional insurance's indivisibility, on disaster insurance behavior in rural China. For simplification, a two-period model is supposed. The following are the symbols that will be used in the model.

The number of farmers is standardized to 1;

$\bar{x}$: Subsistence consumption. Consumption should be larger than the subsistence level, otherwise a household cannot live in the next period;

z_1: Physical assets (initial endowment) in period 1;

y_1: Income in period 1;

x_1: Consumption in period 1;

s: Saving (deposit) in period 1;

β: Insurance coverage-rate $(0 \le \beta \le 1)$;

ρ: Insurance premium-rate $(\rho \ge q)$;

δ: Occurrence of disaster. δ=0 if there is no disaster (for Prob. $1-q$); δ=1 if the disaster destroys physical asset (for Prob. q);

y_2: Income in period 2. $y_2 \ge y_1$, which means there is an economy with income growth. That is based in the reality of China where the economy is developing very fast;

γ : Demand of money (liquidity constraint) in period 2, for Prob. $f(\gamma)=\frac{1}{\Gamma}$ $(0\le\gamma\le\Gamma)$

x_2 : Consumption in period 2;

ζ : Repair (additional investment) of physical assets in period 2;

z_2 : The physical assets at the end of period 2;

$u(z,x)$: The utility function. For simplicity, $u(z,x)=u(x-\bar{x}+z)$ in which $u'>0$ and $u''<0$.

As for the event sequence of the two-period model, please refer to Fig.3.1.

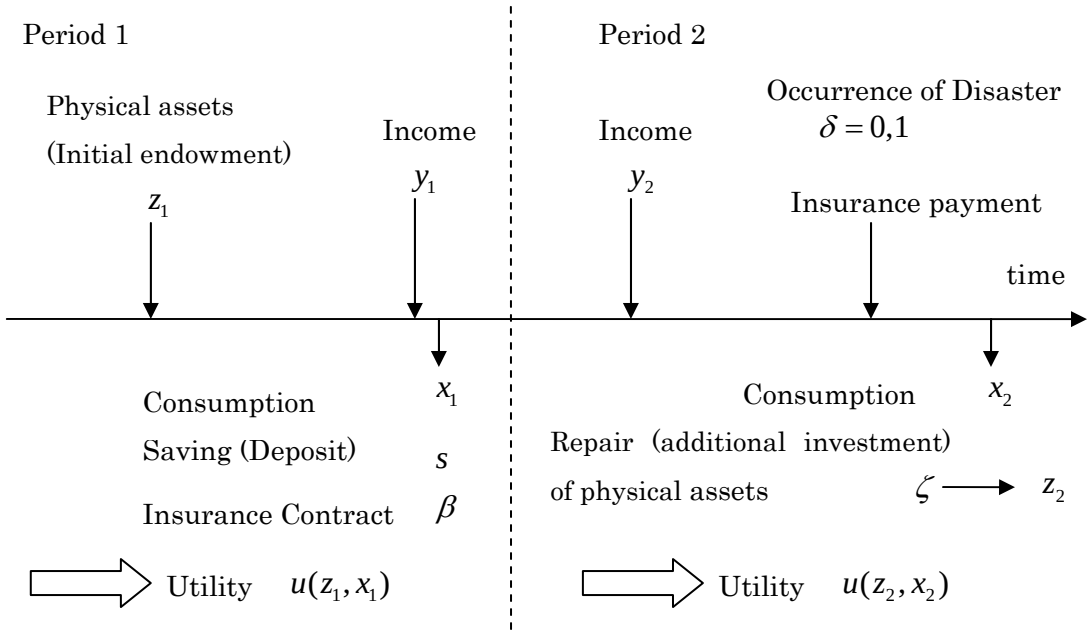

Fig.3.1 Event sequence of the two-period model

(1) Farmer owns initial physical assets z_1 at period 1;

(2) Farmer gets income y_1 at period 1;

(3) Farmer purchases insurance contract in which the coverage rate is β;

(4) Farmer consumes x_1 at period 1;

(5) After purchasing insurance and consumption, farmer deposits s at period 1. s can be negative, which means farmer gets loan at period 1 and repays it at period 2;

(6) With physical assets, z_1, and consumption, x_1, farmer has the utility, $u(z_1,x_1)$, at period 1;

(7) Farmer gets income y_2 at period 2;
(8) Disaster happens with the probability of q;
(9) Insurer supplies farmer with insurance payment βz_1 if the disaster happens;
(10) Farmer constructs physical assets to z_2 by investing ζ;
(11) Farmer consumes x_2 at period 2;
(12) With physical assets, z_2, and consumption, x_2, farmer has the utility, $u(z_2, x_2)$, at period 2.

From the above assumptions, the budget constraints in period 1 can be written as follows:

$$x_1 + s + \beta\rho z_1 = y_1 \tag{3.1}$$

which means the farmer divides income into three parts: insurance purchase, consumption and saving (can be negative, means borrowing).

Likewise for period 2, it holds:

$$x_2 + \zeta = y_2 + s + \delta\beta z_1 \Leftrightarrow x_2 + z_2 = y_2 + s + z_1 - (1-\beta)\delta z_1 \tag{3.2}$$

which means the farmer's money for consumption and physical assets construction is from three sources: saving in period 1 and income and insurance payment in period 2.

Then, the farmer's objective function can be written as follows:

$$W = u(z_1, x_1) + (1-q)u(z_2^0, x_2^0) + qu(z_2^1, x_2^1) \tag{3.3}$$

where

$u(z_2^0, x_2^0)$ is the utility in period 2 without disaster and $u(z_2^1, x_2^1)$ is the utility with disaster. This means the farmer's objective is to maximize two-period expected utility by making optimal arrangement among insurance, consumption, saving and construction. Obviously, the farmer's optimal behavior and maximum utility depend on whether or not there is disaster risk, whether or not insurance is indivisible, and if the farmer faces subsistence and liquidity constraint.

Based on the objective function, i.e., formula (3.3), three cases are discussed respectively as below.

3.3.1 Benchmark case: no disaster risk

In this situation, insurance is not necessary. So the objective function can be rewritten as follows:

$$\max_{s} u(z_1, x_1) + u(z_2, x_2) \tag{3.4a}$$

subject to:

$$x_1 + s = y_1 \tag{3.4b}$$

$$x_2 + z_2 = y_2 + s + z_1 \tag{3.4c}$$

(1) Case without liquidity constraint:

$$s^* = -\frac{1}{2}(y_2 - y_1) < 0$$

That means the farmer will borrow half of their income growth to maximize his two-period utility.

(2) Case with liquidity constraint:

Here, formula (3.4c) changes to $x_2 + z_2 = y_2 + s - \gamma + z_1$. Then the following result can be got:

$$s^* = 0$$

That means there is no saving.

3.3.2 Case 2: disaster risk, fair insurance, choice of insurance coverage-rate

In this situation, the farmer can use fair insurance ($\rho = q$) to finance disaster risk. The objective function can be rewritten as follows:

$$\max_{s,\beta} W = u(z_1, x_1) + (1-q)u(z_2^0, x_2^0) + qu(z_2^1, x_2^1) \tag{3.5a}$$

subject to:

$$x_1 + s + \beta q z_1 = y_1 \tag{3.5b}$$

$$x_2 + z_2 = y_2 + s + z_1 - (1-\beta)\delta z_1 \tag{3.5c}$$

(1) Case without liquidity constraint:

$$s^* = -\frac{1}{2}(y_2 - y_1 + qz_1) < 0$$

That means the farmer will ask for an additional loan that equals half of the insurance premium. In other words, for maximizing two-period expected utility, the farmer makes use of insurance and savings (loan) to transfer disaster risk to the insurer and optimally allocate his two-period income between period 1 and 2. In one word, loan and insurance are complementary to each other.

$$\beta^* = 1$$

That means the farmer will buy a full-coverage insurance contract with fair premium rate.

(2) Case with liquidity constraint

Here, formula (3.5c) changes to $x_2 + z_2 = y_2 + s - \gamma + z_1 - (1-\beta)\delta z_1$. Then the following results can be got:

$$s^* = 0$$

That means there is no saving.

$$\beta^* = \frac{z_1 - (y_2 - y_1)}{(1+q)z_1} < 1$$

That means the farmer prefers a partial-coverage insurance contract when there is liquidity constraint. In other words, a full-cover insurance contract is not attained because of liquidity constraint, even the insurance is fair: premium rate equals the disaster's probability. In this sense, liquidity constraint probably causes insufficient insurance behavior.

3.3.3 Case 3: disaster risk, liquidity constraint, indivisible insurance, subsistence constraint

In this case, $\beta = \overline{\beta}$ and the household does not purchase insurance if $x_1 = y_1 - \overline{\beta} q z_1 < \overline{x}$.

One of the solutions is $s^* > 0$ in case that $y_1 + z_1 > y_2$.

That means even if income grows, under the situation there is subsistence constraint and indivisible insurance, the farmer is likely to save to prepare for disaster risk although it is not the primary function of saving.

3.4 Countermeasures

Based on the above analysis and discussion, the following corresponding countermeasures should be considered:

(1) Insurance companies should provide micro-level (divisible) insurance commodity to solve the conflict between subsistence level consumption and indivisible insurance. But that may increase operation costs for insurers. One optional instrument is governmental support for insurance companies. From the macro level, that is one kind of disaster risk diversification among the whole nation or society. In general, this risk transaction will be more efficient and practical compared with direct disaster payment based on national financial budget;

(2) Liquidity constraint should be relaxed so as to make loans more available for farmers in the post-disaster recovery process. Pledge, such as household assets, should

be evaluated more precisely and transacted in more efficient ways in the market. Besides increasing farmers' ability to get loans, the liquid circulation of farmland management right has the implicit function of diversifying disaster risk among households (Yokomatsu et al., 2007). That will make rural disaster risk easier to pool and finance.

(3) Informal lenders who have other main occupations, such as landlords, entrepreneurs and traders, can take an important role in disaster risk financing since they have a long-term relationship with farmers, which mitigates the problems, such as adverse selection and moral hazard, caused by asymmetric information (Yokomatsu et al., 2007). "Market Inter-linkage" should be expanded to increase farmers' coping capacities for disaster risk financing, and governments should consider their role explicitly in disaster policies. Additionally, this kind of interlinked transaction could be applied in the community-based development of disaster-mitigation infrastructure (Yu et al., 2008b). This will increase farmers' post-disaster outcome and the communities' sustainability. Furthermore, as one kind of innovative method for disaster risk financing, public-private financial services at the community level can combine formal financial sectors' advantages (such as insurance theory) and informal financial sectors' advantages (such as long-term relationship with local communities). This will make the disaster insurance market in rural China more and more standard and efficient.

(4) Applying the idea of a microcredit system, group purchasing of insurance might be effective in some situations, although the fact that group members' disaster risks are correlated should be taken into account. Another way is to collect farmers' micro idle money together based on some kind of credit cooperative (such as Rural Credit Cooperatives (RCCs) in rural China) and invest in capital market with adequate financial risk management (Yu et al., 2008a). This will increase farmers' post-disaster income because the return from capital market is relatively free from disaster risk. Then farmers' subsistence constraint will be relaxed and insurance accessing will be increased.

(5) Public financing with low interest might be socially efficient in cases where damage caused by disaster is completely out of households' control. One way is to establish a national disaster financing fund that supplies disaster-affected areas with low-interest recovery loans to help victims with post-disaster reconstruction and production restoring.

(6) Risk mitigation by governments by means of provision of infrastructure can reallocate disaster risks spatially, resulting in improving the capacity of risk financing. By constructing an inter-provincial flood control project, for example, this will benefit related residents with scale economy and integrated disaster prevention and mitigation.

3.5 Conclusions

(1) In the situation of subsistence constraint, fair insurance and no liquidity constraint, loan and insurance are complementary and farmers prefer full-coverage contract. Because it is not necessary to think about liquidity risk, farmers just maximize their whole-life utility by arranging their total income between period 1 and 2 through saving and transferring disaster risk to the insurer through disaster insurance.

(2) When facing subsistence constraint and liquidity constraint at the same time, there will be no saving and the optimal insurance behavior is partial-coverage contract, even the insurance premium is set at a fair price. The possible reason is that farmers would like to use saving to prepare for the risk of liquidity shock. That requires us to relax farmers' liquidity constraint by improving a pledge's precise evaluation and liquid circulation, involving informal financial sectors and expanding market inter-linkage.

(3) If farmers' poverty stop themselves from purchasing indivisible insurance (they will not have enough money to make subsistence level consumption if they buy insurance), households are likely to save to prepare for disaster risk. However, saving is not the most efficient way to finance disaster risk in an environment where risks faced by households are insurable with low premium rates. So, to promote farmers to get disaster insurance, insurance companies should be encouraged to supply micro-level (divisible) insurance and applying the microcredit system (RCCs) in rural China.

So far, the barriers to farmers' accessing disaster insurance have been investigated and corresponding countermeasures based on microcredit system, informal financial sectors and the circulation of farmland management right have been proposed. In the following chapter 4, a mathematical analysis will be made to figure out how to increase rural disaster risk financing by integrating microcredit system, informal financial sectors and liquid farmland management right.

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Chapter 4 Microcredit, Transaction of Farmland Management Right and Diversification of Disaster Risk in Agricultural Villages

4.1 Introduction

Chapter 3 has investigated and formulated the barriers to farmers' accessing disaster insurance. Suggestions have been made to improve rural disaster risk financing by combining the microcredit system, informal financial sectors and liquid farmland management right. This chapter will develop the relevant risk management models and prove the functions of the above institutions in financing rural disaster risk.

In 1978, agricultural reforms were implemented which abolished the system of people's communes and made farmers operate agricultural production individually. Since this amendment, the production efficiency has been improved remarkably (Wei, 2000). Moreover, in 1996, Chinese Rural Credit Cooperatives (RCCs) put into practice the microcredit loan, which has gradually been popularized in the 2000s. The interest rates are decided by each RCC considering they should be close to the basic interest rate given by People's Bank of China. And in most cases, the contract time term is one year. Diffusion of the microcredit has changed the composition of the financial market in the agricultural area. For example, (Yan, 2002) points out that, in 1998, only 21% of farmers' loans came from the formal financial sectors such as RCCs, who did not seem in favor of providing credit, while 74% of farmers' loans were from the informal financial sectors. However, according to a survey in certain areas of rural China by (Kawahara, 2005a), the amount of the loan from the formal financial sectors is almost equal to that from the informal sectors during 2001-2002. Availability of the formal loan operated by the formal financial sectors are increasing, while the private loan, including informal lending by the business partners like traders, still plays an important role in the financial supply of rural China (Yokomatsu et al., 2007).

At the end of the 1980s, in promoting the development of the agriculture and rural economy and social stability in the countryside, the government of China began to reform the land utilization system in rural China (Kawahara, 2005b; 29th Meeting of the Standing Committee of the Ninth National People's Congress, 2002; Baidu, 2007). Since 1978, the system has been changing from "agricultural cooperation and land communization system" to "contractual management system." And since the 1990s, the reform has been focusing on encouraging the circulation of the right to the farmland

contractual management, which is effected according to the law on a voluntary basis and with the compensation.

Considering the recent institutional movement above, it is evident that the RCCs' microcredit loan has improved the farmers' ability of risk financing, although the following questions still remain unsettled:

(1) Why have RCCs supplied not enough credit to farmers but "micro" credit?
(2) How are the coexistence of RCCs and informal financial sectors in current rural financial markets characterized? Why don't RCCs completely dominate the market in spite of their devastating advantage in risk pooling over the informal sectors?
(3) What kind of effect does the liquidation of the farmland management right have on the disaster risk management in the agricultural areas?

The following factors are listed as the reasons for RCCs' limited ability to control farmers' moral hazard in the disaster risk management:

(1) There is information asymmetry between farmers and RCCs because RCCs are connected to the member farmers only through financial transactions, saving and borrowing, that is, for example, different from the agricultural co-operative system in Japan that has integrated co-operative relationships with the member farmers.
(2) Farmlands cannot serve as collateral for the loan because they belong to the collective. Farmers are also limited to use their houses as a guarantee.
(3) Guarantor systems are not very effective. It is also costly for RCCs to monitor a debtor and his guarantor's economic condition.

This chapter develops the risk management models for the agricultural villages of China to describe the following structures:

(1) The circulation of the right to farmland contractual management will make the risk exposure more homogeneous among the farmers.
(2) For that reason, the ability of RCCs as well as that of the informal financial sectors to manage risk is increased, resulting in a decrease in the risk premium included in the interest of the loan.
(3) Moreover, by involving the informal financial sectors as a stakeholder who can monitor the farmers' condition with low cost due to long-term relationships, the farmers

are less motivated to go into moral hazard in risk mitigation.

The following sections in this chapter deal with the following: Section 2 analyzes the effect of the liquidation of the farmland management right on the risk diversification by a simple model without RCCs, which will contribute to the preparation of the following model. Section 3 incorporates the RCC into the model to investigate the respective role of the RCC and informal financial sectors in disaster risk management. Section 4 concludes the results and refers to remaining issues which should be tackled in the future.

4.2 The liquidation of the farmland management right and diversification of disaster risk

4.2.1 Assumptions

L is the total farmland of rural China. μ is the probability of the disaster that will cause unsuccessful crops. If the crops are unsuccessful, farmers will receive nothing from cultivating. For the reason of simplification, the number of farmers is standardized to 1. Farmers are heterogeneous only with respect to the initial endowment of wealth, θ, that is distributed from 0 to Θ, with the density function, $f(\theta)$. The size of the farmland cultivated by the farmer with the endowment, θ, is represented by $l(\theta)$. The assumptions above are followed by:

$$\int_0^{\Theta} \theta f(\theta) d\theta \equiv \bar{\theta}, \qquad \int_0^{\Theta} l(\theta) f(\theta) d\theta = L, \tag{4.1}$$

where $\bar{\theta}$ is the mean of θ. It is assumed that the farmland management rights are uniformly distributed before transaction, that is $l(\theta) = L$. The farming of land l costs αl at the beginning of the farming period, where α is the input for unit farmland cultivating. Accordingly each farmer's initial wealth does not necessarily cover his costs. So he needs the loan that amounts to $\alpha l - \theta$. In Case I and Case II of this session, the RCCs and the microcredit are not considered, and it is assumed that all the loan is provided by the informal sectors through interlinked transactions, in which two parties trade in at least two markets on the condition that the terms of all such trades are jointly determined (Bell, 1988). The market interlinkage generally provides a way of partially circumventing incomplete or non-existent markets in the developing societies

(Bardhan and Udry, 1999). Now, it is supposed that the local traders as informal financial sectors in the model, who respectively have a long-term relationship with a farmer as each client, and therefore know the farmer's condition and behavior well. Furthermore, it is assumed that traders are homogeneous, competing with one another in the market, and moreover, each trader has one farmer as his partner, respectively. Hence the local traders not only buy agricultural products from the farmers but also supply them with informal financial services such as loans before production,

According to the above assumption, the farmer with θ receives the loan, $m(\theta) = \alpha l - \theta$, from the trader with a contract stating that he will pay back the loan with interest after the successful crop. Then, if the successful crop comes, the farmland l will have production l and the farmer can sell all the production by the price p without any difficulty. Therefore, the farmer gets income, pl, from which he repays the loan to the trader with the interest payment, Ω, that includes the risk premium. If the crop fails, the farmer and the businessman will receive nothing back. Assuming that the trader is risk averse, the market competition implies that the trader's expected utility equals to 0, and Ω satisfies the following equation like:

$$(1-\mu)\cdot u(\Omega) + \mu \cdot u(-m) = 0 \tag{4.2}$$

where $u(\cdot)$ represents the trader's utility function that has the properties like $u'(\cdot) > 0$, $u''(\cdot) < 0$. The first term of the left hand side of (4.2) is the contingent utility of the trader if the crop is successful while the second term corresponds to the case that the crop fails. It is found that Ω depends on the probability of disaster, μ, and the loan size, m. Applying the implicit function theorem on (4.2), the following formula can be got:

$$\frac{\partial \Omega(\mu, m)}{\partial m} > 0, \frac{\partial^2 \Omega(\mu, m)}{\partial m^2} > 0 \tag{4.3}$$

that is, the interest with risk premium is convex with respect to the loan size, m. Hereafter, for simplification, $\Omega(\mu, m)$ is named as "risk premium" and represented by $\Omega(m)$.

4.2.2 Case I: risk diversification in informal financial market

In Case I , it is assumed as the benchmark case that the farmland management right cannot be transacted, namely, the size of the land is given by $l(\theta) = L$ for any θ. Hence the loan that the farmer gets from the trader is $m(\theta) = \alpha L - \theta$. Assuming that the farmer is risk neutral, the expected utility of the farmer in Case I is represented by:

$$W^I(\theta) = (1-\mu)\{(p-\alpha)L - \Omega(m(\theta))\} - \mu\theta \tag{4.4}$$

Since the traders' welfare is zero in the competitive market, the social welfare can be evaluated by integrating the farmers' expected utility such that:

$$SW^I = \int_0^{\Theta} W^I(\theta) f(\theta) d\theta = (1-\mu)(p-\alpha)L - \mu\bar{\theta} - (1-\mu)\int_0^{\Theta} \Omega(m(\theta)) f(\theta) d\theta, \tag{4.5}$$

where $\bar{\theta}$ represents the mean of θ. The first and second terms of the final line of (4.5) mean the total expected profit of the society, while the third term represents the aggregated risk premium farmers pay to the traders if the crop is successful. It implies that the reduction of the aggregated risk premium can improve the social welfare.

4.2.3 Case II: informal financial market and transaction of the farmland management right

In case II, it is assumed that there are transactions of the farmland management right. The loan that the farmer with wealth θ receives from the trader is $m(\theta) = \alpha l(\theta) - \theta$. The expected utility of the farmer is:

$$W^{II}(\theta) = (1-\mu)\{(p-\alpha)l(\theta) - \Omega(m(\theta))\} - \mu\theta \tag{4.6}$$

where $l(\theta)$ is now an endogenous variable. Since there is no externality in the market, the market equilibrium is equivalent to the social optimum. Therefore the solution of the social optimization is formulated with respect to the allocations of the farmland management right as follows:

$$\max_{l(\theta)(0\le\theta\le\Theta)} \quad SW^{II} = \int_0^{\Theta} W^{II}(\theta) f(\theta) d\theta \tag{4.7a}$$

subject to $\int_0^{\Theta} l(\theta) f(\theta) d\theta = L$ (4.7b)

The optimal solutions in the problem above can be attained in the market where each farmer individually maximizes his (her) own expected utility by exchanging the farmland management right and making a loan contract with the trader. The optimal allocation of the farmland management right is characterized by:

$$l^{**}(\theta) = \frac{\theta - \bar{\theta}}{\alpha} + L \qquad (0 \le \theta \le \Theta) \tag{4.8}$$

The optimal size of the farmland the farmer cultivates is proportional to his wealth, θ, which is followed by:

$$m(\theta) = \alpha l^{**}(\theta) - \theta = \alpha L - \bar{\theta} \equiv m^{**} \tag{4.9}$$

namely, the amount of the loan is identical among the farmers. As a result, the equilibrium expected utility of the farmer is given by:

$$W^{II}(\theta) = \left\{(1-\mu)\left(\frac{p}{\alpha} - 1\right) - \mu\right\}\theta + (1-\mu)\left\{\left(\frac{p}{\alpha} - 1\right)m^{**} - \Omega^{**}\right\} \tag{4.10}$$

where $\Omega^{**} = \Omega(m^{**})$ and it is uniform among the farmers. The expected utility is in proportion to the farmer's wealth, θ, that is different from $W^{I}(\theta)$ given by (4.4). The maximized social welfare is identified as follows:

$$SW^{II} = (1-\mu)(p-\alpha)L - \mu\bar{\theta} - (1-\mu)\Omega^{**} \tag{4.11}$$

Compared with SW^{I} given by (4.5), it is found that SW^{II} is maximized by minimizing the aggregated risk premium. Considering that m^{**} is the mean of $m(\theta)$, and the convexity of the risk premium function, $\Omega(m)$, clarified in (4.3), it is found, based on Jensen's Inequality, that:

$$\Omega^{**} \le \int_0^{\Theta} \Omega(m(\theta)) f(\theta) d\theta \tag{4.12}$$

This model assumes a linear system with respect to the farmers' risk neutral preference and production technology in agriculture, other than risk premium defined by the risk averse preference of the trader. Hence, the difference in the social welfare is reflected by the aggregated risk premium, and the maximization of the social welfare with respect to $l(\theta)$ is equivalent to the minimization of the aggregated risk premium with respect to $m(\theta)$. Owing to the convexity of $\Omega(m)$, every farmer's Ω is equalized by $m(\theta) = m^{**}$ at the optimum, namely, farmers' disaster risks are leveled off in the market.

4.3 Farmers' incentive for disaster mitigation and roles of Rural Credit Cooperatives and informal financial sectors

4.3.1 Assumptions

The preceding section has discussed the effect of liquidation of the farmland management right on redistribution of risks in the society. This section discusses how the functions of the informal financial sectors and RCCs can be effectively coordinated in the disaster risk management scheme in rural China.

In this section, the model is expanded in two ways: the RCC that provides the microcredit to the farmers and the practice of risk mitigation by the farmers are introduced, assuming, for simplification, that there are only two farmers (i=1,2) in the society who are the members of the same RCC and whose initial endowments are θ_1 and θ_2 respectively. Case III introduces the social optimal solution, and Case IV describes the market equilibrium. This shows how the moral hazard of the farmers caused by the information limitation of RCCs can be controlled.

In Case III, it is assumed that the RCC provides the loan ϕ_1 and ϕ_2 to farmer 1 and 2 respectively. It is also assumed that the farmers' disaster risks are identical and independent. If farmer i's crop is successful, the RCC will receive the loan back with interest payment, $\tilde{\Omega}_i$ (i=1,2), that includes risk premium. Each farmer demands the loan from the trader by the amount of $m_i = \alpha l_i - \theta_i - \phi_i$ (i=1, 2), which covers the shortfall of monetary resource. On the other hand, the farmers can mitigate the losses in the state of disaster by the mitigation behavior before the event. Supposing that by investing e_i, farmer i gets the harvest $\zeta(e_i)$ in the state of disaster, denote "effort" by e_i, and assume that the unit of e_i is given by labor, or equivalently, time. The

function $\zeta(\cdot)$ has the properties: $\zeta'(\cdot)>0, \zeta''(\cdot)<0$. Moreover, it is assumed that ζ is divided into $\varepsilon_R\zeta$, $\varepsilon_Q\zeta$ and $(1-\varepsilon_R-\varepsilon_Q)\zeta$ for the RCC, the trader and the farmer respectively. It is also assumed that ε_R and ε_Q are constant and positive parameters, and their sum is less than unity. The expected utilities of the RCC and the trader are represented by $W_R(\cdot)$ and $W_Q(\cdot)$ that satisfy:

$$W_R(\phi_1,\phi_2,\tilde{\Omega}_1,\tilde{\Omega}_2,e_1,e_2)=(1-\mu)^2\cdot U(\sum\nolimits_i\tilde{\Omega}_i)+\mu(1-\mu)\sum\nolimits_{i,j(i\neq j)}U(-\phi_i+\varepsilon_R\cdot\zeta(e_i)+\tilde{\Omega}_j)$$
$$+\mu^2\cdot U(\sum\nolimits_i\{-\phi_i+\varepsilon_R\cdot\zeta(e_i)\}) \quad (4.13a)$$

$$W_Q(\phi_i,\Omega_i,e_i)=(1-\mu)\cdot u(\Omega_i)+\mu\cdot u(-m_i+\varepsilon_Q\cdot\zeta(e_i)) \quad (4.13b)$$

where $U(\cdot)$ represents the RCC's utility function that has the properties like: $U'(\cdot)>0$, $U''(\cdot)<0$.

4.3.2 Case III: social optimal allocation of disaster risk

The social optimal problem is represented as follows:

$$\max_{l_i,e_i,\phi_i,\tilde{\Omega}_i,\Omega_i(i=1,2)} SW^{III}=\sum_i W_i^{III} \quad (4.14a)$$
$$=\sum_i\left[(1-\mu)\{(p-\alpha)l_i-\tilde{\Omega}_i-\Omega_i\}+\mu(1-\varepsilon_R-\varepsilon_Q)\zeta(e_i)-\mu\theta_i-e_i\right]$$

subject to

$$l_1+l_2=L \quad (4.14b)$$

$$W_R(\phi_1,\phi_2,\tilde{\Omega}_1,\tilde{\Omega}_2,e_1,e_2)=0 \quad (4.14c)$$

$$W_Q(\phi_i,\Omega_i,e_i)=0 \qquad (i=1,2) \quad (4.14d)$$

The constraint (4.14c) comes from a supposition that the RCC does not enjoy any

surplus for achievement of the public purpose, while the constraint (4.14d) is caused by the market competition among the traders. This leads to the following results:

$$l_1 = \frac{L}{2} + \frac{\theta_1 - \theta_2}{2\alpha},\ \ l_2 = \frac{L}{2} - \frac{\theta_1 - \theta_2}{2\alpha}, \tag{4.15a}$$

$$\phi_1 = \phi_2 \equiv \phi^*,\ \ \tilde{\Omega}_1 = \tilde{\Omega}_2 \equiv \tilde{\Omega}^*(\phi_1, \phi_2, e_1, e_2) \tag{4.15b}$$

$$m_1 = m_2 = \frac{\alpha L - \theta_1 - \theta_2}{2} - \phi^* \equiv m^* \tag{4.15c}$$

$$\Omega_1 = \Omega_2 \equiv \Omega^*(m_i, e_i),\ \ (i = 1, 2), \tag{4.15d}$$

$$e_1 = e_2 \equiv e^*, \tag{4.15e}$$

where ϕ^* and e^* are determined by the following conditions:

$$2\tilde{\Omega}^*_{\phi_i}(\phi^*, \phi^*, e^*, e^*) - \Omega^*_{m_i}(m^*, e^*) = 0, \tag{4.16a}$$

$$-(1-\mu)\left\{\tilde{\Omega}^*_{e_i}(\phi^*, \phi^*, e^*, e^*) + \Omega^*_{e_i}(m^*, e^*)\right\} + \mu\left(1 - \varepsilon_R - \varepsilon_Q\right)\varsigma'(e^*) = 1, \tag{4.16b}$$

where subscripts on $\tilde{\Omega}^*(\cdot)$ and $\Omega^*(\cdot)$ mean partial derivative with respect to corresponding variables. It is found that the RCC would like to supply individual farmers with the same loan and ask for the same risk premium; besides, the private loan from informal financial sectors is also identical between the farmers. Finally, the level of the farmers' effort for disaster mitigation is equalized in the social optimal situation.

4.3.3 Case IV: market allocation of disaster risk

Case III has considered the problem where the social planner determined all the

variables in the society so as to maximize the sum of expected utilities as the objective function. Accordingly, there was no problem caused by information asymmetry. Case IV considers the individual optimization by the farmer i who can induce the moral hazard that he may devote less effort than the social optimal effort, e^*.

Suppose that the farmers are given disaster education with some instruction manual at the beginning, and that they are required to devote e^* level of effort. On the other hand, the RCC has limited information on the farmers' situations and provides the social optimal size of the microcredit $(\phi^*, \tilde{\Omega}^*)$, and does not behave strategically. Note that ϕ^* is given by (4.15b) in Case III and $\tilde{\Omega}^* = \tilde{\Omega}^*(\phi^*, \phi^*, e^*, e^*)$. On the contrary, each farmer behaves in the market so as to maximize his expected utility with respect to the size of the farmland management right and the mitigation effort. Accordingly there may be some difference between e_i $(i = 1, 2)$ and e^*. Here the trader is assumed to monitor each farmer's behavior without any cost and discovers this difference. He seeks the farmer a penalty for deviation from the optimal mitigation effort by the amount of $Z(e_i) \equiv \gamma \cdot (e^* - e_i)$ $(i = 1, 2)$, which is proportional to the level of the moral hazard. γ is assumed to be a constant coefficient decided by the trader, and as is assumed on the effort, the units of the penalty are given by labor or time. The following is the event-sequence in Case IV:

(1) The farmers are instructed by the public sector to devote e^* for the mitigation.
(2) The RCC gives the farmers the microcredit $(\phi^*, \tilde{\Omega}^*)$ where $\tilde{\Omega}^* = \tilde{\Omega}^*(\phi^*, \phi^*, e^*, e^*)$.
(3) The trader announces the risk premium function, $\Omega^\circ(\cdot)$, which is defined more precisely later, and the penalty coefficient, γ.
(4) The farmer i transacts the farmland management right, l_i, in the market, makes a private loan contract, and determines the level of effort, e_i $(i = 1, 2)$.
(5) The market of the farmland management right reaches the equilibrium.
(6) The trader discovers the moral hazard and seeks the penalty.
(7) Disaster either occurs or does not.
(8) The farmers get crops and make repayment to the RCC and the trader.

The expected utility of the RCC and the trader is given by:

$W_R(\phi^*, \phi^*, \tilde{\Omega}^*, \tilde{\Omega}_2^*, e_1, e_2)$ and:

$$W_Q^\circ(\phi_i, \Omega_i^\circ, e_i, \gamma) = (1-\mu)\cdot u(\Omega_i^\circ + \gamma\cdot(e^* - e_i))$$

$$+\mu\cdot u(-m_i + \varepsilon_Q\cdot\zeta(e_i) + \gamma\cdot(e^* - e_i)) \quad (i=1,2), \tag{4.17}$$

where the penalty collected is added to the trader's income. Since the traders are competitive, $W_Q^\circ(\phi_i, \Omega_i^\circ, e_i, \gamma) = 0$, followed by the risk premium function, $\Omega_i^\circ = \Omega_i^\circ(\phi_i, e_i, \gamma)$. The optimization problem of the farmer i $(i=1,2)$ is represented as follows:

$$\max_{l_i, e_i} W^{IV} = (1-\mu)\{(p-\alpha)l_i - \tilde{\Omega}_i^* - \Omega^\circ(m_i, e_i, \gamma)\}$$

$$+\mu(1-\varepsilon_R-\varepsilon_Q)\zeta(e_i) - \mu\theta_i^\circ - e_i - \gamma\cdot(e^* - e_i) \tag{4.18a}$$

subject to:

$$\theta_i^\circ = \theta_i + q\cdot(\frac{L}{2} - l_i) \tag{4.18b}$$

$$m_i = \alpha l_i - \theta_i^\circ - \phi^* = (\alpha+q)\cdot l_i - (\theta_i + \frac{qL}{2}) - \phi^*, \tag{4.18c}$$

where q is the price of the farmland management right in the market, and θ_i° is the wealth after the transaction of the right. The loan from the trader is determined by (4.18c). One obtains the first order conditions with respect to l_i and e_i as follows:

$$(1-\mu)\left\{p - \alpha - (\alpha+q)\Omega_{m_i}^\circ(m_i, e_i, \gamma)\right\} + \mu q = 0 \tag{4.19a}$$

$$-(1-\mu)\Omega_{e_i}^\circ(m_i, e_i, \gamma) + \mu\left(1-\varepsilon_R-\varepsilon_Q\right)\varsigma'(e_i) + \gamma = 1 \tag{4.19b}$$

The market equilibrium condition is given by:

$$l_1 + l_2 = L \tag{4.20}$$

If the trader sets the value of penalty coefficient, γ, at:

$$\gamma^{\circ} = -(1-\mu)\tilde{\Omega}^{*}_{e_i}(\phi^{*}, \phi^{*}, e^{*}, e^{*}), \tag{4.21}$$

the farmers' choices and the market equilibrium will result in:

$$e_1 = e_2 = e^{*}, \quad m_1 = m_2 = m^{*}, \tag{4.22a}$$

$$l_1 = \frac{L}{2} + \frac{\theta_1 - \theta_2}{2\alpha + 2q^{\circ}}, \quad l_2 = \frac{L}{2} - \frac{\theta_1 - \theta_2}{2\alpha + 2q^{\circ}}, \tag{4.22b}$$

$$(1-\mu)\left\{ p - \alpha - (\alpha + q^{\circ})\Omega^{\circ}_{m_i}(m^{*}, e^{*}, \gamma^{\circ}) \right\} + \mu q^{\circ} = 0, \tag{4.22c}$$

where q° is the equilibrium price of the farmland management right. In summary, γ being set at γ° like (4.21), the first order condition for the farmer i, that is identified by (4.19b), becomes equivalent to the social optimal condition (4.16b). Moreover, by transacting the farmland management right in the market, the size of the private loan is equalized between the farmers and, furthermore, identical to the social optimal level. Hence, under the optimal risk management scheme, one arrives at:

$$SW^{IV} = \sum_i W_i^{IV} = SW^{III} \tag{4.23}$$

namely, the social optimal welfare is achieved in the decentralized market.

4.4 Conclusions

This chapter has developed the risk management models for the agricultural villages of China to investigate the effective coordination between the RCC and the informal financial sectors with the liquid market on the farmland management right provided. The circulation of the farmland management right makes the farmers' loan and disaster mitigation effort more homogeneous in equilibrium, this increases the ability of RCCs

as well as that of the informal financial sectors to pool risk, resulting in a decrease in the risk premium included in the interest of the loan. Moreover, by making use of the informal financial sectors' monitoring ability, farmers are less motivated to induce the moral hazard in disaster risk mitigation. In that sense, in disaster risk financing in Chinese agricultural communities, there is some complementary functioning between the microcredit system that leaves some roles for informal financial sectors and the liquidation of the farmland management right.

As for the future work, one should take into account RCCs' operational strategy and interaction with the farmers. Now Chapter 5 will investigate and formulate the cooperative characteristics of RCCs and the farmers' motivation for contributing in RCCs' sustainability under RCCs' institutional reformation.

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Chapter 5 Improvement of Microcredit's Sustainability and Farmers' Welfare: the Study on the Institutional Reformation of Rural Credit Cooperatives

5.1 Introduction

In Chapter 4, it has been shown that the microcredit system based on RCCs can play an important role in rural disaster risk financing. However, RCCs' commercial sustainability is facing the challenge induced by inefficient management and farmers' ignoring RCCs' sustainability. This will affect RCCs' continuous ability to finance rural disaster risk and then farmers' long-run benefit. This chapter will concretely investigate relevant insufficiencies and mathematically examine how to improve RCCs' commercial sustainability and farmers' long-term utility.

Chinese Rural Credit Cooperatives (RCCs) were founded in 1951 (Baidu, 2008a). In the beginning, RCCs financed from farmers and mainly supplied members with financial services. The initial purpose of RCCs is to support agricultural production through supplying mutual aid among local farmers. After more than 50 years development, the current objective of RCCs has been enriched to support agriculture, rural development, cooperative economy and members' domestic economy (Baidu, 2008b). The capital sources have been extended to share-selling income, common reserve fund and saving while the main job of RCCs is still supplying members with financial services. During the past 50 years, RCCs have been doing much positive affect on the development of rural China (Chen and Qiu, 2006). However, RCCs still have some insufficiencies that motivate one reformation started in 2000 (Zhang, 2006). The core of the reformation is construction of property right system under the supervision and direction of local government. The main purpose is to improve RCCs' commercial sustainability. Although some improvements have been achieved, there are still some insufficiencies that are pointed out by preceding studies as follows:

(1) Shareholders (RCCs' members) do not participate in the management of RCCs efficiently. As for individual farmers, it is not economical to participate in the management of RCCs for their small investments. For most farmers, to invest in RCCs is only the way to get the loan from RCCs. As long as the stable income gain from investment in RCCs is guaranteed, individual shareholders do not care about the daily operation and management of RCCs (Wang, 2006; Shangguan, 2006).

(2) There are too many political interventions that affect RCCs' operation and

management seriously. The principle-agent relationship between shareholders and managers is intervened by the government. As a matter of general fact, the provincial government decides on the senior managers of the Provincial Union of RCCs that appear during the process of the above reformation, and the Provincial Union of RCCs decides the senior managers of the County Union of RCCs. That makes the managers' objective different from the shareholders' (Zhang, 2006; Tao, 2006; Ji and Zhang, 2006).
(3) The loan from RCCs is mainly allocated to traditional agricultural production that suffers very much from disasters. If the disaster happens, RCCs' repayment rate and profit rate will be affected seriously (Wang, 2006).
(4) In general, farmers do not care about RCCs' sustainability. Farmers are not aware of the possibility of RCCs' bankruptcy after the reformation because of their deficient participation in RCCs' management and operation. They think the government will support RCCs regardless if the unsuccessful repayment (induced by huge disasters) makes it difficult for RCCs to survive. That opinion makes the disaster mitigation effort of farmers is not adequate (Zhang, 2006; Shangguan, 2006).
(5) RCCs' staff does not have enough motivation to focus on RCCs' daily operation and business extension. Without active participation and efficient supervision from members, it is difficult to make staff do adequate management and operation for the long-term benefit of RCCs' members (Wang, 2006; Shangguan, 2006; Ji and Zhang, 2006).

Correspondingly, according to the present related research, the following countermeasures should be considered:
(1) Give members corresponding discounts on loan interest rates according to their individual investment in RCCs. Furthermore, RCCs should allocate the profit to the members according to their individual contribution (Wang, 2006; Shangguan, 2006).
(2) Make RCCs more independent through the legislation for rural credit cooperation (Zhang, 2006; Wang, 2006; Shangguan, 2006).
(3) Support rural enterprises and make relatively higher profit income from them (Zhang, 2006; Wang, 2006; Tao, 2006; Ji and Zhang, 2006).
(4) Carry out new management mode and property right system reformation according to local realities (Zhang, 2006; Wang, 2006; Shangguan, 2006; Ji and Zhang, 2006; Liang, 2006).
(5) With adequate financial risk management and proper operation, RCCs should mainly support agriculture, rural economy and farmers (Zhang, 2006; Shangguan, 2006; Tao, 2006; Liang, 2006).

According to the above statement, it is true that the participation of shareholders (RCCs' members) in RCCs' management is very important for RCCs' efficiency and sustainability improvement. Only with the efficient management from members, can RCCs really work for their real owners' benefit and the development of rural China. This chapter will focus on the farmers' participation in the management of RCCs. The rest of this chapter consists of the following parts: Section 2 will make analytical description of the model. In section 3, the numerical analysis will be carried out. Finally, in section 4, some corresponding conclusions will be discussed.

5.2 The model

5.2.1 Model framework

As mentioned above, there are assumed to be only two parties, RCCs and farmers. The latter is the only investor to RCCs. That means farmers are the only members and owners of RCCs. After the investment, the managers of RCCs will make the decision about daily operation and loan allocation. During the decision process, by assumption, there is no intervention from the government after some successful institutional reformation. And farmers can voluntarily choose whether or not they want to participate in RCCs' management. As mentioned before, the main loan of RCCs is allocated to traditional agricultural production that depends too much on natural disaster. Correspondingly, that will greatly affect the repayment and profit rate of RCCs. It is natural for us to think about lending the main loan to other kinds of production with a relatively stable return. But one important job of RCCs' is to support agriculture. That means some kind of balance should be made among several loan allocations. As an innovative way, it is assumed that RCCs' loan will be separated into three parts: agricultural loan, credit to other financial institutions (such as saving in commercial banks) and some risky investment (such as lending to rural enterprises). The main job of RCCs' management process is to decide the exact ratio among the three loan allocations. After the ratio decision, farmers will receive the loan from RCCs and do the cultivation. In general, the crop will be affected if the disaster happens. By assumption, farmers' disaster mitigation investment will decide on the remaining ratio of post-disaster crop. Finally, RCCs will receive the repayment from the farmers' crop, interest income from other banks and profit return from risky investment. Later it will be examined whether the RCCs' asset is less than before. If the answer is negative, the

similar process of loan allocating, loan lending, cultivating, disaster mitigating, loan repaying and RCCs' asset checking will happen continuously. And if the answer is positive, that means RCCs cannot afford the loan to farmers anymore. In other words, at least as for farmers, RCCs fall in the bankruptcy. That will disable farmers' continuous agricultural production.

For simplification, the event-sequence is arranged as follows:
(1) Farmers make investment to RCCs.
(2) RCCs' managers make loan allocation among agricultural loan, safe investment and risky investment.
(3) Farmers get the loan from RCCs.
(4) Farmers cultivate land and mitigate disaster.
(5) Disaster happens with the probability of μ.
(6) RCCs' get the repayment from farmers, other banks and risky investment.
(7) RCCs will continue to supply farmers with a loan in the next period if their asset is more than the initial one.

According to the above arrangement, it is shown that loan allocation ratio and farmers' mitigation investment will affect RCCs' sustainability. And RCCs' sustainability decides farmers' long-term benefit. That means that there is the farmers' potential motivation to participate in RCCs' management and optimal disaster mitigation effort for optimizing their own long-run benefit. In other words, the job is to find out how to encourage farmers to participate in RCCs' management and what is the optimal disaster mitigation investment through the coming model.

For simplification, the number of farmers and that of RCCs are respectively standardized to be 1. The initial asset of RCC consists of common reserve fund and farmers' investment (necessary for becoming RCC's member). And it is assumed that the loan amount for the agricultural loan is fixed. The management process of RCC is to decide the ratio between the safe investment and the risky investment.

5.2.2 Farmers' utility before institutional reformation

Before institutional reformation of RCC, let us suppose that farmers do not know and neither care about RCC's decision on the ratio between the safe investment and the risky investment. They only care about their income from cultivating. And they think

that RCC will not fall in bankruptcy even if they fail to pay a loan and interest back to RCC in the case of huge disasters; because they believe the government will support RCC anyway. In other words, farmers believe the disaster will not affect the probability of getting the loan in next time. For the coming analysis, the following symbols will be used:

(1) μ : the probability of disaster.

(2) l : the loan from RCC to farmers.

(3) hl : the production function of farmers. h is a constant.

(4) ρ : the loan interest rate asked by RCC from farmers.

(5) β : the discount factor.

(6) σ : farmers' disaster mitigation effort that varies from 0 to 1.

(7) c : the opportunity cost of farmers' disaster mitigation effort.

(8) $\alpha\gamma(\sigma)$: the remaining rate of crops after disaster. α is a constant while $\gamma(\sigma)$ is a function of σ. $\gamma(\sigma)$ and σ both distribute between 0 and 1. In numerical simulation, $\gamma(\sigma)$ is specified like $\gamma(\sigma)=\sigma(2-\sigma)$.

(9) I : the investment from each farmer to RCC.

(10) r : the constant interest rate for farmers' investment to RCC before institutional reformation.

According to the above, the farmers' net income should be $hl-(1+\rho)l$ if the disaster does not happen. Correspondingly, the farmers' net income will be $\max[\alpha\gamma(\sigma)hl-(1+\rho)l,0]$ if the disaster happens. Because, farmers are assumed to give all the crops to RCC if the post-disaster crop is less than the repayment farmers should give to RCC. Then, the farmers' expected utility can be written as follows:

$$\begin{aligned} W^I &= (1-\mu)\{[hl-(1+\rho)l]+\beta W^I\} \\ &\quad +\mu\{\max[\alpha\gamma(\sigma)hl-(1+\rho)l,0]+\beta W^I\}-c\sigma+Ir \end{aligned} \tag{5.1}$$

Respectively, the farmers' optimal problem can be expressed as follows:

(1) If $\alpha\gamma(\sigma)hl \geq (1+\rho)l$. That means post-disaster crop is more than the repayment that farmers should give to RCC.

$$\underset{\sigma}{Max}\, W^I = \frac{(1-\mu)[hl-(1+\rho)l]}{1-\beta}+\frac{\mu[\alpha\gamma(\sigma)hl-(1+\rho)l]-c\sigma+Ir}{1-\beta} \tag{5.2}$$

(2) If $\alpha\gamma(\sigma)hl < (1+\rho)l$. That means post-disaster crop is less than that farmers

should give to RCC.

$$\underset{\sigma}{Max} W^{I} = \frac{(1-\mu)[hl-(1+\rho)l]-c\sigma+Ir}{1-\beta} \tag{5.3}$$

Considering the consistency of the constraints about $\alpha\gamma(\sigma)hl$ and $(1+\rho)l$, the farmers' optimal disaster mitigation effort, σ^{I^*}, and expected utility, W^{I^*}, can be got by comparing the results of formula (5.2) and (5.3).

5.2.3 Farmers' utility after institutional reformation

This section starts to study the farmers' utility after RCC's institutional reformation. The farmers' utility under three different situations is discussed respectively: without perfect information about RCC's management, with perfect information about RCC's decision and with efficient participation in RCC's management.

5.2.3.1 Farmers' utility without perfect information about RCC's management

In this case, farmers are supposed to behave again according to their original knowledge about RCC's management and operation before institutional reformation. That means farmers will do σ^{I^*} for disaster mitigation and expect utility as W^{I^*}. But their real expected utility, W^{II^*}, in this situation will be different from W^{I^*} because RCC now faces the possibility of bankruptcy after institutional reformation. The probability for farmers to get loans in the next period will be affected if RCC's sustainability is destroyed by the unsuccessful repayment induced by the huge disaster. At the end of each period, after getting the repayment from farmers, the return from safe investment and that from risky investment, RCC's asset will be compared with that initial one. If the former is bigger than the latter, RCC will survive and farmers will get RCC's net income at the end of this period and the agricultural loan in next period. If RCC's asset is smaller than that initial one, RCC will fall in bankruptcy and farmers will not get the agricultural loan in next period. That means the farmers' cultivation will be stopped.

For above extended discussion, the following symbols should be marked:
(1) A_0: RCC's initial asset. In the model, it is assumed that the loan allocated to other investment than agricultural loan is constant in each period as long as the RCC's operation continues. Then the total loan allocated to safe investment and risky

investment is $A_0 - l$.

(2) η: the ratio of the loan allocated to risky investment. It varies from 0 to 1. That means the loan allocated to safe investment is $(1-\eta)(A_0 - l)$ and that to risky investment is $\eta(A_0 - l)$.

(3) θ: the stochastic rate of return from risky investment.

(4) R: the deterministic rate of return from safe investment.

(5) A_i^n: RCC's asset at the end of period i when there is no disaster in period i.

$$A_i^n = (1+\rho)l + \eta(A_0 - l)\times\theta + (1-\eta)(A_0 - l)R \tag{5.4}$$

(6) A_i^d: RCC's asset at the end of period i when there is disaster in period i.

$$A_i^d = (1+\rho)l + \eta(A_0 - l)\theta + (1-\eta)(A_0 - l)R \quad \text{if } \alpha\gamma(\sigma)hl \geq (1+\rho)l \tag{5.5}$$

$$A_i^d = \alpha\gamma(\sigma)hl + \eta(A_0 - l)\theta + (1-\eta)(A_0 - l)R \quad \text{if } \alpha\gamma(\sigma)hl < (1+\rho)l \tag{5.6}$$

(7) $P^n = \Pr ob(A_i^n \geq A_0)$: the probability that RCC's asset at the end of period i is bigger than that initial one when there is no disaster in period i.

(8) $P^d = \Pr ob(A_i^d \geq A_0)$: the probability that RCC's asset at the end of period i is bigger than that initial one when disaster occurs in period i.

In this case, for simplicity, RCC's staff is assumed to allocate the loan between the safe investment and the risky one averagely because they do not have enough motivation to maximize the income from investment without farmers' participation in RCC's management. That means η=0.5.

Additionally, let us assume that the profit of RCC in each period, $A_i^n - A_0$, is consumed by the farmer in that period and cannot be saved for the following periods.

Till now, the farmers' utility can be written as follows:

$$W^{II} = (1-\mu)\{[hl-(1+\rho)l]+P^n(A_i^n - A_0 + \beta W^{II})\}$$

$$+\mu\{\max[\alpha\gamma(\sigma)hl-(1+\rho)l,0]+P^d(A_i^d - A_0 + \beta W^{II})\}-c\sigma \qquad (5.7)$$

where:

$A_i^n = (1+\rho)l + 0.5(A_0 - l)\theta + 0.5(A_0 - l)R$;

$A_i^d = (1+\rho)l + 0.5(A_0 - l)\theta + 0.5(A_0 - l)R$ if $\alpha\gamma(\sigma)hl \geq (1+\rho)l$;

$A_i^d = \alpha\gamma(\sigma)hl + 0.5(A_0 - l)\theta + 0.5(A_0 - l)R$ if $\alpha\gamma(\sigma)hl < (1+\rho)l$.

By considering the consistency of the constraints about $\alpha\gamma(\sigma)hl$ and $(1+\rho)l$, the farmers' real expected utility, W^{II^*}, in this case can be got by applying σ^{II^*}, equals to σ^{I^*}, in equation (5.7).

5.2.3.2 Farmers' utility with perfect information about RCC's decision

In this case, farmers are assumed to have perfect information about RCC's decision about the loan allocation ratio between safe investment and risky investment. Although farmers can get all the profit from the above investment, they cannot affect the investment ratio. Farmers can only maximize their expected utility by choosing adequate disaster mitigation effort. That means the ratio of the loan allocated to risky investment, η, will still be 0.5.

Let us recall the expression of farmers' real expected utility mentioned in the above case.

$$W^{III} = (1-\mu)\{[hl-(1+\rho)l]+P^n(A_i^n - A_0 + \beta W^{III})\}$$

$$+\mu\{\max[\alpha\gamma(\sigma)hl-(1+\rho)l,0]+P^d(A_i^d - A_0 + \beta W^{III})\}-c\sigma \qquad (5.8)$$

where

$A_i^n = (1+\rho)l + 0.5(A_0 - l)\theta + 0.5(A_0 - l)R$;

$A_i^d = (1+\rho)l + 0.5(A_0 - l)\theta + 0.5(A_0 - l)R$ if $\alpha\gamma(\sigma)hl \geq (1+\rho)l$;

$A_i^d = \alpha\gamma(\sigma)hl + 0.5(A_0 - l)\theta + 0.5(A_0 - l)R$ if $\alpha\gamma(\sigma)hl < (1+\rho)l$.

Then the farmers' optimal problem can be expressed as follows:

$$\underset{\sigma}{Max} W^{III} = \frac{(1-\mu)[hl-(1+\rho)l]+(1-\mu)P^n(A_i^n - A_0)}{1-(1-\mu)P^n\beta - \mu P^d\beta} + \frac{\mu\max[\alpha\gamma(\sigma)hl-(1+\rho)l,0]+\mu P^d(A_i^d - A_0)}{1-(1-\mu)P^n\beta - \mu P^d\beta} - \frac{c\sigma}{1-(1-\mu)P^n\beta - \mu P^d\beta} \tag{5.9}$$

So the following optimal solutions can be obtained respectively.

(1) If $\alpha\gamma(\sigma)hl \geq (1+\rho)l$. That means $A_i^n = A_i^d$ and $P^n = P^d$.

$$\underset{\sigma}{Max} W^{III} = \frac{(1-\mu)[hl-(1+\rho)l]}{1-P^n\beta} + \frac{\mu[\alpha\gamma(\sigma)hl-(1+\rho)l]}{1-P^n\beta} + \frac{P^n(A_i^n - A_0) - c\sigma}{1-P^n\beta} \tag{5.10}$$

(2) If $\alpha\gamma(\sigma)hl < (1+\rho)l$.

$$\underset{\sigma}{Max} W^{III} = \frac{(1-\mu)[hl-(1+\rho)l]+(1-\mu)P^n(A_i^n - A_0)}{1-(1-\mu)P^n\beta - \mu P^d\beta} + \frac{\mu\max[\alpha\gamma(\sigma)hl-(1+\rho)l,0]+\mu P^d(A_i^d - A_0)}{1-(1-\mu)P^n\beta - \mu P^d\beta} - \frac{c\sigma}{1-(1-\mu)P^n\beta - \mu P^d\beta} \tag{5.11}$$

Considering the consistency of the constraints about $\alpha\gamma(\sigma)hl$ and $(1+\rho)l$, the farmers' optimal disaster mitigation effort, σ^{III^*}, and expected utility, W^{III^*}, can be got by comparing the results of formula (5.10) and (5.11).

5.2.3.3 Farmers' utility with efficient participation in RCC's management

In this case, farmers are supposed to efficiently participate in RCC's management by deciding loan allocation ratio between a safe investment and a risky one. Here, farmers can maximize their expected utility by choosing adequate disaster mitigation effort and loan allocation ratio.

The farmers' utility can be written as follows:

$$W^{IV} = (1-\mu)\{[hl-(1+\rho)l]+P^n(A_i^n - A_0 + \beta W^{IV})\}$$

$$+\mu\{\max[\alpha\gamma(\sigma)hl-(1+\rho)l,0]+P^d(A_i^d - A_0 + \beta W^{IV})\}-c\sigma \qquad (5.12)$$

Where:

$A_i^n = (1+\rho)l + \eta(A_0 - l)\theta + (1-\eta)(A_0 - l)R$;

$A_i^d = (1+\rho)l + \eta(A_0 - l)\theta + (1-\eta)(A_0 - l)R$ if $\alpha\gamma(\sigma)hl \geq (1+\rho)l$;

$A_i^d = \alpha\gamma(\sigma)hl + \eta(A_0 - l)\theta + (1-\eta)(A_0 - l)R$ if $\alpha\gamma(\sigma)hl < (1+\rho)l$.

So the following optimal solutions can be got respectively.

(1) If $\alpha\gamma(\sigma)hl \geq (1+\rho)l$. That means $A_i^n = A_i^d$ and $P^n = P^d$.

$$\underset{\sigma,\eta}{Max} W^{IV} = \frac{(1-\mu)[hl-(1+\rho)l]}{1-P^n\beta} + \frac{\mu[\alpha\gamma(\sigma)hl-(1+\rho)l]}{1-P^n\beta} + \frac{P^n(A_i^n - A_0)-c\sigma}{1-P^n\beta} \qquad (5.13)$$

(2) If $\alpha\gamma(\sigma)hl < (1+\rho)l$.

$$\underset{\sigma,\eta}{Max} W^{IV} = \frac{(1-\mu)[hl-(1+\rho)l]+(1-\mu)P^n(A_i^n - A_0)}{1-(1-\mu)P^n\beta-\mu P^d\beta} + \frac{\mu\max[\alpha\gamma(\sigma)hl-(1+\rho)l,0]+\mu P^d(A_i^d - A_0)}{1-(1-\mu)P^n\beta-\mu P^d\beta}$$

$$-\frac{c\sigma}{1-(1-\mu)P^n\beta-\mu P^d\beta} \qquad (5.14)$$

With considering the consistency of the constraints about $\alpha\gamma(\sigma)hl$ and $(1+\rho)l$, the farmers' optimal disaster mitigation effort, σ^{IV^*}, expected utility, W^{IV^*}, and the ratio of the loan allocated to risky investment, η^*, can be got by comparing the results of

formula (5.13) and (5.14).

5.2.4 Farmers' acceptation on institutional reformation

In China, there are enormous numbers of RCCs, each of which has an inherent long history and custom respectively. Hence, the central government must have been uncertain about how deeply and promptly farmers' participation in decision-making is adopted in each RCC. In other words, it is reasonable to presume that the central government might have thought that only partially the democratic decision making where farmers were involved would penetrate at the beginning of the new system. Put it in another way, if farmers had known the economic environment after the institutional reform correctly, as well as the likelihood that they could not take part in the decision-making, farmers would not have approved of the reformation.

Finally, it is also assumed in the model that RCC introduces the decision-making system (where farmers decide) with the probability of ν. In other words, not all the RCCs follow the new decision making rule the central government tries to introduce. That means, if farmers decide to involve themselves in RCC's reformation process, their expected utility (from the view point of the central government) will be $W^{V^*} = \nu W^{IV^*} + (1-\nu)W^{III^*}$. And if and only if $W^{V^*} > W^{I^*}$, RCC's institutional reformation will improve farmers' welfare and finally be accepted by farmers finally. Otherwise, after knowing RCC's economic environment correctly, farmers would like to continue behaving with the mind of the original RCC's mechanism. That means there is some kind of threshold value, ν^*, for ν to decide farmers' acceptation on RCC's institutional reformation. So, for improving farmers' long-run benefit and giving farmers enough motivation to support and involve RCC's institutional reformation, the central government should make the probability of RCC to introduce the post-reformation decision making system in which farmers can represent and practice their opinion higher than ν^*.

5.3 The numerical analysis

In the following numerical analysis, the following parameters are set.

(1) μ, the probability of disaster, equals to 0.01;

(2) l, the loan from RCC to farmers, equals to 20000.

(3) h equals to 1.2 while hl is the production function of farmers.

(4) ρ, the loan interest rate asked by RCC from farmers, equals to 0.05 (The People's Bank of China, 2007; Haiyan Rural Credit Cooperative Union, 2007; Baidu, 2008c).

(5) β, the discount factor, equals to 1/(1.04) (The People's Bank of China, 2007).

(6) σ, farmers' disaster mitigation effort, varies from 0 to 1.

(7) c, the opportunity cost of farmers' disaster mitigation effort, equals to 50.

(8) α equals to 0.9 while $\alpha\gamma(\sigma)$ is the remaining rate of crops after disaster and $\gamma(\sigma)=\sigma(2-\sigma)$.

(9) I, the investment from each farmer to RCC, equals to 10000.

(10) r, the constant interest rate for farmers' investment to RCC before institutional reformation, equals to 0.05.

(11) A_0, RCC's initial asset, equals to 30000.

(12) $\eta(A_0-l)$, the loan allocated to risky investment, equals to 10000η.

(13) $(1-\eta)(A_0-l)$, the loan allocated to safe investment, equals to $10000(1-\eta)$.

(14) θ, the rate of return from risky investment, obeys a uniform distribution with the mean of 1.05. For comparative statistics, the value range of θ is assumed to be [0.3, 1.8], [0.5, 1.6] and [0.7, 1.4] respectively.

(15) R, the rate of return from safe investment, equals to 1.05 (The People's Bank of China, 2007).

According to the above assumptions, we can get the following results shown in Table 5.1.

(1) After the institutional reformation, without comprehensive understanding of RCC's new mechanism, farmers will behave as before and their real utility will be much less than they expect.

(2) With RCC's institutional reformation and perfect information about that, farmers' optimal disaster mitigation effort is increased from 0 to 0.88. That means farmers' comprehensive information about RCC's management and operation will increase farmers' optimal disaster mitigation effort; because farmers get to know their disaster mitigation effort will affect RCC's sustainability and their own long-term benefit.

(3) Farmers' optimal expected utility will be decreased if they have no ability to affect RCC's management, while the amount of optimal expected utility will be increased if farmers can participate in RCC's decision process efficiently. That means farmers will

accept RCC's reformation if and only if the probability of RCC to introduce the post-reformation decision making system in which farmers can represent and practice their opinion is higher than v^*.

Table 5.1 Results of numerical analysis (Continued)

θ	σ^{I^*}	σ^{II^*}	σ^{III^*}	σ^{IV^*}
[0.3, 1.8]	0	0	0.88	0.88
[0.5, 1.6]	0	0	0.88	0.88
[0.7, 1.4]	0	0	0.88	0.88

Table 5.1 Results of numerical analysis (Continued)

θ	W^{I^*}	W^{II^*}	W^{III^*}	W^{IV^*}
[0.3, 1.8]	90,220	14,354	14,580	115,151
[0.5, 1.6]	90,220	17,380	17,786	115,151
[0.7, 1.4]	90,220	38,458	41,419	115,151

Table 5.1 Results of numerical analysis (Continued)

θ	$P^{n^{II}}$	$P^{n^{III}}$	$P^{n^{IV}}$	η^*
[0.3, 1.8]	0.70	0.70	1	0.20
[0.5, 1.6]	0.77	0.77	1	0.27
[0.7, 1.4]	0.93	0.93	1	0.43

Table 5.1 Results of numerical analysis

θ	$P^{d^{II}}$	$P^{d^{III}}$	$P^{d^{IV}}$	v^*
[0.3, 1.8]	0	0.70	1	0.75
[0.5, 1.6]	0	0.77	1	0.74
[0.7, 1.4]	0	0.93	1	0.66

Note: P^{n^i} and P^{d^i} mean the final value of P^n and P^d in case i.

(4) In any case of value range for θ, $W^{III^*} < W^{I^*} < W^{IV^*}$. That means the final outcome

of investment in capital market depends on whether or not there is efficient financial risk management. With adequate risk management, the investment in capital market can increase farmers' long-run benefit.

(5) With the rise of the variance of θ, under the situation in which it is impossible for farmers to affect RCC's management, farmers' expected utility decreases. That means, without adequate management about investment risk, the more risky the capital market is, the more the farmers' expected utility gets hurt.

(6) In Table 5.1, $P^{d^{IV}} > P^{d^{III}} > P^{d^{II}}$. That means, after institutional reformation, giving farmers' perfect information about RCC's management will increase RCC's sustainability during disaster time. And with full ability to affect RCC's decision, that positive influence becomes more active. Similarly, $P^{n^{IV}} > P^{n^{III}} = P^{n^{II}}$ in Table 5.1. That means only the integration of perfect information and management participation can increase RCC's sustainability during the years without disaster.

(7) In Table 5.1, $P^{n^{IV}} = P^{d^{IV}}$ =1. That means, with perfect information and full ability to affect RCC's decision, farmers would like to make sure RCC will continue into the next period during either disaster time or normal seasons.

(8) With the rise of the variance of θ, the optimal ratio of the loan allocated to risky investment decreases. That means, with the full ability to affect RCC's decision, the more risky the capital market, the more carefully farmers manage investment.

(9) With the rise of the variance of θ, the threshold value, v^* , increases. That means the more risky the capital market is, the more important RCC's introduction about the post-reformation decision making system in which farmers can represent and practice their opinion.

(10) Under the situation in which farmers have full ability to affect RCC's management, farmers' expected utility would not depend on the variance of θ. That means, with efficient participation and supervision from farmers on RCC's financial risk management, farmers' expected utility will be free from the risk of the capital market.

5.4 Conclusions

Based on the above calculations and discussions, we can get the following conclusions:

(1) Farmers' long-run benefit depends on RCCs' sustainability which is determined by the repayment rate and profit rate. In general, the repayment rate is determined by the farmers' disaster mitigation effort and the profit rate depends on RCCs' loan allocation. Without enough knowledge about RCCs' management, farmers will not make adequate disaster mitigation effort and without the supervision from RCCs' members (farmers), RCCs' staff will not have enough motivation to do efficient loan allocation to maximize profit rate. So the key way to improve farmers' long-run benefit is to make farmers efficiently participate in RCCs' management. Here participation has two aspects: comprehensive understanding of RCCs' new operation mechanism and deciding RCCs' loan allocation between different investments.

(2) Under RCCs' original mechanism, the government will support RCCs when the huge disaster induces great unsuccessful repayment from farmers. From the farmers' aspect, their disaster mitigation effort will not affect RCCs' post-disaster sustainability, so they just consider how to maximize their long-term expected utility with taking the loan as granted. That makes the farmers' disaster mitigation effort far from enough and RCCs' sustainability is inadequate for farmers' long-run benefit.

(3) After the institutional reformation, with the perfect information about RCCs' operation, farmers will increase their disaster mitigation effort and RCCs' sustainability. Because farmers get to know their disaster mitigation effort will affect RCCs' sustainability and their own long-term benefit. But the farmers' expected utility has been decreased because of farmers' disability on affecting RCCs' management. That will hold farmers back from getting to understand RCCs' new operation mechanism.

(4) After the institutional reformation, with the efficient participation in RCCs' management, farmers' disaster mitigation effort, RCCs' sustainability and farmers' long-run utility will be increased at the same time. Because under this situation, with comprehensive knowledge about RCCs' operation and efficient participation in RCCs' management, farmers get to know their disaster mitigation effort will affect RCCs' post-disaster sustainability and their own long-run benefit. Furthermore, with full ability to decide loan allocation ratio, farmers can and actually do practice adequate investment strategy to maximize RCCs' profit rate and their own long-term utility.

(5) For farmers to receive perfect information about RCCs' operation (to make farmers do adequate disaster mitigation effort) is firmly related to for farmers to own full ability to participate in RCCs' management (to maximize RCCs' profit rate). People cannot separate them and try to finish the former job individually. Because without the ability

to participate in RCCs' management, farmers' long-run expected utility will be decreased because of being involved in RCCs' new operation mechanism. Under that situation, after knowing RCCs' economic environment correctly, farmers will not wish to follow the reformation process of RCCs.

(6) At the beginning of RCCs' reformation, because of being used to pre-reformation operation mechanism under which farmers cannot represent their opinion on RCCs' management, some RCCs will not wish to follow the reformation decision of the central government very well. In other words, RCCs only introduce the post-reformation decision making system in which farmers can represent and practice their opinion with some certain probability. And this probability will decide the farmers' real expected utility after reformation (from the view point of the central government) and the farmers' acceptation on RCCs' reformation. Farmers will compare the benefit after reformation with their original one. They will continue to support reformation if the former is bigger, and vice versa. So the principal job is to make the probability of RCCs' to introduce the post-reformation decision making system in which farmers can represent and practice their opinion as high as possible. The possible way could be carrying out some efficient communication mechanism that will make it easier for farmers to receive RCCs' information and represent their opinion to RCCs' staff. One optional method is the legislation and supervision from the government to RCCs with the participation motivation from the government to farmers.

(7) With the rise of the variance of the return from risky investment, RCCs' efficient management about financial risk (deciding the loan allocation between safe and risky investment) becomes more and more important. Correspondingly, farmers will ask for more and more ability or opportunity to participate in RCCs' management and allocate less and less loans to risky investment.

(8) With efficient participation and supervision from farmers on RCCs' financial risk management, maintaining RCCs' main job of supporting agriculture, RCCs can make use of capital market to improve the sustainability while making farmers' long-run benefit free from the financial risk.

As mentioned in Chapter 1, besides disaster risk transfer, disaster mitigation is also instrumental for the rural disaster risk management. As the only formal institution that supplies farmers with loans, besides financing farmers' disaster risk, RCCs are supposed to play an additional role in improving the development of disaster-mitigation infrastructures in agricultural communities. Now, in Chapter 6, it will be discussed how to promote community-based disaster-mitigation infrastructure development based on

the group loan from RCCs.

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Chapter 6 Contribution of Group Loan to Sustainability of Agricultural Communities: Collaborative Development of Community Disaster-mitigation Infrastructure

6.1 Introduction

In Chapter 4 and 5, the role of RCCs in disaster risk transfer has been studied. In Chapter 4, the complementary functioning among RCCs, the informal financial sectors, and the liquid farmland management right in improving rural disaster risk transfer has been examined. In Chapter 5, with a view to make RCCs' disaster risk transfer function more sustainable, study has been carried out to discuss how to improve RCCs' post-disaster commercial sustainability. In this chapter, a focus is placed on RCCs' positive and active effect on rural disaster mitigation.

In China, more and more farmers move to urbanized areas because of the subsistence problem induced by natural disasters and an increase in income in urban areas. That makes the urbanization in China occur excessively fast. At the same time, too much farmland is occupied and the sustainability of agricultural communities is under a direct threat (Zhou, 2006). To mitigate the above problems, besides improving rural disaster risk transfer, the central government requires governments at all levels to develop the community-based disaster-mitigation infrastructure, such as early warning systems, shelters, emergency preplans, disaster mitigation facilities, and residents' awareness of disaster mitigation (the General Office of the State Council, 2007).

Unfortunately, farmers do not have enough motivation to develop the community-based disaster-mitigation infrastructure primarily for the following reasons (Chen, 2008).
(1) Farmers are too poor to be involved in developing the infrastructure. Although the disaster-mitigation infrastructure will make the post-disaster harvest enough for farmers' subsistence, its development takes time. Before the infrastructure is finished, the farmers' post-disaster harvest is still very low and cannot afford the infrastructure development and their own subsistence at the same time. So, farmers will face the subsistence problem if they spend money for infrastructure developing.
(2) Even if some farmers have enough money to develop the disaster-mitigation infrastructure, it will not be economical and efficient because their production scale is always very small.

On the other hand, there are potential incentives for farmers (including the former farmers working in cities) to develop community-based disaster-mitigation infrastructures. Firstly, infrastructure development will help increase their post-disaster harvest. Secondly, after collaborative work on the infrastructure, farmers' interpersonal relationships will become strengthened and active community knowledge and awareness on disaster mitigation will come out. This will improve the community's ability to conduct disaster mitigation and relief, such as mutual aid, special care for disadvantaged groups, and mutual enlightenment or comfort. All these things compose some kind of community culture (social capital at the community level) that will also increase farmers' post-disaster utility in rural areas. Obviously, the former farmers working in cities cannot benefit from the similar community culture existing among urban residents. It is impossible for them to be involved in urban community disaster-mitigation because they just work and live in urban areas provisionally (Zhao et al., 2004; Li et al., 2006; Liu, 2007; San, 2005). This means the development of the community disaster-mitigation infrastructure can increase farmers' post-disaster welfare and encourage former farmers working in cities to come back to their original agricultural communities and be involved in infrastructure developing. Then, the sustainability of agricultural communities will increase.

To sum up, the key problem is stated as follows: Although the infrastructure can improve every farmer's welfare by increasing the post-disaster harvest and developing community culture, it is not economical and efficient for partial farmers to develop the infrastructure without help of others. In other words, this requires collaborative work that also requires the participation and contribution of former farmers working in cities. On the other hand, although the welfare-improvement induced by the infrastructure is attractive to former farmers working in cities, they cannot come back to agricultural communities and take part in the development of the infrastructure because they cannot survive during the process of infrastructure development. So the major question is to figure out how to achieve the collaborative work by making former farmers survive during the process of infrastructure development, if some mechanism is designed based on community.

For improving rural loan supply, RCCs (Rural Credit Cooperatives, the only formal financial institution that supplies farmers with loans in rural China) put into practice the individual and group microcredit loans (without guarantee requirement) in 1996, which have gradually been popularized since 2000 (Kawahara, 2005a). In general, the

amount of the microcredit loan does not exceed the local farmers' average annual income, while the interest rate is decided by each RCC, considering it should be close to the basic interest rate given by the People's Bank of China. The contract term is one year in most cases. In the case where a larger amount is demanded, the group microcredit loan is available with the loan group consists of 3-5 rural households (the People's Bank of China, 2000; the People's Bank of China, 2001).

The group microcredit loan from RCCs has been supplying farmers with necessary funds for post-disaster reconstruction and restoring of production (Chen, 2008; Anhui Rural Credit Cooperative Union, 2007; Zhuang and Wu, 2008). For example, after the earthquake in Sichuan, China on May 12, 2008, Jiulong Rural Credit Cooperative (in Wangcang County, Guangyuan City, Sichuan Province) supplied the affected farmers (who do not have a guarantee) with group loans for after-earthquake reconstruction (Chen, 2008). In order to mitigate the problem with shortage of funds necessary for developing disaster-mitigation infrastructures, some agricultural sectors of rural China started to apply the group loan supplied by RCCs to promote the development of the community-based disaster-mitigation infrastructure (Haiyan Rural Credit Cooperative Union, 2007; Haining Rural Credit Cooperative Union, 2007; Song, 2008; Wang, 2008). For example, in Cangxi County, Sichuan Province, China, RCCs supply farmers with group microcredit loans to support the collaborative development of small farmland water systems (Song, 2008). In general, the collaborative work is operated and managed by a union of households which consist of farmers from the same village or several adjacent villages. Farmers can invest in the collaborative development by way of money or labor. In the whole Cangxi County, based on this kind of mechanism, more than 1700 small farmland water systems have been developed in 2007. And the mechanism, called "Cangxi Mode" is being extended in the whole Sichuan Province, especially the agricultural sectors where the local governments face financial difficulties.

From the above statement, it follows that the group loan from RCCs can help rural disaster victims with disaster risk financing for post-disaster subsistence and disaster mitigation financing. This means farmers can refer themselves to group loans when they face the post-disaster subsistence problem under the situation where they are developing a disaster-mitigation infrastructure. So, with a view to relax the subsistence constraint and motivating collaborative development of infrastructure, let us consider how to make use of group loans in developing the disaster-mitigation infrastructure to improve community-based disaster mitigation and agricultural communities'

sustainability in rural China.

6.2 The model

6.2.1 Model environment

For simplification, a two-period model is constructed in this chapter. There are two farmers: R (skilled) and P (unskilled). Formal loan from RCCs is applicable only if the household can repay it after one-period time. With a disaster, R can survive through two periods, while P has to move to an urbanized area for subsistence. For developing the community-based disaster-mitigation infrastructure, R and P should work together. To help P to survive, R supplies P with internal subsidy. Correspondingly, R will require P to provide some labor for developing the infrastructure. So the internal subsidy here is one kind of inter-linked transaction between consumption and labor in informal financial market. At the same time, as an option, R can choose to obtain a group loan with P or just get an individual loan from RCCs.

6.2.2 Assumptions and mathematical symbols used

(1) Disaster (such as drought) occurs in the middle of each period. This assumption is based on reality. Northwest rural areas in China suffer drought every year (www.news.cn, 2007).
(2) Two farmers: R (skilled) and P (unskilled).
(3) $F_R(l) = \sigma l$: Production function of R in which $\sigma > 1$.
(4) $F_P(l) = l$: Production function of P.

(5) l_{ij} : Labor invested for production by farmer i in period j.

(6) δ : Post-disaster remaining rate of production when there is no any disaster mitigation. $\delta < 1$ That means, in each period, farmer R will get $\delta\sigma l_{Rj}$ and farmer P will get δl_{Pj}.

(7) L : Labor endowment for each farmer in each period, that is assumed to be $L > 1$.
(8) $\bar{c}$: The subsistence constraint for each period (minimum consumption for surviving each period).
(9) Formal loan is applicable only if the household can repay it after one period time.

And it is assumed that RCCs can forecast farmers' ability to repay in the future.

(10) Net interest rate of loan is zero both for individual and group loan.

(11) $\delta L < \bar{c}$: Farmer P needs to borrow $\bar{c} - \delta L$ after disaster in Period 1 because $\delta L < \bar{c}$. However, farmer P cannot repay the loan in Period 2 because $\delta L - (\bar{c} - \delta L)$ (residual money after repaying) $< \bar{c}$ (minimum consumption for surviving each period). So, formal lender (RCCs) does not lend to farmer P in Period 1.

(12) $\delta\sigma L > \bar{c}$: Farmer R can survive each period even if there is no disaster-mitigation infrastructure.

(13) z : The disaster-mitigation infrastructure in the community. z is public goods/service (having non-competitiveness in consumption) such as farm water systems. The community disaster-mitigation infrastructure is developed in period 1 by investing 1 unit of capital and 1 unit of labor, and it will only work in period 2 because developing infrastructure takes time. Under the situation with z, the post-disaster remaining rate of production will increase to δ^z.

(14) $\delta^z L > \bar{c}$: This means that with disaster-mitigation infrastructure, farmer P can make enough production for surviving each period.

(15) $U(c_{i1} + c_{i2}, z) = c_{i1} + c_{i2} + \nu^z$: Farmer i's utility function for two periods. $U(c_{i1} + c_{i2}, z)$ is subject to $c_{i1}, c_{i2} \geq \bar{c}$ and ν^z meaning farmer i's utility-rise because of z. ν^z is assumed to be induced by the community culture which is derived from collaborative work and enjoyed by R and P together in period 2.

(16) $\delta\sigma + 1 > \delta^z\sigma L - \delta\sigma L$: This means it is not economical for R to develop the infrastructure alone.

(17) $\delta(L-1) + \delta^z L < 2\bar{c}$: which means P cannot make the individual loan even if the disaster-mitigation infrastructure is developed in period 2. The assumption is equivalent to $\delta < \dfrac{2\bar{c} - \delta^z L}{L-1}$.

(18) m : Periodical wage in urbanized area where there is no opportunity for former-farmers to enjoy the community disaster-mitigation infrastructure. $m \geq \bar{c}$. That means P can survive if they migrate to cities. Here, we assume $\sigma > \dfrac{m}{\delta L} \Rightarrow 2m < 2\delta\sigma L$, which means R has no motivation to move to a city. Later, for comparative analysis, we will also analyze the case where $\sigma < \dfrac{m}{\delta L} \Rightarrow 2m > 2\delta\sigma L$, which motivates R to move.

6.2.3 Case I: group loan (GL) is not provided

If there is no community disaster-mitigation infrastructure, R consumes his production, while P leaves the community at the beginning of period 1 and lives in an urban area because he knows that he would not be able to survive after a disaster in rural area. Then R's, P's and social welfare will be as follows:

R: W_R (N(no GL), 0(no community infrastructure))=$U(c_{R1}+c_{R2},0)=2\delta\sigma L$; (6.1)

P: W_P (N, 0)= $2m$. (6.2)

$SW(N,0)=2\delta\sigma L+2m$ (6.3)

If farmer R and P decide to develop a community disaster-mitigation infrastructure, R gets 1 unit loan from RCCs at the beginning of period 1 (it should be repaid at the end of period 1) and invests it for the infrastructure. At the same time, R requests P to provide 1 unit labor for the infrastructure by promising to supply P with internal subsidy in the future. After a disaster, R supplies consumption goods, s, to P to let P consume $\bar{c}$ at the end of period 1. For his own subsistence in period 1, R borrows an individual loan, b, from formal lender (RCCs) and repays it in period 2. As for the concrete event sequence, please refer to Fig.6.1.

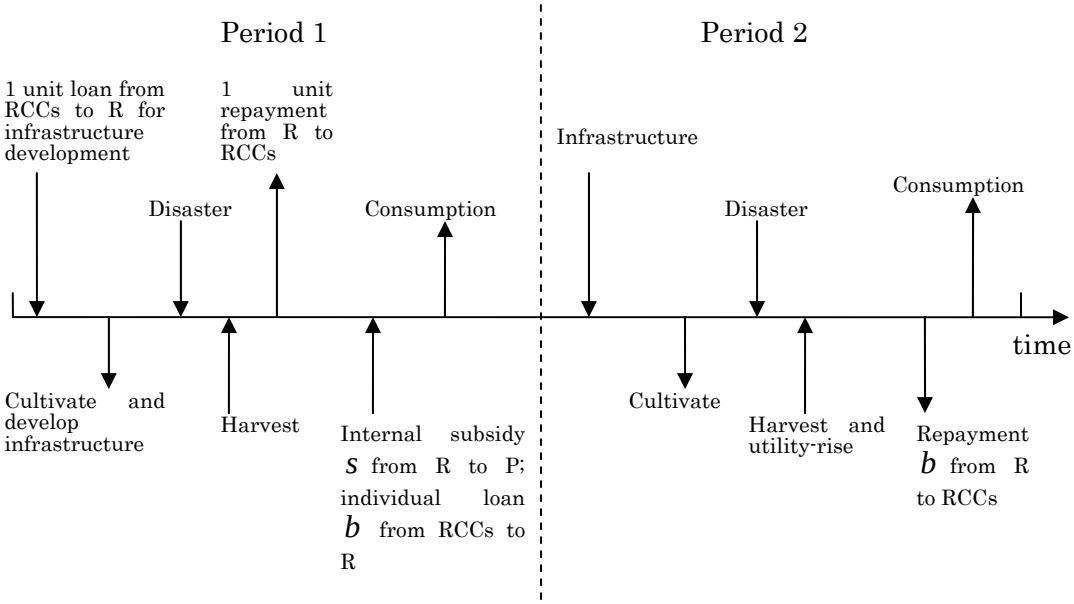

Fig.6.1 Event sequence of Case I

Then R's and P's welfare will be as follows:

R: $W_R(N,z) = \{\delta\sigma L - 1 - s + b\} + \{\delta^z \sigma L - b\} + v^z$ (6.4)

P: $W_P(N,z) = \{\delta(L-1) + s\} + \delta^z L + v^z$ (6.5)

Subject to

$\delta(L-1) + s = \bar{c}$ (subsistence constraint for farmer P in period 1) (6.6)

$\delta\sigma L - 1 - s + b = \bar{c}$ (subsistence constraint for farmer R in period 1) (6.7)

$\delta^z L \geq \bar{c}$ (subsistence constraint for farmer P in period 2) (6.8)

$\delta^z \sigma L - b \geq \bar{c}$ (subsistence constraint for farmer R in period 2-same as the borrowing constraint of farmer R: $b \leq \delta^z \sigma L - \bar{c}$) (6.9)

where

b : the loan of farmer R from formal lender (RCCs)

s : the internal subsidy from R to P

According to the above analysis, the conditions that this case is feasible and Pareto improvement are as follows:

$\delta(L-1) + s = \bar{c}$ (subsistence constraint for farmer P in period 1) (6.6)

$\delta\sigma L - 1 - s + b = \bar{c}$ (subsistence constraint for farmer R in period 1) (6.7)

$\delta^z L \geq \bar{c}$ (subsistence constraint for farmer P in period 2) (6.8)

$\delta^z \sigma L - b \geq \bar{c}$ (subsistence constraint for farmer R in period 2) (6.9)

$W_R(N,z) > W_R(N,0) \Rightarrow \delta\sigma L + \delta^z \sigma L - 1 - s + v^z > 2\delta\sigma L$ (6.10)

$W_P(N,z) > W_P(N,0) \Rightarrow \delta(L-1) + s + \delta^z L + v^z > 2m$ (6.11)

where formula (6.10) and (6.11) make sure there is Pareto improvement.

Based on the above conditions, the following deduction can be obtained:

Formula (6.6) $\Rightarrow$ $s = \bar{c} - \delta(L-1)$ (6.12)

Formula (6.7) and (6.12) $\Rightarrow$ $b = 2\bar{c} + 1 - \delta[\sigma L + (L-1)]$ (6.13)

If $\sigma < \dfrac{2\bar{c} + 1 - \delta(L-1)}{\delta L}$, b is positive; otherwise, b is negative, which means R can save part of their income for the next period.

Assumption 14) makes (6.8) always true.

Now (6.9) is the critical condition that represents the borrowing constraint in the individual loan, which is with (6.13) transformed into

$$\sigma \geq \frac{3\bar{c} + 1 - \delta(L-1)}{\delta L + \delta^z L} \tag{6.14}$$

Formula (6.10) and (6.12) $\Rightarrow$ $v^z > \delta[\sigma L - (L-1)] + \bar{c} + 1 - \delta^z \sigma L$ (6.15)

Formula (6.11) and (6.12) $\Rightarrow$ $v^z > 2m - \bar{c} - \delta^z L$ (6.16)

The above deduction can be concluded as follows:

The conditions for R and P's subsistence constraint (survival of the community) are given as follows.

$$s = \bar{c} - \delta(L-1) = s_1^* \tag{6.12}$$

$$b = 2\bar{c} + 1 - \delta[\sigma L + (L-1)] = b^* \tag{6.13}$$

$$\sigma \geq \frac{3\bar{c} + 1 - \delta(L-1)}{\delta L + \delta^z L} = \sigma_1^* \tag{6.14}$$

The conditions for Pareto improvement are derived as follows:

Let $\sigma_1^{**} = \dfrac{\delta^z L + 2\bar{c} + 1 - 2m - \delta(L-1)}{\delta^z L - \delta L}$ (6.17)

When $\sigma \leq \sigma_1^{**}$, we have $\delta[\sigma L - (L-1)] + \bar{c} + 1 - \delta^z \sigma L \geq 2m - \bar{c} - \delta^z L$. This means we

only need $v^z > \delta[\sigma L-(L-1)]+\bar{c}+1-\delta^z\sigma L$ to guarantee Pareto improvement. Similarly, we only need $v^z > 2m-\bar{c}-\delta^z L$ to guarantee Pareto improvement when $\sigma > \sigma_1^{**}$. We can conclude the condition for Pareto improvement as follows:

$$v^z > v_1^{z^*}(\sigma) = \begin{cases} \delta[\sigma L-(L-1)]+\bar{c}+1-\delta^z\sigma L & if \quad \sigma \le \sigma_1^{**} \\ 2m-\bar{c}-\delta^z L & if \quad \sigma > \sigma_1^{**} \end{cases} \tag{6.18}$$

Based on formula (6.14) and (6.18), it follows that Pareto improvement can be realized and the community disaster-mitigation infrastructure will be developed if and only if $\sigma \ge \sigma_1^*$ and $v^z > v_1^{z^*}$. $\sigma \ge \sigma_1^*$ guarantees that R and P can survive period 2 in the case of supplying P with internal subsidy in period 1 and repaying the loan to RCCs in period 2. And $v^z > v_1^{z^*}$ guarantees that R's and P's utilities will be increased after the infrastructure development. With the development of the infrastructure, R's two-period utility in the agricultural community will increase. Similarly, with the development of the infrastructure, the two-period utility P can get in the agricultural community will be larger than that in an urbanized area, and P would like to come back to agricultural communities. R and P both are motivated to do collaborative development for the infrastructure. In a word, $\sigma \ge \sigma_1^*$ guarantees that the community has the ability (R can supply P with internal subsidy to help him survive period 1) to preserve the infrastructure, and $v^z > v_1^{z^*}$ guarantees that R and P have the incentives to develop the infrastructure. Then, with the development of the infrastructure, one obtains R's welfare, P's welfare and social welfare, respectively as follows:

$$W_R(N,z) = \delta[\sigma L+(L-1)]+\delta^z\sigma L-1-\bar{c}+v^z \tag{6.19}$$

$$W_P(N,z) = \delta^z L+\bar{c}+v^z \tag{6.20}$$

$$SW(N,z) = W_R(N,z)+W_P(N,z) = \delta[\sigma L+(L-1)]+\delta^z(\sigma L+L)-1+2v^z \tag{6.21}$$

where

$$\sigma \geq \sigma_1^* \tag{6.22}$$

$$v^z > v_1^{z^*} \tag{6.23}$$

6.2.4 Case II: group loan (GL) is provided

In this case, R borrows 1 unit loan (it should be repaid at the end of period 1) from RCCs and invests it for the infrastructure at the beginning of period 1. At the same time, R requests P to provide 1 unit of labor for infrastructure by promising to supply P with internal subsidy in the future. As for subsistence in period 1, R and P borrow the group loan, $B = b_R + b_P$ (b_R for R and b_P for P), from RCCs. b_R is just enough to make sure R can consume $\bar{c}$ in period 1. Similarly, b_P is just enough to make sure P can consume $\bar{c}$ in period 1. And in period 2, after repaying the group loan to RCCs, R supplies P with internal subsidy, s, to let P consume $\bar{c}$ in period 2. As for the concrete event sequence, please refer to Fig.6.2.

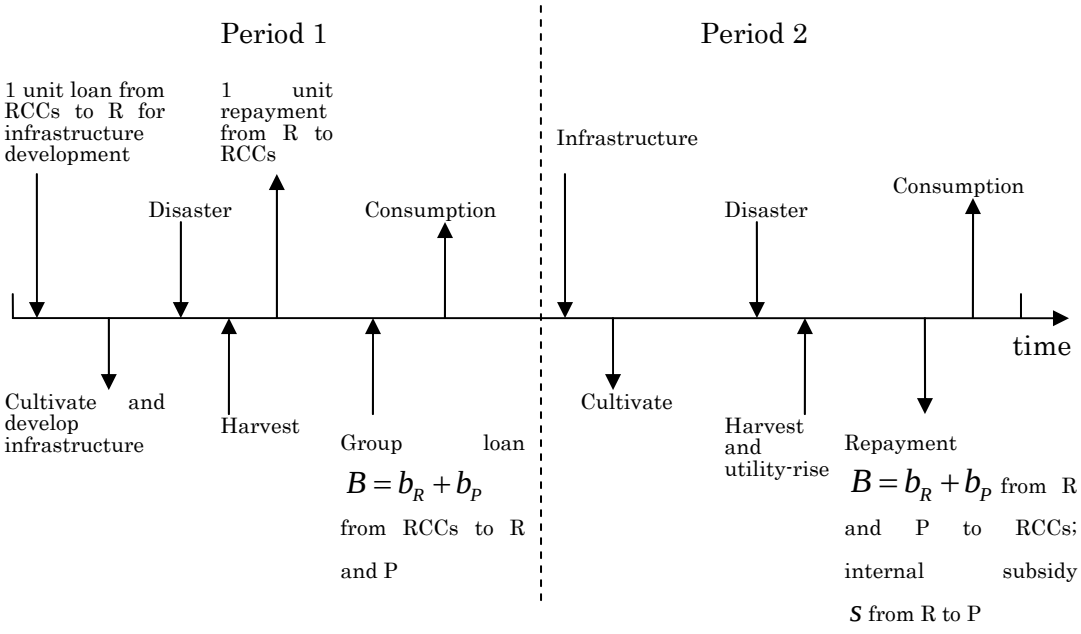

Fig.6.2 Event sequence of Case II

Then R's and P's utilities are as follows:

R: $W_R(G,z) = \{\delta\sigma L - 1 + b_R\} + \{\delta^z \sigma L - b_R - s\} + v^z$ (6.24)

P: $W_P(G,z) = \{\delta(L-1) + b_P\} + \{\delta^z L - b_P + s\} + v^z$ (6.25)

Subject to

$\delta(L-1) + b_P = \bar{c}$ (subsistence constraint for farmer P in period 1) (6.26)

$\delta\sigma L - 1 + b_R = \bar{c}$ (subsistence constraint for farmer R in period 1) (6.27)

$\delta^z L - b_P + s = \bar{c}$ (subsistence constraint for farmer P in period 2) (6.28)

$\delta^z \sigma L - b_R - s \geq \bar{c}$ (subsistence constraint for farmer R in period 2) (6.29)

where

b_R : the loan of farmer R from the formal lender (RCCs)

b_P : the loan of farmer P from the formal lender (RCCs)

The combination of the last two constraints equals the borrowing constraint of the community:

$b_R + b_P \leq \delta^z(\sigma L + L) - 2\bar{c}$ (6.30)

which means the total production net of the minimum consumption in period 2 is larger than the repayment of the loan.

According to variable assumptions and the above analysis, the conditions that this case is feasible and Pareto improvement are as follows.

$\delta(L-1) + b_P = \bar{c}$ (subsistence constraint for farmer P in period 1) (6.26)

$\delta\sigma L - 1 + b_R = \bar{c}$ (subsistence constraint for farmer R in period 1) (6.27)

$\delta^z L - b_P + s = \bar{c}$ (subsistence constraint for farmer P in period 2) (6.28)

$\delta^z \sigma L - b_R - s \geq \bar{c}$ (subsistence constraint for farmer R in period 2) (6.29)

$W_R(G,z) > W_R(N,0) \Rightarrow \delta\sigma L + \delta^z \sigma L - 1 - s + \nu^z > 2\delta\sigma L$ (6.31)

$W_P(G,z) > W_P(N,0) \Rightarrow \delta(L-1) + s + \delta^z L + \nu^z > 2m$ (6.32)

where formula (6.31) and (6.32) make sure there is Pareto improvement.

Based on the above conditions, the following deduction can be obtained:

Formula (6.26) $\Rightarrow$ $b_P = \bar{c} - \delta(L-1)$ (6.33)

Formula (6.27) $\Rightarrow$ $b_R = \bar{c} + 1 - \delta\sigma L$ (6.34)

If $\sigma < \frac{\bar{c}+1}{\delta L}$, b_R is positive; otherwise, b_R is negative, which means R can save in period 1 either for his consumption or the fund for internal subsidy to P in period 2.

Formula (6.28) and (6.33) $\Rightarrow$ $s = 2\bar{c} - \delta^z L - \delta(L-1)$ (6.35)

From assumption 17) s is positive, meaning P needs the internal subsidy from R.

Now, by substituting (6.34) and (6.35) into the borrowing constraint for the group loan, (6.30), we get

$$\sigma \geq \frac{4\bar{c} + 1 - \delta^z L - \delta(L-1)}{\delta L + \delta^z L} \quad (6.36)$$

Formula (6.31) and (6.35) $\Rightarrow$ $\nu^z > 2\bar{c} + 1 + \delta[\sigma L - (L-1)] - \delta^z(\sigma L + L)$ (6.37)

Formula (6.32) and (6.35) $\Rightarrow$ $\nu^z > 2m - 2\bar{c}$ (6.38)

The above deduction can be concluded as follows:

The conditions for R and P's subsistence constraint (survival of the community) are

derived as follows:

$$s = 2\bar{c} - \delta^z L - \delta(L-1) = s_2^* \tag{6.35}$$

$$B = b_R + b_P = 2\bar{c} + 1 - \delta[\sigma L + (L-1)] = B^* \tag{6.39}$$

$$\sigma \geq \frac{4\bar{c} + 1 - \delta^z L - \delta(L-1)}{\delta L + \delta^z L} = \sigma_2^* \tag{6.36}$$

The conditions for Pareto improvement are derived as follows:

$$\text{Let } \sigma_2^{**} = \frac{4\bar{c} + 1 - 2m - \delta(L-1) - \delta^z L}{\delta^z L - \delta L} \tag{6.40}$$

When $\sigma \leq \sigma_2^{**}$, we have $2\bar{c} + 1 + \delta[\sigma L - (L-1)] - \delta^z(\sigma L + L) \geq 2m - 2\bar{c}$. This means that we just need $\nu^z > 2\bar{c} + 1 + \delta[\sigma L - (L-1)] - \delta^z(\sigma L + L)$ to guarantee Pareto improvement. Similarly, we just need $\nu^z > 2m - 2\bar{c}$ to guarantee Pareto improvement when $\sigma > \sigma_2^{**}$. We can conclude the condition for Pareto improvement as follows:

$$\nu^z > \nu_2^{z^*}(\sigma) = \begin{cases} 2\bar{c} + 1 + \delta[\sigma L - (L-1)] - \delta^z(\sigma L + L) & \text{if} \quad \sigma \leq \sigma_2^{**} \\ 2m - 2\bar{c} & \text{if} \quad \sigma > \sigma_2^{**} \end{cases} \tag{6.41}$$

Pareto improvement can be realized and the community disaster-mitigation infrastructure will be developed if and only if $\sigma \geq \sigma_2^*$ and $\nu^z > \nu_2^{z^*}$. Similarly as in case I, $\sigma \geq \sigma_2^*$ makes sure the community has the ability to get the group loan for subsistence and preserving the infrastructure, and $\nu^z > \nu_2^{z^*}$ makes sure R and P have the incentives to develop the infrastructure. Then, R's welfare, P's welfare and social welfare will be

$$W_R(G,z)=\delta[\sigma L+(L-1)]+\delta^z(\sigma L+L)-1-2\bar{c}+\nu^z \tag{6.42}$$

$$W_P(G,z)=2\bar{c}+\nu^z \tag{6.43}$$

$$SW(G,z)=W_R(G,z)+W_P(G,z)=\delta[\sigma L+(L-1)]+\delta^z(\sigma L+L)-1+2\nu^z \tag{6.44}$$

where

$$\sigma \geq \sigma_2^* \tag{6.45}$$

$$\nu^z > \nu_2^{z^*} \tag{6.46}$$

6.2.5 Comparative Analysis

For comparing case I and II, I additionally define the following value.

(1) Let $\sigma^{***}=\dfrac{3\bar{c}+1-2m-\delta(L-1)}{\delta^z L-\delta L}$ (6.47)

(2) Based on the assumption $\bar{c}<\delta^z L$, we have $\sigma_2^*<\sigma_1^*$ and $\sigma_2^{**}<\sigma^{***}<\sigma_1^{**}$. For simplification, we assume $\dfrac{m}{\delta L}<\sigma_2^*$, $\sigma_1^*<\sigma_2^{**}$ and $\sigma_1^{**}<\dfrac{1}{\delta^z L-\delta(L+1)}$.

Considering the consistency of the above additional assumptions and those in section 6.2.2 (variable assumptions), the concrete values of parameters are set down as follows.

$\bar{c}$=6.088; δ=0.806; L=7.196; δ^z=0.92; m=6.088

And the range of σ should be $\dfrac{m}{\delta L}<\sigma<\dfrac{1}{\delta^z L-\delta(L+1)}$.

According to the above settings, we can get the following numerical values of endogenous variables.

σ_1^* =1.149; σ_1^{**} =3.202; σ_2^* =1.106; σ_2^{**} =1.904; σ^{***} =2.553; $\frac{m}{\delta L}$ =1.05; $\frac{1}{\delta^z L-\delta(L+1)}$=69.716; s_1^*=1.094; s_2^*=0.562

Please refer to Fig.6.3 for the results of the comparative analysis.

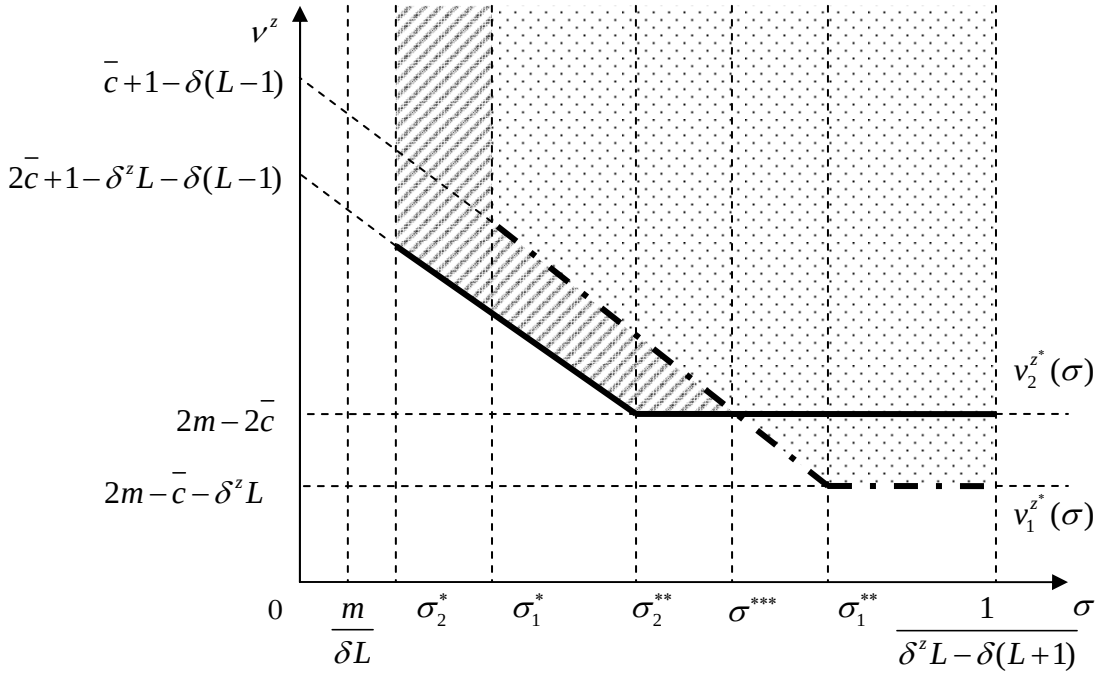

Fig.6.3 Results of the comparative analysis between case I and II ($\sigma > \frac{m}{\delta L}$)

In Fig.6.3, the bold line is decided by formula (6.18) and the slope of oblique part is $\delta L-\delta^z L$. And the bold and dashed line is decided by formula (6.41) and the slope of oblique part is also $\delta L-\delta^z L$. Within the area filled with dots and oblique lines, Pareto improvement will be realized and infrastructure will be developed. That means, within that area, P will come back to agricultural sectors and community's sustainability will be increased. Concretely, the area filled with dots stands for the case in which there is no group loan. Within that area, we have $\sigma \geq \sigma_1^*$ and $v^z > v_1^{z^*}$. The community has the ability and incentive to do collaborative development of the community-based disaster-mitigation infrastructure, and the community's sustainability will increase. And the area beyond bold line stands for the case in which there is a group loan. Within

that area, we have $\sigma \geq \sigma_2^*$ and $v^z > v_2^{z^*}$. In that area, with the group loan, the community has the ability and incentive to do collaborative development of the community-based disaster-mitigation infrastructure, and the community's sustainability will increase. Obviously, when the local production level is relatively low ($\sigma < \sigma^{***}$), the application of group loans can expand the possibility for the development of the disaster-mitigation infrastructure, and for Pareto improvement and the sustainable community. The increased possibility is the area filled with oblique lines.

Additionally, from comparative analysis, we have the following results.

(1) $s_1^* > s_2^*$

That means the application of the group loan can decrease P's dependence on R. With group loan, P can also get the loan from RCCs in period 1 after disaster. That means, with the application of group loan, the occasion when R should supply P with internal subsidy changes from period 1 to period 2. And in period 2, with the infrastructure, P's post-disaster production gets increased compared with that in period 1. Correspondingly, P's demand for subsidy in period 2 will get decreased compared with that in period 1.

(2) $b^* = B^*$

That means the application of the group loan will not change community's loan demand. The design of group loan just changed the way to allocate loan among the community. Without group loan, RCCs just supply R with loan. And with group loan, RCCs also supply P with loan. That change in allocation will not change whole community's demand for loan to make sure R and P both survive period 1 after disaster without community disaster-mitigation infrastructure.

Since now, we start to study the situation where the monetary income in urban areas is larger even for R. That means $2m^\circ > 2\delta\sigma L \Rightarrow \sigma < \frac{m^\circ}{\delta L}$ and R has the motivation to move to the city. Correspondingly, in case I, the condition for Pareto improvement changed to be as below.

$$v^z > v_1^{z^{*^\circ}}(\sigma) = \begin{cases} 2m^\circ + \bar{c} + 1 - \delta^z \sigma L - \delta[\sigma L + (L-1)] & if \quad \sigma \leq \sigma_1^{**^\circ} \\ 2m^\circ - \bar{c} - \delta^z L & if \quad \sigma > \sigma_1^{**^\circ} \end{cases} \tag{6.48}$$

where

$$\sigma_1^{**^\circ} = \frac{2\bar{c} + 1 + \delta^z L - \delta(L-1)}{\delta^z L + \delta L} \tag{6.49}$$

And in case II, the condition for Pareto improvement changed to be as below.

$$\nu^z > \nu_2^{z^*}(\sigma) = \begin{cases} 2m^\circ + \bar{c} + 1 - \delta[\sigma L + (L-1)] - \delta^z(\sigma L + L) & if \quad \sigma \le \sigma_2^{**^\circ} \\ 2m^\circ - 2\bar{c} & if \quad \sigma > \sigma_2^{**^\circ} \end{cases} \tag{6.50}$$

where

$$\sigma_2^{**^\circ} = \frac{3\bar{c} + 1 - \delta^z L - \delta(L-1)}{\delta^z L + \delta L} \tag{6.51}$$

Additionally, there is no change on σ_1^*, σ_2^*, s_1^*, s_2^*, b^* and B^*.

For comparative analysis, the following additional assumptions are made:

(1) Let $\sigma^{***^\circ} = \frac{3\bar{c} + 1 - \delta(L-1)}{\delta^z L + \delta L}$ (6.52)

(2) Because of the assumption of $\bar{c} < \delta^z L$, we have $\sigma_2^{**^\circ} < \sigma_2^* < \sigma_1^* = \sigma^{***^\circ} < \sigma_1^{**^\circ}$. For simplification, we assume $\sigma_1^{**^\circ} < \frac{m^\circ}{\delta L} < \frac{1}{\delta^z L - \delta(L+1)}$.

Considering the consistency, we let m° equal 20. And the range of σ should be $\frac{\bar{c}}{\delta L} < \sigma < \frac{m^\circ}{\delta L}$.

According to the above settings, we can get the following numerical values of endogenous variables.

$\sigma_1^{**^\circ}$ =1.192; $\sigma_2^{**^\circ}$ =0.616; σ^{***° =1.149; $\frac{\bar{c}}{\delta L}$ =1.05; $\frac{m^\circ}{\delta L}$ =3.448

Please refer to Fig.6.4 for the results of the comparative analysis.

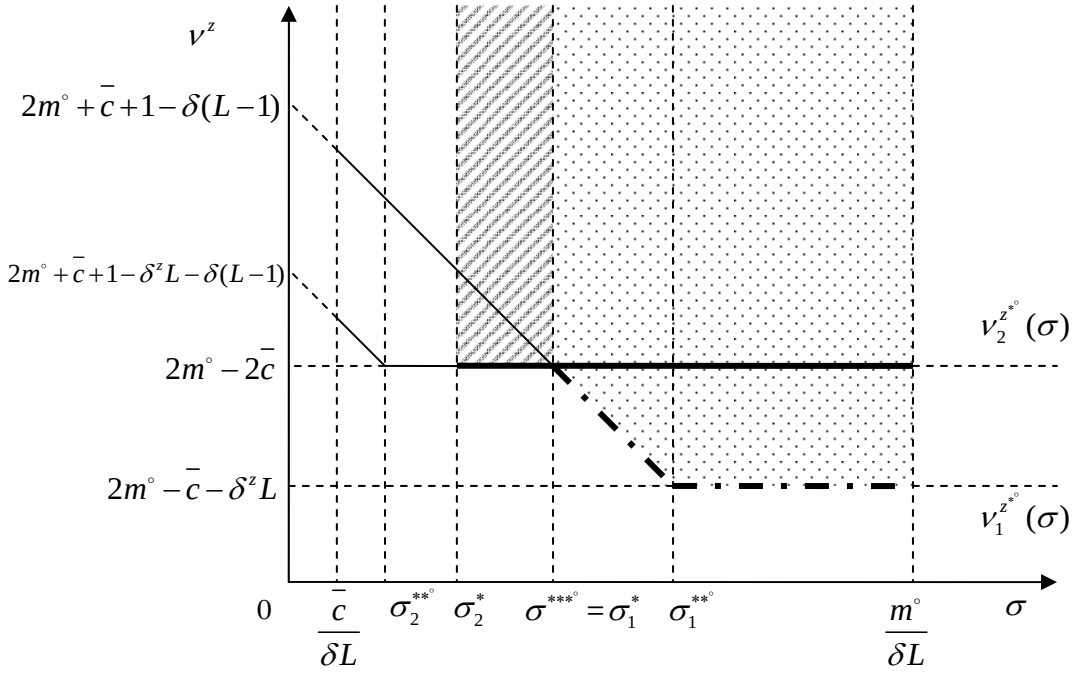

Fig.6.4 Results of comparative analysis between case I and II ($\sigma < \frac{m^\circ}{\delta L}$)

In Fig.6.4, the bold and dashed line is decided by formula (6.48) and the slope of oblique part is $-\delta L-\delta^z L$. And the bold line is decided by formula (6.50). Within the area filled with dots and oblique lines, Pareto improvement will be realized and infrastructure will be developed. That means, within that area, P will come back to agricultural sectors and community's sustainability will be increased. Concretely, the area filled with dots stands for the case in which there is no group loan. Within that area, we have $\sigma \geq \sigma_1^*$ and $v^z > v_1^{z^{*\circ}}$. The community has the ability and incentive to do collaborative development of the community-based disaster-mitigation infrastructure, and the community's sustainability will increase. And the area beyond the bold line stands for the case in which there is a group loan. Within that area, we have $\sigma \geq \sigma_2^*$ and

$v^z > v_2^{z^*}$. The community has the ability and incentive to do collaborative development of the community-based disaster-mitigation infrastructure and the community's sustainability will increase. Obviously, when the local production level is relatively low ($\sigma < \sigma^{***^\circ}$), the application of the group loan can expand the possibility for the development of the disaster-mitigation infrastructure, and for Pareto improvement and the sustainable community. The increased possibility is the area filled with oblique lines.

Similarly with the comparative analysis when $\sigma > \frac{m}{\delta L}$, we have the following additional results.

(1) $s_1^* > s_2^*$

(2) $b^* = B^*$

According to the above parameters setting, we have

$$\frac{\bar{c}}{\delta L} = \frac{m}{\delta L} < \sigma_2^{**^\circ} < \sigma_2^* < \sigma_1^* = \sigma^{***^\circ} < \sigma_1^{**^\circ} < \sigma_2^{**} < \sigma^{***} < \sigma_1^{**} < \frac{m^\circ}{\delta L} < \frac{1}{\delta^z L - \delta(L+1)} \quad (6.53)$$

$$2m^\circ - \bar{c} - \delta^z L > v_2^{z^*}(\sigma_2^*) \quad (6.54)$$

Based on formula (6.53) and (6.54), we put Fig.6.3 and Fig.6.4 together to get Fig.6.5 to compare the situation in which there is no motivation for R to move to the city with the situation where R has the incentive to migrate. Here, we suppose $\sigma < \frac{m^\circ}{\delta L}$. If $\sigma > \frac{m^\circ}{\delta L}$, R does not have motivation to move. Then it is not necessary to do comparative analysis.

In Fig.6.5, the area filled with dots stands for the case where the periodical wage in the urbanized area is high ($m^\circ > \sigma\delta L$), Pareto improvement can be realized, infrastructure will be developed, and the agricultural community is sustainable. And the area filled with dots and oblique lines stands for the case where the periodical wage in the urbanized area is low ($m < \sigma\delta L$), Pareto improvement can be realized, infrastructure

will be developed, and the agricultural community is sustainable. Obviously, high periodical wage in cities will decrease the possibility for a sustainable community. The area filled with oblique lines is the decreased amount. Furthermore, the higher wage level will induce less possibility of the sustainable community because the bold and dashed line in Fig.6.5 will rise, and the area filled with oblique lines will increase.

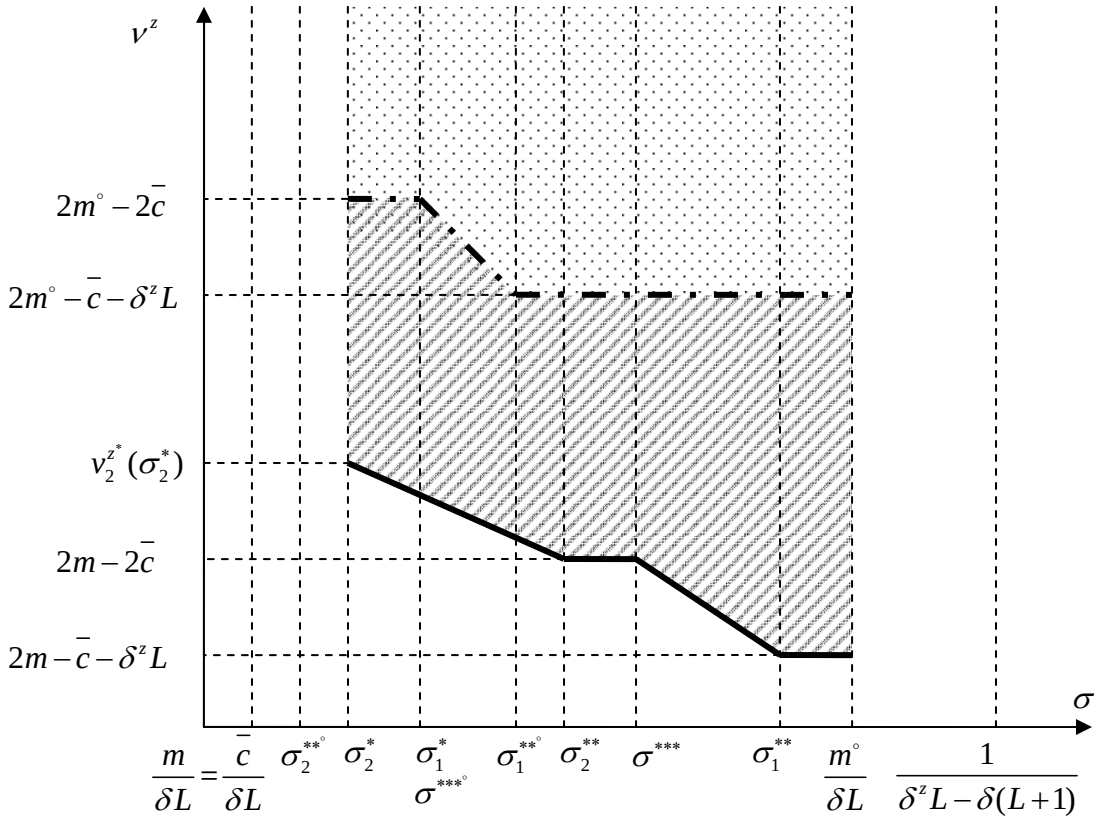

Fig.6.5 Comparative analysis between high-wage and low-wage situations

6.3 Conclusions

In this chapter, with a view to relax the subsistence constraint and promoting collaborative action among farmers, how to introduce the group loan in the community-based disaster-mitigation infrastructure development in rural China has been discussed. Besides making the comparative analysis between non-group-loan and group-loan cases, we have also studied the situation where the periodical wage in the urbanized area is high enough to motivate skilled farmers to migrate. The following findings as well as policy implications have been derived:

(1) With the community-based disaster-mitigation infrastructure, the farmers' welfare will increase because of the increased post-disaster harvest and utility-rise induced by the community culture which is derived from collaborative work and involvement in the infrastructure development. This will attract former farmers working in cities to come back to their original rural sectors, making agricultural communities more sustainable. But here arise two major obstacles for the community-based disaster-mitigation infrastructure development in rural China: (i) subsistence constraint; (ii) welfare difference between rural and urban areas. The former makes agricultural communities unable to develop the infrastructure. And the latter makes farmers (at least partially) not motivated to be involved in the collaborative development of the infrastructure.

(2) Under the situation where R and P decide to develop the community-based disaster-mitigation infrastructure, the application of group loans can decrease P's dependence on R. With the group loan, P can also get the loan from RCCs in period 1 after a disaster. That means, with the application of group loans, the occasion when R should supply P with internal subsidy changes from period 1 to period 2. And in period 2, with the infrastructure, P's post-disaster harvest gets increases compared with that in period 1. Correspondingly, P's demand for subsidy in period 2 decreases compared with that in period 1. This positive effect induced by the application of the group loan can expand the possibility for the development of the disaster-mitigation infrastructure. In other words, the application of the group loan can make the collaborative development of the disaster-mitigation infrastructure also work in the rural areas where the community's ability to supply internal subsidy is relatively low. For example, the northwest rural areas of China are suffering poverty and drought at the same time. We can motivate local RCCs to carry out group loans, considering collaborative development of farm water systems correspondingly.

(3) The application of the group loan will not increase the community's loan demand. In other words, there will not be extra pressure on RCCs to supply much more loan to farmers when RCCs carry out group loan among agricultural communities to promote collaborative development of infrastructure. The design of group loans just changes the way to allocate loans among the community. Without the group loan, RCCs simply supply R with a loan. And with the group loan, RCCs also supply P with a loan. This change in allocation will not change the whole community's demand for loans that are necessary to make sure R and P both survive period 1 after a disaster without a community disaster-mitigation infrastructure. This is good news for rural development

because the present loan supply in rural China is far from enough. If this idea of developing infrastructure by applying group loans induces an extra loan demand in rural China, it will become less practical.

(4) When the local agricultural production level is relatively low, the application of the group loan can expand the possibility for the development of the disaster-mitigation infrastructure, and for Pareto improvement and the sustainable community. Firstly, the application of the group loan will decrease the requirement on the community's ability (R's production level, σ, will decide if R can get a large enough loan from RCCs to make sure the whole community (including R and P) survives period 1) to implement the collaborative development of the infrastructure. Secondly, the application of the group loan can reduce the minimum amount of utility-rise for farmers (including R and P) to obtain enough incentives to achieve the collaborative development of the infrastructure. Definitely, this positive effect induced by the group loan can make the idea of the collaborative infrastructure development suitable for more rural areas, especially the relatively undeveloped agricultural communities located in middle and western China. This can be very meaningful for Chinese rural development and even the development of all of China because Chinese current guideline for development is to strengthen economy development in the middle and western areas of the country. The development in these areas depends very much on rural development because agricultural communities are the main part there. Obviously, developing the disaster-mitigation infrastructure by applying group loans can accelerate local rural development over there by improving agricultural communities' sustainability and ability to prevent and mitigate disaster.

(5) The level of periodical wage in urbanized areas will not affect the requirement on the community's ability (R's production level, σ, that will decide R can get a large enough loan from RCCs to make sure the whole community (including R and P) survive period 1) to implement the collaborative development of the infrastructure. That means the local agricultural production level is the pivotal factor for applying the group loan to promote the collaborative development of the infrastructure in agricultural communities. In some senses, this will give encouragement to those agricultural communities located in relatively undeveloped provinces where urban areas cannot support rural areas in terms of development. Again, that is good news for rural development in the middle and western areas of China where the whole economy is relatively undeveloped and agriculture and agricultural production cannot get much support from industry and

cities.

(6) The high wage level in the cities will decrease the possibility for the development of the disaster-mitigation infrastructure, and for Pareto improvement and the sustainable community. Former farmers working in urbanized areas will ask more utility-rise induced by the community culture which is derived from collaborative work to be incentives for coming back to agricultural communities and joining in the collaborative development of the infrastructure when their income in cities increases. Additionally, skilled farmers will also migrate to cities if the wage level in cities is high enough. This will make it more difficult to attract enough farmers back to agricultural communities to do the collaborative development of the infrastructure. Furthermore, too much migration from rural areas to cities induced by large income differences will damage the local agricultural production ability and worsen the situation of farmland occupied by urban construction. This will decrease the local agricultural production level and deteriorate the rural ecological environment. Rural communities' ability to do disaster mitigation will become worse and worse, which is not good for rural development and agricultural communities' sustainability. This requires the government to carry out some practical and efficient macro-policies to reduce income differences between rural areas and cities. This will help to implement the mechanism of developing the community-based disaster-mitigation infrastructure with group loans or other efficient idea to improve agricultural communities' sustainability and ability of disaster mitigation in the future.

(7) The utility-rise, v^z, induced by the community culture, which is derived from collaborative work and enjoyed by farmers together, is very important to reduce the welfare difference between rural and urban areas and give farmers enough motivation to be involved in the collaborative development of the disaster-mitigation infrastructure. If there is no v^z and farmers only care about monetary income, even R will become more inclined to migrate to an urbanized area when the income in cities is relatively high. Then the collaborative infrastructure development based on the group loan will not be carried out, and the advantage of the group loan in motivating the collaborative infrastructure development will not make sense. As one kind of revised institution, the application of the group loan in improving the disaster-mitigation infrastructure needs to be combined with the developing community-based culture (such as mutual aid, special care for disadvantaged groups, and mutual enlightenment or comfort that will increase farmers' post-disaster utility) to make collaborative infrastructure

development more beneficial, attractive, practical, efficient, and obtainable. And in general, this kind of community culture is based on local interpersonal relationships or traditional functions. This means adequate attention should be given to improving and extending local conventional culture or functions when applying some innovative ideas to improve the community disaster-mitigation infrastructure. In other words, the complement between revised institutions and traditional functions is important and meaningful for disaster risk management in agricultural sectors of China.

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Chapter 7 Conclusions

7.1 Summary of research outcomes

This thesis has studied how new institutions and conventional mechanisms provided by community and traders in a regional economy can be effectively combined to cope with disasters in Chinese agricultural communities. The major findings of each chapter are as follows:

In Chapter 1, the background, objectives and structure of this thesis have been discussed. It was pointed out that with the rapid increase and growing seriousness of disaster-caused losses in rural China, more and more attention needs to be paid to disaster prevention and mitigation in agricultural communities of China. As far as disaster risk financing, such as disaster mitigation financing and disaster risk transfer, is concerned, it is important to examine how new institutions and conventional mechanisms provided by the community and local traders in a regional economy can be effectively combined to cope with disasters. In this chapter, the following items have been identified, and the structure of this study has been described accordingly:

(1) Why normal commercial insurance does not work in Chinese agricultural communities.

(2) How to finance disaster risk and increase farmers' welfare by integrating microcredit systems, informal financial sectors, and transaction of farmland management right.

(3) How to improve farmers' awareness, motivation and ability to prevent and mitigate disasters by combining RCCs' institutional reform.

(4) How to improve the sustainability of agricultural communities and increase farmers' welfare through the collaborative development of the disaster-mitigation infrastructure based on group loans.

In Chapter 2, the status of policy, practice and research works regarding disaster risk management in Chinese agricultural communities has been reviewed with a focus on community-based disaster risk financing. Because of its necessity and significance for mitigating rural poverty induced by natural disasters and promoting China's reform,

opening-up, and modernization, this study has focused on rural disaster mitigation financing and disaster risk transfer at the community level. It is true that financial services at the community level are very important for disaster risk financing in Chinese agricultural communities. However, there is a big lack of concrete mechanisms and theoretical analysis of how to improve disaster risk transfer and disaster-mitigation infrastructure development with financial services based on the traditional functions and revised institutions of local communities. Thus, this chapter has given an overview of related realities in rural China such as the circulation of the management right of farmland that diversifies disaster risk among farmers; the development of informal financial sectors that supply farmers with complementary disaster risk financing; and RCCs' realities and institutional reformation that focuses on improving RCCs' commercial sustainability. Based on the above realities, it has been formulated and studied how to concretely carry out community-based disaster risk financing in rural China through efficiently combining informal financial sectors, institutional reformation of Rural Credit Cooperatives (RCCs), transaction of farmland management right, group loan supplied by RCCs and so on.

In Chapter 3, the barriers to insuring against disaster in rural China have been studied by focusing on the micro structure of households' insurance behavior. Although it is not the primary function of saving, it has been found that farmers prefer preparing disaster risk by saving. First, the following rational reasons have been listed in relation to subsistence problems, liquidity constraint, and insurance's indivisibility.

(1) If they spend money on insurance, farmers cannot buy enough food and will surely die from hunger. In general, disaster insurance is indivisible and the premium is not affordable for farmers.

(2) People face not only disaster risk but other risks such as disease, famine, traffic accidents and so on. Disaster insurance is not attractive because it only insures disaster risk, which is not prioritized by most farmers.

In order to improve disaster risk financing in rural China by overcoming the above difficulties, the following measurements have been proposed:

(1) Liquidity constraint should be relaxed so as to make loans more available for farmers in the post-disaster recovery process. Pledge, such as household assets, should

be evaluated more precisely and transacted in more efficient ways in the market.

(2) "Market Inter-linkage" should be expanded to increase farmers' coping capacities for disaster risk financing, and governments should consider their role explicitly in disaster policies. Informal lenders who have other main occupations, such as landlords, entrepreneurs and traders, can take an important role in disaster risk financing since they have a long-term relationship with farmers, which mitigates the problems, such as adverse selection and moral hazard, caused by asymmetric information. Additionally, this kind of interlinked transaction could be applied in the community-based development of disaster-mitigation infrastructures.

(3) Applying the idea of a microcredit system, group purchasing of insurance might be effective in some situations. Another way is to collect farmers' micro idle money together based on some kind of credit cooperative (such as Rural Credit Cooperatives (RCCs) in rural China) and to invest in capital market with adequate financial risk management.

In Chapter 4, the risk management models for the agricultural communities of China have been developed to describe the following structures:

(1) The circulation of the right to farmland contractual management will make the risk exposure and disaster mitigation effort more homogeneous among the farmers.

(2) For that reason, the ability of RCCs as well as that of the informal financing sectors to manage risk is increased, resulting in a decrease in the risk premium included in the interest of the loan. Correspondingly, farmers' welfare will be increased.

(3) Moreover, by involving the informal financial sectors as a stakeholder who can monitor the farmers' condition with low cost due to long-term relationships, the farmers are less motivated to go into moral hazard in risk mitigation. Thus, the social optimal welfare is achieved in the decentralized market.

In that sense, in disaster risk financing in Chinese agricultural communities, there is some complementary functioning between the microcredit system that leaves some roles for informal financial sectors and the liquidation of the farmland management right.

In Chapter 5, it has been studied how to improve Chinese agricultural communities' financial ability against disaster risk by increasing RCCs' sustainability and farmers' welfare through promoting farmers' efficient participation in RCCs' management and operation. Here efficient participation has two aspects:

(1) Comprehensive understanding of RCCs' new operation mechanism.

(2) Full ability to decide RCCs' loan allocation between different investments.

Farmers' long-run benefit depends on RCCs' sustainability, which is decided by the following factors:

(1) Repayment rate, which is determined by farmers' disaster mitigation effort.

(2) Profit rate which depends on RCCs' loan allocation among agricultural loan, safe investment and risky investment.

Without enough knowledge about RCCs' management, farmers will not make adequate disaster mitigation effort and without the supervision from RCCs' members (farmers), RCCs' staff will not have enough motivation to achieve efficient loan allocation in order to maximize profit rate. Therefore the key to improving farmers' long-run benefit is to make farmers efficiently participate in RCCs' management.

With farmers' efficient participation in RCCs' management and operation, RCCs' commercial sustainability and farmers' long-term welfare can be improved from the following aspects:

(1) With comprehensive understanding of RCCs' new operation mechanism, farmers will increase their disaster mitigation effort because farmers become aware that their disaster mitigation effort will affect RCCs' post-disaster commercial sustainability and their own long-run benefit.

(2) With full ability to decide loan allocation ratio, farmers can and actually do practice an adequate investment strategy to use capital market in order to maximize RCCs' profit rate, increase RCCs' financial ability against disaster (financing disaster losses by the return from capital market) and also improve their own long-term welfare.

(3) With efficient participation and supervision from farmers on RCCs' financial risk management, maintaining RCCs' main job of supporting agriculture, RCCs can make use of capital market to improve the sustainability while making farmers' long-run benefit free from the financial risk.

Furthermore, for farmers, receiving perfect information about RCCs' operation (to motivate farmers make adequate disaster mitigation effort) is firmly related to owing full ability to participate in RCCs' management (to maximize RCCs' profit rate, and also farmers' utility). In RCCs' new operation mechanism, people cannot separate the two things and try to finish them individually.

At the beginning of RCCs' reformation, because of being used to pre-reformation operation mechanism under which farmers cannot represent their opinion on RCCs' management, some RCCs will not wish to follow the reformation decision of the central government very well. In other words, RCCs only introduce the post-reformation decision making system in which farmers can represent and practice their opinion with some certain probability. And this probability will characterize the farmers' real expected utility after reformation (from the view point of the central government) and the farmers' acceptance of RCCs' reformation. Farmers will compare the benefit after reformation with their original one. They will continue to support reformation if the former is larger, and vice versa. So the question is to make the probability of RCCs' to introduce the post-reformation decision making system in which farmers can represent and practice their opinion as high as possible. A possible way could be bringing in some efficient communication mechanism that will make it easier for farmers to receive RCCs' information and to express their opinion to RCCs' staff. One option is to use a method of legislation for and supervision of RCCs by the government coupled with farmers' participation.

In Chapter 6, it has been studied how to improve disaster-mitigation infrastructure development and agricultural communities' sustainability in rural China by applying the group loan supplied by RCCs. With community-based disaster-mitigation infrastructure, farmers' welfare will increase because of increased post-disaster harvest, and utility-rise induced by the community culture (social capital at the community level) which is derived from collaborative work and involvement in developing infrastructure. That will encourage former farmers working in cities to come back to their original

rural sectors; this makes agricultural communities more sustainable. But here arise two major obstacles for community-based disaster-mitigation infrastructure development in rural China: (i) subsistence constraint; (ii) welfare difference between rural and urban areas. The former makes agricultural communities unable to develop infrastructure. And the latter makes farmers (at least partial) not motivated to be involved in the collaborative development of infrastructures. Collaborative development of community-based disaster-mitigation infrastructure based on group loan can expand the possibility for the development of disaster-mitigation infrastructure, and for Pareto improvement and the sustainable community from the following aspects:

(1) The application of group loan can make collaborative development of disaster-mitigation infrastructure also work in the rural areas where community's ability to supply internal subsidy is relatively low.

(2) There will not be extra pressure on RCCs to supply much more loans to farmers when RCCs carry out group loans among agricultural communities to promote collaborative development of infrastructure. The design of group loans just changed the way to allocate loan among the community. This change will not change community's loan demand.

(3) The application of group loan can make the idea of collaborative infrastructure development suitable for more rural areas, especially the relatively undeveloped agricultural communities located in middle and west China. First, the application of group loan will decrease the requirement on the community's ability to implement collaborative development of infrastructure. Second, the application of group loan can reduce the minimum amount of utility-rise for farmers to obtain enough incentives to achieve collaborative development of infrastructure.

(4) Collaborative development of community-based disaster-mitigation infrastructure based on group loan also works in those agricultural communities located in relatively undeveloped provinces where industry cannot support agriculture and agricultural communities in terms of development.

Furthermore, the utility-rise induced by the community culture (social capital at the community level) which is derived from collaborative work and enjoyed by farmers together, is very important to reduce the welfare difference between rural and urban

areas and give farmers enough motivation to be involved in the collaborative development of the disaster-mitigation infrastructure. In general, this kind of community culture is based on local interpersonal relationships or traditional functions. This means that adequate attention should be given to improving and extending local culture or conventional functions when applying some innovative ideas to improve the community-based disaster-mitigation infrastructure. In other words, the complement between revised institutions and traditional functions is important and meaningful for disaster risk management in agricultural sectors of China.

Chapter 7 has summarized the main contributions of this entire thesis including, the remaining remarks to follow:

7.2 Future research

As for the future work, the following should be remarked.

(1) To investigate more circumstantially practical conditions of the inter-linkage market.

As we know, the idea of inter-linkage market belongs to informal financial institutions that are reviving in rural China. Its regulation, development and application need empirical foundation and a suitable policy environment. To make the combination of microcredit system and inter-linkage market more practical and efficient, we should make it clear how inter-linkage market works in Chinese agricultural communities concretely. Then, based on local realities, we can formulate feasible principles and policies to monitor and promote the development of inter-linkage market with considering its potential and positive role in disaster risk financing in rural China. Additionally, local RCCs and agricultural communities can make use of inter-linkage market to finance disaster risk in a more flexible and efficient way.

(2) To examine how to make farmers' efficient participation in RCCs' management and operation more realistic, practical and obtainable.

As concluded in Chapter 5, the key is to improve RCCs' sustainability, community's financial ability against disaster risk and farmers' long-term welfare, and to make farmers efficiently participate in RCCs' management. However, at the beginning of

RCCs' reformation, some RCCs would not like to follow the reformation decision of the central government very well because they are used to pre-reformation operation mechanism under which farmers cannot represent their opinion on RCCs' management. At the same time, it is also difficult to improve farmers' awareness and ability to express their opinion on RCCs' management and operation. For motivating RCCs' institutional reformation and promoting the development and application of RCCs' innovational decision-making system, the government should design suitable incentive mechanisms for RCCs' staff and farmers. This requires us, in our future research, to investigate and formulate how to make the benefit distribution among the government, RCCs' staff, and farmers more efficient.

Appendix

Questionnaire

Firstly, we quietly appreciate your time and attention! This survey is conducted only for the purpose of academic research. The information obtained from the interviewee will not be diffused and the data will not be used for any commercial or private purpose.

Please answer the following questions with the help of interviewer.

1 What is the name of the Rural Credit Cooperative you work for?

2 When was this Rural Credit Cooperative founded?

3 What is the location and contact information such as E-mail, telephone number and fax number of this Rural Credit Cooperative?

4 Loan Purpose
What kind of business is your microcredit loan supposed to support?

5 Qualification
What are the qualifications to receive the microcredit loan? And who may meet such qualifications?

6 Credit Assessment
How do you assess the borrower's credit condition? In other words, how do you decide to lend the loan or not?

7 The Structure of Credit Assessment Group
Is there any special group for credit assessment? If yes, what is its detailed structure?

8 Guarantee
Is the guarantee necessary for the borrower to get loan? If yes, what kind of guarantee is acceptable? Do you think that is enough or not? If not, what kind of guarantee extra you will suppose?

9 Loan Upper Limitation

Is there any amount limitation for each individual loan? If yes, what is the limitation? And how do you set it?

10 Loan Term

How do you determine the term for each individual loan?

11 Loan Interest Rate

How do you determine the interest rate for each individual loan? Do you think that is enough for covering the cost of capital, the lost of loan and the cost of loan operation? If not, what interest rate will you suppose?

12 Loan Obtaining

How does the borrower receive the loan after his credit condition is proved good to receive the microcredit loan? Is it to get the total loan directly at one time, or the borrower can choose frequency and each individual sub-amount?

13 Repayment Frequency

How frequently should the borrower repay the loan and related interest? How do you determine the frequency?

14 Credit Insurance

In general, do you buy any credit insurance or carry out any similar thing (such as group fund <1% of the loan> and special saving <at least 5% of the loan> in the case of group-lending) for each individual loan? If yes, how do you carry it out?

Do you think the present credit insurance for the microcredit loan is enough or not? If not, will you welcome the group credit insurance supplied by the commercial insurance company? Or, what kind of credit insurance would you like to be made available?

15 Saving Interest Rate

If there is special saving for each individual microcredit loan, what is the saving interest rate for this kind of saving?

16 Loan Management

After lending, how do you manage each individual loan (such as periodic loan requirement or periodic repayment from borrowers)? By special account, loan card or

other methods?

17 Loan Monitoring

After lending, how do you monitor the status of using (such as what kind of business the borrower invested the loan in, did the borrower use the loan efficiently and so on) of each individual loan? Do you think it works or not? If not, what kind of monitoring system will you propose?

18 What is the average repayment rate of the microcredit loan? What kinds of factors determine the repayment rate? In other words, for simplification, what is the relationship between the repayment rate and farmers' cultivating effort?

19 Incentives for Staff

Is there any incentive to motivate the staff to extend the micro-credit loan as efficiently as possible? If yes, what is the concrete incentive system? Do you think it is efficient or not? If not, what kind of system you will propose?

Here, extending the microcredit loan includes making the loan available for more farmers (outreach), the borrowers use the loan more efficiently (impact), the repayment rate become higher and the microcredit program more profitable (sustainability).

20 Other Profit Sources

Beside interest income, is there any source for this RCC to get profit? If yes, what is it and how do you operate it?

21 Please describe freely any other problems, in your opinion, should be studied for RCCs. Any of your advice will be used in our research to improve policies and management systems for RCCs' future sustainable development.

This is the end of the questions. Thank you again for your cooperation.