Choosing Rules for Cooperation: A Case Study of the Rotating Savings and Credit Association (ROSCA) in China

互助慣行のルール選択：中国における回転型貯蓄信用講(ROSCA)の事例研究を通して

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Abstract

The study of the evolution of cooperation has attracted attention from a wide range of academic disciplines. Humans tend to cooperate in various ways and the evolutionary process of human cooperation has been discussed. Nowak and Sigmund (2005) stated that in human society, once cooperation is established, "a complex evolution takes place, which depends on the size of the population, the cost-to-benefit ratio, the average number of rounds, and the probability of errors." Among many factors affecting this evolution process, it is widely acknowledged that reciprocity is of great significance, leading to the establishment of cooperation (especially indirect cooperation). In this study, I consider the rotating savings and credit association (ROSCA) as a case to study cooperation, which ROSCA is considered by many people as one of the most prevalent forms of informal mutual financial aid in developing countries. The discussion of ROSCAs in the previous literature has focused on three main dimensions. First, ROSCAs work as a substitute for insurance, especially in developing countries where markets for insurance do not function well (Ambec, 2007; Klonner, 2003). Second, ROSCAs enable the purchase of durable goods: the model of Besley, Coate, and Loury (1993) shows that, in comparison with autarky, ROSCAs enable participants to buy durable goods sooner. Third, ROSCAs can help people to cope with their self-control problems and serve as a commitment device (Ambec, 2007). However, limited research has focused on evolutions in ROSCA rules. As a traditional method for cooperation, ROSCAs demonstrate huge rule disparities both temporally and geographically. It has been observed that in China, normally only one type of ROSCA, with a given set of rules, is dominant in each region although some other types with different rules do coexist. This observation has stimulated my research into how and why these rule disparities occur and what parameters affect people's choices among various rules in a ROSCA.

In this research, an agent-based model within an evolutionary imitation game is established. An important part of game theory, evolutionary imitation game theory tries

to explain how a new behaviour or a new rule is diffused among the whole society by assuming that people adopt new things when they encounter others who have already adopted them. I follow this theory and, to imagine the trajectory of rule preference changes, propose an imitation game which allows participants to learn about new ROSCA types by encountering and learning from others. The basic assumption is that when adopting a new ROSCA rule, each individual makes a rational choice to select a ROSCA type that maximizes his or her payoff as compared to the last choice according to his/her degree of reciprocity. The results show that each ROSCA rule evolves as if it finds its niche formed by people's different levels of reciprocity and time discounting rates. Different ROSCA rules directly influence participants' monetary benefits. The simulation results show that the value placed on reciprocity has a significant effect on people's rule preferences. The simulation also reproduced the social states where different ROSCAs coexist with others in an equilibrium, even when some rules clearly dominate others. In the more heterogenous societal settings there is a dominant ROSCA type, but other types may coexist. These results can explain some aspects of the current ROSCA situation in China where there are four types of ROSCA having a long history and yet, even with the passage of time, these types still coexist in different areas (societies).

Chinese ROSCAs are affected foremost by the country's long history of informal finance. Moreover, the influence of cultural dimensions and specific Chinese habits, beliefs and values should not be underestimated. Interviews were conducted in five Chinese villages to directly measure economic characteristics of individuals and investigate how these parameters correlate with their ROSCA rule preferences. A particular focus was given to the role of the discounting rate. Results show that ROSCA rules are different in the villages where the time discounting rates are distributed diversely, as compared to those where they are uniform. People who participate in Interest ROSCA are more patient and have higher discount rates, whereas participants in No interest ROSCA are more impatient and have lower discount rates. By comparing ROSCA operating situations in different villages, it was found that signing a contract in advance and holding face-to-face meetings are essential for sustaining cooperation. Although sanctions in the contract are

sometimes difficult to enforce, social connections (deepened by regular meetings) and the fear of punishment are important factors influencing people's cooperative behaviours. Additionally, a leader's ability and responsibility are critical factors for the group's success.

I conclude that the evolutionary fitness of a certain ROSCA rule can be explained by needs, patience, reciprocity and their distributive compositions. Apart from the factors discussed here, there are still many other factors which can also affect people's rule preferences. Simulation and mathematical models are effective for exploring possible dynamisms of social interactions when there are large numbers of people involved. These results provide a new insight into the theory of collective rule choice that triggers the evolution of cooperation and they supply advice for the design of informal financial mechanisms.

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Chapter 1 INTRODUCTION

This thesis proposes a methodology and framework for simulating human choices about rules to be used in a cooperative financial institution. Cooperation is considered a decisive organising principle of human society (Nowak, 2006) and, based on documented history, it is clear that humans tend to cooperate in various ways. Amongst preferences and choice on rules of an individual and the society constitute some fundamental concepts. Therefore, an understanding of preferences related to cooperation rules and the required conditions is essential for maintaining and enhancing cooperation in our society. Much research has contributed to the understanding of how such cooperative behaviours emerge and evolve. As a widely present informal financial institution with a long history in many areas, a rotating savings and credit association (ROSCA) has been considered an important institution for mitigating poverty in a cooperative, mutual-aid way. Thus, in this thesis, the ROSCA institutional form is used as the case for discussing preferences and rule choices in relation to human cooperative behaviour.

As an informal financial institution, alleviating shortage of funds and providing mutual help are the foundations of ROSCA; therefore, three dimensions — monetary income, spirit of reciprocity, and social interaction — are focused in this thesis. I will explore how these dimensions affect ROSCA participants' rule choices by employing computer simulation and investigation in the field.

1.1 Background

The study of human rule choices for cooperation and their evolution has attracted attention from a wide range of academic disciplines. Nowak and Sigmund (2005) stated that in human society, once cooperation is established, "a complex evolution takes place, which depends on the size of the population, the cost-to-benefit ratio, the average number of rounds, and the probability of errors." Among many factors affecting the dynamic process, it is widely acknowledged that reciprocity is of great significance, leading to the establishment of cooperation (especially indirect cooperation).

Meanwhile, there is a continued and intense interest in financial mechanism design which is focused on how to involve more small and rural savers using more cooperative approaches. A rotating savings and credit association (ROSCA) is one of the most prevalent forms of informal financial institution in developing countries. Institutional forms similar to ROSCAs also exist in other places around the world. A widely used method of cooperation, rules of ROSCAs show huge temporal and geographical disparities.

As observed in real cases and related papers, one important characteristic of a ROSCA is that it originally emerged among people who lived in an isolated area and who had limited access to formal financial institutions. Thus, when someone needed an item of lumpy consumption (such as for house construction, a wedding, treatment for disease, or other emergency use), he or she could only rely on personal borrowing from relatives or friends. This history may explain the ROSCA mechanism formation process when mutual-aid

action frequently happens among the same group of people.

Another key feature is that contributions to the money pot are voluntary. The ROSCA is managed successfully when all participants contribute to the fund after they have received their payment (Koike, 2015). In this sense, a ROSCA requires strict cooperation, otherwise the system collapses even if only one member of the group defaults.

ROSCA has been practiced as a useful informal financial institution for several hundred years in regions all around the world. In this research, rule choices and cooperative behaviours related to ROSCAs in China (*Hui* or *Hehui* in Chinese) are studied. *Hui* in China still exist to this day and have survived for hundreds of years, suggesting an economic adaptation and special contribution to local sectors of the Chinese economy.

1.2 Objective and Research Questions

The research objectives of this thesis are twofold: first, to demonstrate disparities in ROSCA rules and their development track in China from a historical view; and second, to propose a methodology and framework for systematically and comprehensively simulating the process of ROSCA rule choosing and the evolution of cooperation in China. The research questions raised by the objectives and to be explored in the thesis are as follows.

1. *How can various ROSCA mechanisms and rules emerge, be sustained or coexist under different social situations?*

A widely used method of cooperation, ROSCAs in China exist as a variety of schemes with huge temporal and geographical disparities. However, it has been observed that normally only one type of ROSCA scheme is dominant in each region. This stimulates the research question about how these rule disparities occur and, most importantly, whether people's choices among various rules for a ROSCA are affected by different social situations and personal characteristics in these regions. There is little reported research on this issue. A ROSCA supplies us with an empirical case for studying the evolution of cooperation in terms of how different schemes emerge. The above incentives, seemingly mixed up to some extent, give us sufficient impetus to discuss the potential factors behind the mechanism.

2. *What is the effect of social interaction and learning on ROSCA rule choosing?*

As a salient approach to discussing the evolution of cooperation in human society, imitation game on an agent-based level has been proposed in previous studies and used to explore how cooperation emerges in a society. Participating in a ROSCA group is a collective behaviour and highly correlated with social interactions. This raises the research question of how preferences and choices about ROSCA rules may change in a dynamic and interactive social environment.

3. *How can the sustainability of ROSCA cooperation be evaluated from the viewpoint of computer simulation and field investigation?*

Development economists have spent much effort on poverty alleviation and improving the financial accessibility of fragmented markets, especially in developing countries. In

China, and all around the world, ROSCA has been an efficient financial instrument available to a variety of people. Studying the cooperative behaviours in ROSCAs can supply a deeper understanding of both the evolution of cooperation and a better design for a financial market mechanism.

1.3 Structure of the Thesis

This thesis is organised as follows. Chapter II defines the scope of the study and reviews relevant literature. First, a review of the evolution of cooperation and of rule choice is presented. Then a detailed description of ROSCA and related research in the existing literature is provided. It is argued that, although a number of previous papers have discussed the evolutionary process of human cooperation, there has been limited research into and discussion of how to combine this literature with real cases of human cooperation. Therefore, ROSCA is an indicative exemplar for studying the above issues. Finally, a historical research approach is adopted to illustrate the development of ROSCA in China. The historical development is outlined in terms of its religious origin and self-admission function in ancient China, which is considered a precursor of current ROSCA forms.

Chapter III describes the research methodology. First, related previous ROSCA models are introduced as the basis for constructing the ROSCA model in this thesis. Then, the basic idea of evolutionary game theory is described and the definition of an evolutionary stable strategy (ESS) is provided. As one of the motivations for participation and a profound cooperation principle, reciprocity is introduced and modelled in computer simulations to explore how it affects rule choices. To demonstrate the process of social

interaction, an imitation game using an agent-based model (ABM) is introduced.

In Chapter IV, more detailed ROSCA rule disparities are described. Following this, the basic ROSCA model is built up and four ROSCA types observed in China are concluded from various documents and cases. In particular, reciprocity is considered as a fundamental factor affecting participants' preferences and thus involved in the expected utility by defining altruistic behaviour in terms of participating in a ROSCA group.

Chapter V introduces the imitation game as one of the key aspects of evolutionary theory, in which individuals are assumed to have the potential to learn and renew their strategies by encounters with each other. The imitation game based on ROSCA is constructed in this chapter to simulate how people's preferences change along with learning behaviour. The computer simulation results are shown in this chapter, including the situations of homogenous and heterogenous societies by focussing on reciprocity and time discounting. Furthermore, social changes in the rule-choosing process and some extreme social situations are also simulated and discussed. This enables the depiction and understanding of the influence of reciprocity and time discounting on people's choices.

Chapter VI presents the main results from the field investigation in China. The fieldwork was conducted in an area where ROSCA has been widely practiced by the local people and ROSCA rule disparities have been observed temporally and geographically. Interviews were conducted in five villages and the detailed ROSCA rules of each village are summarized the reasons behind the choice of those rules are also recorded in the conversations. In addition, time discounting experiments were conducted to evaluate local people's time discounting rates. According to the regression analysis, an individual's time

discounting rate is related to both personal characteristics and ROSCA rule choices.

Finally, the research process and the main findings of this research are summarised in Chapter VII. Potential future research directions are also suggested.

Chapter 2 COOPERATIVE BEHAVIOUR AND RULE CHOICES IN HUMAN SOCIETY: LITERATURE REVIEW

Based on documented history, we see that humans tend to cooperate in various ways. The study of human cooperation and selection of cooperation rules has attracted attention from a wide range of academic disciplines. This thesis focuses on cooperation behaviour and rule disparities by examining ROSCA participation in China. The current chapter aims to clarify the scope of this issue, to review previous research and its limitations, and to explore potential research directions.

The structure of this chapter is as follows. Section 2.1 thoroughly describes the development history of the ROSCA in China, which supplies literature evidence regarding the origin and development of ROSCAs. Several cases of failed cooperation in China are listed and the importance of understanding the motivation for cooperation and its changing process are highlighted. Section 2.2 reviews previous research on human cooperation, which is discussed from diverse perspectives. In particular, the studies on the evolution of cooperation and related game, most of which have focussed on the emergence process of cooperation and the conditions. Previous researches raise the question of how humans develop different cooperation rules and what are the potentially influencing factors. In section 2.3, related research on reciprocal behaviours in human cooperation is discussed, as reciprocity has been recognised as a key trigger in the

evolution of human cooperation. The concrete theoretical developments are acknowledged and their limitations are also discussed. Hereby, this thesis focusses on a more practical research approach by taking an exemplar of human cooperation that has naturally emerged in many parts of the world and been widely adopted and using this case to study the issue of cooperation and rule choices. In section 2.4, a detailed definition of a ROSCA is provided along with the classifications of different ROSCA types as categorised by previous researchers.

2.1 A Brief History of ROSCA in China: A Traditional Communal Power

ROSCAs are one of the most prevalent forms of informal financial institutions in developing countries. According to the thorough investigation by researchers at Ohio University (Adams & Fitchett, 1992), ROSCAs have appeared in different countries with various names and forms. In this section, a brief history of ROSCA is introduced, with a special focus on the origin of ROSCA and its historical development path. By sorting the development history of ROSCA in China, a mutual-aid spirit as a traditional communal power is considered as the most essential in the its mechanism.

2.1.1 A brief history and social implications

In China, ROSCAs are known as *Hehui* or *Hui* and they act as civilian financial organisations. According to the literature, the history of the formal ROSCA mechanism can be tracked back as early as the Tang dynasty (618–907) (Wang, 1930). Figure 2.1

shows the earliest remaining female *Hui* contract, which is mainly about rotating food and labour during the 10th century. This contract strictly described the rules of the *Hui*, including the time and venue of monthly regular meetings, the amount of food to contribute at each meeting, and the responsibilities for each individual. All the members signed on the contract have reached agreement. Additionally, punishment rules were explained in this contract for a person who reneged from this *Hui*. At that time, rotating food, labour, and money were the popular ways to mutually help each other. No case has been observed where extra interest or compensation was charged for an earlier obtainment in this period.

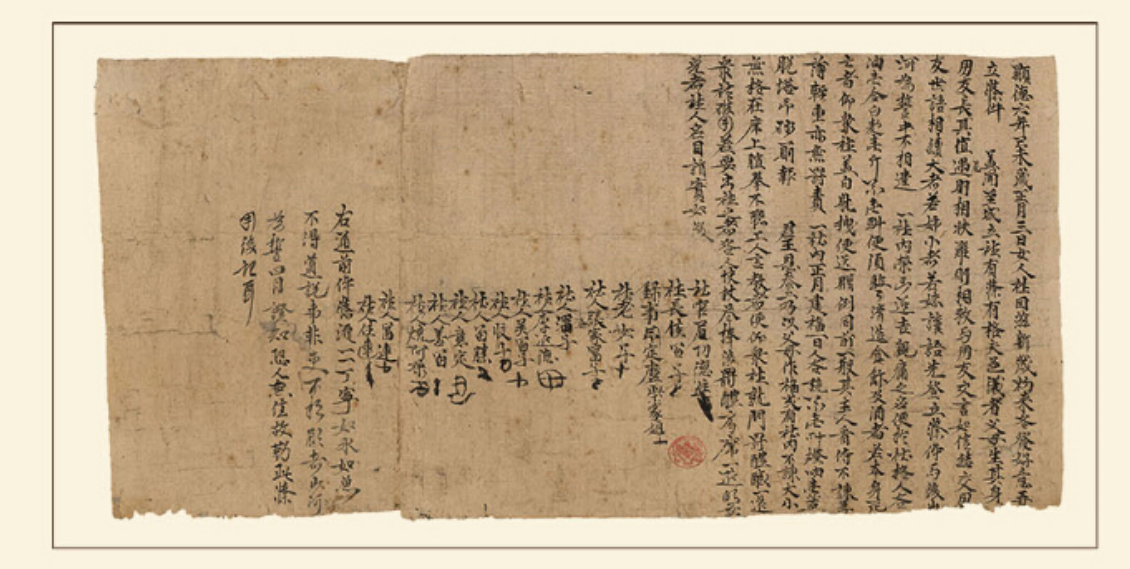

Figure 2.1 A *Hui* Contract on Rotating Food and Labor in a Female Group (*A.C.* 959) (Chinese title: 后周显德六年乙未岁正月三日女人社再立条件)

These kinds of rules went through hundreds of years of development until, in the latter part of the Qing dynasty (1616–1912) and in the Republic of China (1912–1948), *Hehui* reached their peak in terms of number of groups, popularity, and the variety of rules. At that time, depending on the motivation, *Hehui* had many different names and rules, such

as Fushou Hui (福寿会), Laoren Hui (老人会) to raise funds for funerals, Duiji Hui (堆积会), Suojin Hui (缩金会), Sanyi Hui (三益会), and Shensuo Hui (伸缩会), which charge extra interest as the rules stipulated. Types of *Hui* that charge extra interest normally have more complex rules and structures, and were more popular in urban than in rural areas. Chinese renowned sociologist Fei Xiaotong in his book *Peasant Life in China: A Field Study of Country Life in the Yangtze Valley* (1939, p. 145) explained that ROSCAs in rural China were mainly used for fund raising, such as for weddings and funerals. Xiaotong examined a remote village in Jiangsu Province as a case study to explain how mutual assistance occurred at that time. Wang (1930, p. 302-305) pointed out that an urban ROSCA is characterized by a weaker mutual aid spirit than a ROSCA in villages, and they tend to have shorter sessions with higher risks. Many of these urban types of ROSCAs were aimed at procuring production funds in several provinces along the southern coastal line of China that developed from the commodity economy at that time.

With the establishment of the People's Republic of China in 1949 and the launch of the planned economy, *Hehui* almost stagnated due to strict finance regulations and lack of free market. Following the reforms of the 1970s, China's commodity economy developed and *Hehui* revived again spontaneously. Since then, a variety of ROSCA rules have been observed, demonstrating huge temporal and geographic disparities. Historically, central or local governments in China have intervened in the development of ROSCA, sometimes in a quite heavy-handed manner. Normally, when large defections emerge frequently in ROSCA groups, strict regulations are released and the government tends to intervene in the activities. As some exisiting literatures state, although ROSCA also once existed in

Japan and one of its evolutionary charateratics was from ROSCA group with leader to without leader. However, by observing the hisory in China, I found that until today, almost the ROSCA group has a leader (sometimes even more than one), and leader plays a more and more important role in member selection and organising meetings. More details will also be demonstrated in Section 6.3.

The historical documentation of ROSCAs in China is not always continuous and clear. However, documents and cases can be always found in different periods, supplying hints for tracking its development and matching with the historical environment.

The names of ROSCAs in China may vary in different times and places. Wang (1930) differentiates three types that existed during the Qing dynasty. The first was *Lun-hui* (rotating ROSCA), in which the order of obtaining the money pot was negotiated by agreement during the organising meeting. The second was *Yao-hui* (dice-rolling ROSCA), in which the order was decided by lot or rolling dice at each meeting. The third type was *Biao-hui* (auction ROSCA), in which the money pot went to the person who was willing to offer the highest interest rate in that round.

For motivating participation, ROSCAs in China encourage joint savings and provide mutual help for weddings, funerals, travel, or productive purposes.

2.1.2 Origin of ROSCA in China and its development

(1) Religious origin

In the current literature, it is commonly accepted that ROSCAs (*Hui*) in China originated

from Buddhist traditions. During the initial period of their development, the use of ROSCAs was mainly for social gatherings and the preparation for pilgrimages.

Historical materials in Dun-huang (敦煌) show that during the Tang dynasty (618-907), social and religious clubs known as *she* (社) or *she-yi* (社邑) were organised by the local Buddhist monasteries to promote the Buddhist religion through finance activities (Yang, 1952). However, social and economic functions were also demonstrated. One of these clubs was called *zhui-xiong-zhui-ji* (追凶追吉) ("to follow up when there is a happy or unhappy event"); it was established to help members pay for a funeral, a wedding or travel. According Wang's (1930) estimate, normally there were ten to fifteen clubs attached to one monastery, and the number of members in each club averaged from 25 to 40 people (Wang, 1930; Yang, 1952). Originally, the word *she* referred to a shrine to god, later deriving the meaning of a social and religious club which promoted social welfare by district unit in ancient China. The character of *she* was intimately connected with a mutual financing function for commoners.

(2) Autonomous institution

During the Tang Dynasty, however, the existence of mutual financing associations was not only occurring in monasteries, but also in non-religious arenas. Some people emphasised its importance for social welfare purposes.

There is one representative case recorded in the literature from Hunan Province, China, during the Tang Dynasty. At that time, peasants were poor and could not afford cattle for plowing. Wei Zhou, who was the prefect in the area, organised the local people into

twenty *she* or clubs. Quite similar to the ROSCA motivation of buying durable goods, in these *she*, each household contributed a certain sum to the club each month. Members in the same club decided the order of obtaining the money pot to buy a cow. This organization showed the efficacy of solving a fund-shortage problem through joint savings in an autonomous way. In this case, the main objective of the club was to ensure that each household would have access to durable productive assets.

A similar Japanese case is documented by Ryuzaburo in his book *The Origin of Health Insurance Jorei in Munakata Area* (1979) (Japanese titile:「健保の源流"筑前宗像の定礼」). According to Ryuzaburo, documentary evidence in Munakata area shows that from the early 1800s and especially during Tempo famines of the 1830s, a cooperative called *Jorei* was established and becoming popular. *Jorei* was a mutual aid instituition which participants contributed in cash or kind and from which money was withdrawn to pay for medical services. It worked both normal years and epidemics, which distributed medical care to the villagers. Also, a physician paid by the cooperative made regular visits to the areas.

(3) Disaster relief function

When it came to the Song Dynasty (宋朝) (960-1679), another famous famine relief organisation was proposed, also highly related to ROSCA. The *She-cang* (社倉) (granary club) was introduced by the great philosopher Zhu Xi (朱熹) (1130-1200).

She-cang (社倉) was the social security system in ancient China for the prevention of famine. The source of rice in the granary was the government or donations from

commoners and it was used as relief loans to the people in the summer. In the harvest period, people were able to repay the loans with 20 percent interest. The interest was reduced by 50 percent in years of slight famine and cancelled completely in years of serious famine (Yang, 1952). Although the project was under government supervision, its management was in the hands of village elders, local literati, and retired officials. These kinds of mutual aid associations again showed outstanding effectiveness in the disaster relief function in ancient China.

It would not be accurate to define a ROCSA as a purely financial institution, similar to a pawnshop, for instance. The key factor in the proliferation of *she* was the recognition that disasters and emergencies were unavoidable and inevitable for each household. Thus, ROSCAs were highly reliant on the mutual trust and aid social networks, with the basic motivation for participation being to help people in plight and free-riding rarely happening intentionally. The ROSCA is rooted in existing social networks and motivated by the reciprocal spirit.

(4) Village structure and autonomy

Beginning in the Song dynasty (宋朝) (960-1679), the *Xiangyue* (鄉約) system (community compacts) was proposed; these were public contracts of social conduct and mutual support concluded by members of village communities in traditional China. In case of famine or other hardship, community members had the duty to support each other. The semi-independence of townships and villages enabled ordinary people to participate in the decision-making process in terms of welfare and social exchange. The realisation of autonomous, fixed, and unchanging units in each village made it possible for villagers

to contract long-term agreements.

There are many factors leading to a lack of success in rural financial institutions. Amongst the most important prerequisites is the nurturing of credit relations in low-income countries as Izumida (2003) concluded in the book *Rural Development Finance: Asian Experiences and Economic Growth*.

In most cases, the rural financial institutions that were established in policy were made under top-down initiatives, which may ignore the will and customs of farmers. The reasoning behind this strategy was that the funds for investment were lacking in the rural areas of developing countries, and modernisation could be accomplished easily by injecting funds from the outside through policy agencies. But modernisation cannot be achieved when ignoring the farmers' ideas and behavioural principles. Ultimately, formal financial institutions that were formed top-down failed to win the farmers' trust, and the system of credibility that allowed renting of funds was not sufficient.

In the book *Ordinary Economies in Japan: a historical perspective* (Page 73-74), Najita (2009) recounts the relation between city form changes and the establishment of ROSCAs in the Tokugawa period in Japan. Najita considers that because of the creating of *jokamachi* (castle town) in the Tokugawa *bakuhan* regime, “villagers had the power in determining the welfare and internal affairs of the village community”. Therefore, ROSCAs were established and utilized as the mutual aid system for villagers to solve some emergent issues and “participating or not was solely decided by each villager as a separate decision.”

It has been widely observed that ROSCA meetings are normally held with a meal, which enriches its status as more than a means of gathering funds: it provides the opportunity for members to strengthen the mutual responsibility and monitoring among the group.

(5) Simplicity and variation

The preference for ROSCA, especially in developing areas, is explained not only by the financial aspects of the institution, but also by the emphasis on its relative simplicity in terms of functions, procedures and organisations (Bouman, 1995).

Smith, in his book *Village Life in China: A Study in Sociology* (1899), provides a good description of a ROSCA rule at the end of the 19th century, which was similar to a modern rule:

> The simplest of the many plans by which mutual loans are effected, is the contribution of a definite sum by each of the members of the society in rotation to some other one of their number. When all the rest have paid their assessment to the last man on the list, each one will receive back all he put in and no more. (Page 152-153)

In the associations where the rate of interest is fixed, the only thing to be decided by lot or by throwing of dice, will be the order in which the members draw out the common fund. In others, sometimes the interest is left open to competition, which may take place by a kind of auction. Each member announces orally what he or she is willing to pay for the use of pot for one turn, with the highest bid taking precedence for that one turn.

A large ROSCA in China might include more than forty members and the commitment

may last more than twenty years. Thus, a participant can often sell his or her place in a club to another person (depending on the needs of purchaser and seller, this might be at a discounted or higher price). Also, a share can usually be inherited by a member's relatives as an asset.

2.1.3 Several cases of large-scale defection in ROSCAs

No account of the history of ROSCA in China would be complete without a mention of the defection cases that happened in recent decades. Although cooperative mutual aid organisations such as ROSCAs have been important, and in some historical stages even the dominant financial sources for participants in many areas, their early success was marred by later large-scale failures.

Table 2.1 lists eight large-scale ROSCA defection cases that happened in recent decades in China. All of these cases involved quite a large number of participants and amount of money. And each of them ended in a failure caused by one of the members wrapping up the whole money pot and refusing to continue to contribute to the group, intentionally or not. The most famous defection case happened in Leqing town, as shown in the first column of Table 2.1. More than 50,000 members belonged to the same ROSCA group and the frequency of meetings had become almost every day. This group started with several businessmen who wanted to raise lumpy funds to enlarge their businesses. More and more local people became involved as they did not limit group capacity. During the peak, around 80% of the whole town population had joined the group. However, this mechanism did not last long and two years later a defection happened, leading to a large monetary loss of more than 2 billion Chinese *yuan*. Even today, many researchers are still

discussing why this big failure happened and how to prevent defections. The common lessons learned from the Leqing case may be summarised as follows. First, because a ROSCA is a mutual aid financial institution, its altruistic spirit should not be ignored. In the case of the Leqing ROSCA, the later rule charged very high interest, which went against the ROSCA's original intention. Second, traditional ROSCAs happened in a relatively homogenous society and relied heavily on social monitoring systems. This implies the group membership should be limited to people who have strong social links with each other, and group capacity should also be controlled. Furthermore, a too-large amount of money in the pot could spur a defection.

Table 2.1 Large-scale ROSCA defection cases in China since the 1980s

Year	Place	Members	Amount of Pool	ROSCA Type
1986	Leqing, Zhejiang Province	50,000+	2 billion *yuan*	Random
1999	Pingyang, Zhejiang Province	1,000+	365 million *yuan*	Random
2001	Pingyang, Zhejiang Province	?	10 million *yuan*	Random
2001	Cangnan, Zhejiang Province	200	2.4 million *yuan*	Bidding
2004	Fuan, Fujian Province	?	900 million *yuan*	Bidding
2010	Taixing, Jiangsu Province	100,000+	3 billion *yuan*	Bidding
2011	Ninghai, Zhejiang Province	1,500	540 million *yuan*	Bidding
2011	Fuding, Fujian Province	6,000+	190 million *yuan*	Bidding

As discussed in previous literature, ROSCAs can improve individual welfare and have advantages over formal financial institutions in terms of accessibility and feasibility. However, the performance and efficiency of ROSCAs are sophisticated with highly related internal and external factors. From the large-scale failure cases of ROSCAs in

China, it can be seen that how to sustain cooperation and choose proper ROSCA rules are important issues that remain unresolved both theoretically and empirically.

2.2 Cooperation and its Evolution

This section provides a detailed definition of cooperation in human society and discusses the five novel mechanisms for the evolution of cooperation described in the previous literature in which the role of reciprocity is highlighted. The related cooperation games are also briefly introduced. The evolution of cooperation includes complex and dynamic aspects, which research scope and model extracted from empirical world are also continuously changing.

2.2.1 What is cooperation?

In traditional biological fields of study, cooperation and its evolution are favorite topics especially as they relate to the variances of natural selection and the dynamic interactive process. In recent decades, there is increasing research interest about human cooperation from the viewpoints of the social sciences and economics fields, which consider human cooperation as a key aspect of social development, particularly within the current globalisation process. However, there remains an key unsolved issue which seems contradictory to the competition observed in the natural selection process, that is, why would an individual help or cooperate with another when doing so sometimes cannot maximise his or her own benefit. To tackle this question, a detailed definition of this *cooperative dilemma*, based on those in Nowak (2012) and Hauert et al. (2006), is given

in this section.

In the given payoff matrix,

$$\begin{array}{cc} & \begin{array}{cc} \text{C} & \text{D} \end{array} \\ \begin{array}{c} \text{C} \\ \text{D} \end{array} & \begin{pmatrix} R & S \\ T & P \end{pmatrix} \end{array}$$

where strategy C is *cooperation* and strategy D is *defection*, the situation is defined as follows. The above game is a cooperative dilemma if (1) two strategy C adopters obtain a higher payoff than the two players taking strategy D, i.e., R > P, and (2) the players who adopt strategy C still have an incentive to default. This latter can arise from: (2a) if T > R, then it is beneficial to defect when encountering a cooperator; (2b) if P > S, then defection is a better strategy to adopt when playing with a defector; and (2c) if T > S, then choosing strategy D is better. If at least one of these three conditions hold, then this is defined as a cooperative dilemma. One of the most stringent cooperative dilemmas (Nowak, 2012), the Prisoner's Dilemma, can be defined as T > R > P > S (Rapoport & Chammah, 1965). However, in the traditional Prisoner's Dilemma, the defection strategy is more dominant than the cooperation strategy and thus, under natural selection, populations always favour a defection strategy. As one case of cooperation game, the Public Goods Game, which has been observed in numerous empirical studies, is defined and widely discussed. In the Public Goods Game, *N* players can independently decide to contribute some money to a common pool which is then divided equally among all *N* players, no matter whether or how much they have contributed to the pool. Naturally, the income-maximising strategy is to contribute nothing. However, in real cases, many

players still choose to contribute and cooperation emerges. Lots of theoretical and experimental research has been intensively focussed on this issue.

2.2.2 The evolution of cooperation

(1) Five key mechanisms for the evolution of cooperation

Nowak and his research group have been focusing on the evolution of cooperation and how to sustain cooperation in human society. Nowak (2006) considered cooperation as a decisive organizing principle of human society, where evolution is found to be necessary to construct new levels of organization. He discussed the five novel mechanisms for the evolution of cooperation known as kin selection, direct reciprocity, indirect reciprocity, network reciprocity, and group selection. In this section, these five rules are introduced with brief descriptions.

Kin selection

The idea of kin selection is based on the well-known Hamilton's rule, illustrated by the remark rule: I will jump into the river to save two brothers or eight cousins (Hamilton, 1964). This idea indicates that natural selection could favour cooperation if the players are related genetically.

Direct reciprocity

Certainly, it is not enough to discuss cooperation only among relatives when cooperation is widely observed among unrelated individuals. Trivers (1971) proposed that direct

reciprocity promotes cooperation between a dyad of players interacting repeatedly. In direct reciprocity, the same two individuals are repeatedly encountering one another. In each round, each of the two players can choose a strategy of cooperation or of defection. In the famous computer tournaments, Axelrod (1981) discovered that *tit-for-tat* is a good strategy for playing this game, where one does whatever the other player did in the previous round. Nowak (2005) describes this behaviour as "A helps B, and B helps A."

Indirect reciprocity

In indirect reciprocity, any two players are supposed to encounter each other at most once. Thus, the personal enforcement in direct reciprocity which leads to cooperation must be enacted as a community enforcement in indirect reciprocity. Nowak describes this behaviour as having two flavours: "upstream reciprocity" is based on a recent positive experience which can be summarised as "A helps B, and B helps C" and "downstream reciprocity" is built more on *reputation*, where A has helped B, thereby earning a high reputation, and therefore receives help from C. Thus, the key element in indirect reciprocity is reputation.

Network reciprocity

The above arguments are based on a well-mixed population, where everyone has the same chance of interacting with everyone else. However, in real societies, the spatial structures or social networks cannot be ignored. In a structured society, cooperators have a greater possibility of existing by forming a cluster in the network where they can help each other.

Group or multi-level selection

Nowak proposed the idea of group selection in 2006 and promoted this idea to multi-level selection in 2012, pointing out that selection occurs not only on an individual level but also at a group level. The key concept is that a group of cooperators might be more successful than a group of defectors. Thus, group or multi-level selection can promote the evolution of cooperation.

(2) Sustaining cooperation

Axelrod (1981) suggests that a social norm is essentially an implicit rule that members of society feel compelled to adhere to. One way of creating and sustaining such a norm is via internalisation, where a norm becomes so entrenched in a society that violating it causes psychological discomfort.

Masclet (2003) published a pioneering study demonstrating that non-monetary punishments, such as expressions of disapproval, can enhance cooperation. The efficacy of non-monetary punishments was compared with that of monetary punishments.

Chaudhuri (2011) mentions that one obvious mechanism for promoting cooperation is to allow for communication among participants. (This is observed in ROSCAs where people gather together and hold meetings to collect money because they consider that face-to-face communication is an effective intervention for maintaining cooperation. More detailed discussion of this topic will be provided in Chapter 6.)

However, limitations of the above-mentioned research have been revealed. Ohtsuki et al (2009). determined that punishment can only supply a small marginal effect on the evolution of cooperation. Cordell & McKean (1992) also mentioned that although direct

pecuniary punishments occur in the real world frequently, ordinary citizens usually do not have the right to destroy another person's property, nor do they have the authority to impose fines.

Reputation is essential in indirect reciprocity, in which an action between donor A and recipient B is observed by the rest of the population. However, the methods for evaluating an individual's reputation can be a vague system in which all members' criteria are different. Sometimes information is partial, such as when not all the actions of cooperators and defaulters can be observed by everyone: defaulters may escape to another group where players are lacking the full information about him or her (hardness of observation). At the same time, the dilemma of "goodness" appears: "I am a good person, but if I refuse to help a bad person, will the people observing my behaviour judge me as good or bad?"

2.3 Reciprocity

Nowak and Sigmund (2005) state that in human society, once cooperation is established, "a complex evolution takes place, which depends on the size of the population, the cost-to-benefit ratio, the average number of rounds, and the probability of errors." Among many factors affecting the evolution process, it is well acknowledged that reciprocity is of great significance, leading to the establishment of cooperation.

Reciprocity and reciprocal altruism

In *A theory of reciprocity*, Falk and Fischbacher (2006) present a formal theory of reciprocity and particularly distinguish *reciprocity* from *reciprocal altruism*. Reciprocity

is a behavioural response to perceived kindness and unkindness. The key aspects of a reciprocal action are i) the consequences of the action, and ii) the actor's underlying intentions. A reciprocal altruistic is only willing to be reciprocal if future rewards are expected from reciprocal behaviours.

As mentioned in section 2.2, reciprocity—especially indirect reciprocity based on reputation—leads to the evolution of cooperation, and in this process, reputation building and complex social interactions happen.

Jordan et al. (2016) conclude that humans frequently cooperate without carefully weighing the costs and benefits, which is an uncalculated way to signal their trustworthiness to observers. Based on Jordan et al. (2016)'s theory and experimental results, reciprocity has emerged as a dominant explanation for the motivation to join a ROSCA group: cooperating today can bring benefits tomorrow.

Although the subject is of great relevance to group decision-making, there has been little effort to investigate systematically the evolution of cooperation by using case studies to produce more evidence about this topic. The exploration of the links between reciprocity and other cases (or institutions) in the real world for cooperative interaction may reveal further opportunities for better understanding how human cooperation develops.

2.4 Cooperative and Informal Mutual Aid Institutions

The Universal Financial Access (UFA) goal is that by 2020 adults who currently are not part of the formal financial system will have access to a transaction account to store

money, and to send and receive payments as the basic building block to manage their financial lives (UFA 2020). The first goal of the Sustainable Development Goal (SDG) is to end poverty in all its forms, everywhere. Even though increasing the accessibility of credit and formal finance for the poor has been high on the agenda for governments and institutions, success has stalled in most rural financial institutions in developing areas for a long period (Yaron, 1992a; Adams et al., 1984), although certain institutions, such as ROSCAs, work better in some areas. This raises worthwhile questions such as: What are the barriers to financial inclusion, especially in developing areas? Why do people in developing countries with access to formal financial institutions still use informal financial institutions which may be less secure? In this section, the informal financial institutions called ROSCAs are defined and the related literature is reviewed. A brief summary of ROSCAs history may help us understand more about the needs in impoverished areas. By tracking the establishment of mutual finance cooperatives, we may find answers about how ordinary people have cooperated with each other since ancient times to cope with emergencies. Exploring the mechanisms of and motivations for these informal financial institutions is crucial for improving financial accessibility and designing an inclusive financial system.

2.4.1 Definition and classification

There is continued and intense interest in designing financial mechanisms which involve more small and rural savers. Despite the development of microfinance, based on recent data it is estimated that 2.7 billion adults remain unbanked, especially in the developing world (Bauchet, 2018; Cull & Morduch, 2017). Numerous studies have stressed the

importance of offering more inclusive and diverse financial services and have shed light on informal financial institutions (IFIs). One of the most prevalent forms of informal financial institution, ROSCAs usually happen among relatively homogenous people who live close to each other and have similar consumption abilities or preferences, with limited outside financial resources. A self-managed organisation, a ROSCA is considered a poverty alleviation tool, motivating local people to mobilise their own resources and finance growth from their profits (Seibel, 2001). Kovsted (1999) described the origin of a ROSCA as a "private borrowing-lending club," which highlights its mutual help function in its development history. In most cases, when someone had need of money for a single item expense such as for house construction, a wedding, treatment for disease, or other emergency use—i.e., lumpy consumption—(s)he could only rely on personal borrowing from relatives or friends. Also, an important form of social capital, a ROSCA may provide a solution to finance access issues in less developed areas and at the same time strengthen mutual trust in a community.

Basically, a ROSCA holds regular meetings. At each meeting, everybody contributes to a common *money pot*, and the funds collected are given to one of the members. This process continues at each meeting until every member has received the funds once. Despite this common principle, ROSCAs can be found in most developing countries with different names and management structures. According to the thorough investigation by researchers at Ohio University (Adams, D. W., & Von Pischke, J. D., 1992), ROSCAs have appeared in different countries with various names, forms, and rules, for example, *paluwagan* in the Philippines, *mujin* or *tanomoshiko* in Japan, *hui* in China, *kei* in Korea, *pasanakus* in Bolivia, *djanggi* in Cameroon, *susu* in Trinidad, *ekubs* in Ethiopia, and *chit*

in India. ROSCA rules also vary widely in terms of the amount of funds in the money pot, the number of members, frequency of meetings, and so forth.

2.4.2 Motivations for participation

One of the main research interests in previous studies has been the motivation for participating in a ROSCA group. This is also considered to be highly related to preferences regarding ROSCA rule choices, as an appropriate mechanism design can attract more participants. In this section, research on the motivations for participating in a ROSCA is reviewed.

Informal: A complement of formal

There is a great deal of evidence implying that formal financial markets are highly fragmented and imperfect (Conning, 2007). Hence, informal financial institutions such as ROSCAs are considered an effective complement of the formal structures. Although much remains unknown about the interaction between formal and informal finance, Madestam (2014) considers that informal institutions can be either complements or substitutes due to the imperfect formal financial market.

Enforcement and commitment function

Anderson et al. (2009) thoroughly researched the enforcement issues in ROSCAs and discussed what kinds of institutional design can be used to deter default. By comparing the *random* and *fixed* ROSCA types, they found evidence to support that the method used to allocate ranks (orders) matters, with the random method tending to exacerbate

enforcement problems. At the same time, social sanctions play a role in sustaining the success of a ROSCA.

Recent work has started to explore the commitment device function of ROSCAs from the perspective of time preferences. In the work of Bonan et al. (2019), using household survey data from Benin, present-biased preferences were related to participation in ROSCAs and funeral groups, as well as the level of contributions made to such groups.

Bauchet and Larsen (2018) analysed the data from Taiwan bidding ROSCAs, focussing on whether social relationships influence ROSCA success and contribution behaviour. They reveal a strong association between members' connections to the ROSCA leader and their bidding behaviour; members with looser ties to the leader tend to use the ROSCA as a credit device, whereas with closer relationships, people use the ROSCA as a saving device.

Early-pot motivation

Early-pot motivation refers to the phenomenon that people prefer to obtain the money pot as soon as possible. Normally, obtaining the money pot earlier allows them to cope with urgent money needs (a substitute for insurance) or to buy expensive durable items (quick financing of the purchase) (Dagnele & Lemay-Boucher, 2012). The model of Besley, Coate, and Loury (1993) shows that, in comparison with autarky, ROSCAs enable participants to buy durable goods sooner.

Self-control motivation (later order preference)

ROSCAs are considered a way to encourage and accelerate individual savings, particularly for those who have problems with self-control if they want to save money. Under this motivation, people also use the ROSCA as a commitment device to save money; in this case, they would like to obtain money in one of the later orders. Because the mechanism of the ROSCA is based on group liability, it can help participants solve their self-control problems to some extent.

2.4.3 Cooperation maintenance mechanism

Limited research has focused on temporal and geographical differences in ROSCA rules. Research on how ROSCAs are organised, in terms of underlying individual preferences, and how different group compositions and rules influence default risk, may provide a clearer picture of the role of rural informal finance and increase diversity in financial mechanisms. In this paper, ROSCAs in China, where they are called *Hui* or *Hehui*, are studied. ROSCAs have a long history in China. Although they have disappeared in some developed areas, ROSCAs are still a popular informal mutual aid financial institution in rural areas. The features of China's *Hui* have much in common with those of other countries. That *Hui* have survived until today suggests that they serve an economically useful function. There are reasons why a study of *Hui* may be attractive. First, *Hui* are still considered an important informal financial mechanism in rural China. There is continued, intense interest in the design of financial institutions that can attract the accumulated wealth of the small rural saver (Hamada, 2000) and, despite the emergence of modern financial institutions, *Hui* continue to be popular in rural China. Second, *Hui* are an example of how human societies form cooperative mechanisms. Third, *Hui* are

closely related to economics, society, and culture. I hypothesised that the characteristics of the *Hui* are correlated with local situations and people's preferences. In this study, I particularly focus on rule disparities in different villages. Basic household information was collected in the field and, through recorded interviews and narrative analysis, this paper tries to illustrate local peoples' preferences related to ROSCAs and to determine potential reasons for such preferences. The particular characteristics of each ROSCA probably respond in some way to the needs of the population living in the area.

The choice of mechanism for allocating the ROSCA order has been of considerable interest to previous researchers. Kovsted and Lyk-Jensen (1999) pay particular attention to the choice between random and bidding ROSCAs. With the consideration of outside funds, their results show that both types can improve participants' welfare, and people's choices depend on both the cost of obtaining financial resources outside the ROSCA and the dispersion of type of ROSCA members.

Ambec and Treich (2007) established a model based on the premise that people want to avoid spending unexpected money on purchasing "superfluous goods." Thus, ROSCAs are viewed as a commitment device which helps people to cope with self-control problems.

As described previously, ROSCAs might have originated from private borrowing mechanisms. However, once a ROSCA evolved into a more organised form and became larger, and because it is hard to forecast the coming of emergencies, it was recognised that later obtainers could be motivated by gaining extra funds (interest) as the compensation for waiting; this can be incorporated into the rules when the orders are

negotiation-oriented. Different ROSCA rules emerge naturally.

As the previous literature shows, *Hui* relied heavily on the community monitoring system enforced by local networks. But, as *Hui* become larger, moral hazard problems inevitably happen. Historically, several *Hui* containing thousands of members terminated with defections, which caused huge losses to the members.

As noted previously, a ROSCA group is managed successfully when all participants contribute to the fund after they have received their payment; otherwise the system collapses even if only one member of the group defaults. However, limited research has simulated and discussed the fitness of a social rule and how it evolves or distinguish by using agent-based model, which allows each individual has his or her own preference on rule choice. In Koike et al. (2010, 2015)'s research, they used agent-based model and simulate the situations when cooperation in ROSCA can be maintained or collapse; they suggest peer selection and forfeiture rule should be combined to punish free rider. This literature shows the possibility of simulating social rule choice by assuming individual's preference.

Chapter 3 RESEARCH METHODOLOGY

The objective of this chapter is to describe the research methodology from the viewpoint of an evolutionary cooperative game based on imitation behaviour and ROSCA utility calculation.

Section 3.1 describes the targeted ROSCA scheme in this thesis with reference to the most referred ROSCA models. When constructing the utility model of participating a ROSCA group, first, its financial characteristics is highlighted by separately calculating the cost and benefit of joining a ROSCA group. Next, based on the literature and history review in Chapter II, the mutual-aid spirit, which also refers to reciprocity, is considered in the utility function. The imitation game is considered an effective framework for explaining rule choices, especially in the process of evolution of cooperation. Thus, the imitation game is adopted as the main approach to explain the choices of rules for cooperation in ROSCAs. To examine the results obtained in the computer simulations, questionnaire interviews and a preference experiment were designed. This approach enables the researcher to combine computer simulation with empirical study.

3.1 The Evolution of Cooperation Rule Choices in ROSCA

3.1.1 Towards the construction of a ROSCA model

The considerable literature on ROSCAs reveals many variations of how they work in

practice. In these papers, ROSCA rules and mechanisms for determining the order of obtaining the money pot have been widely discussed and have been used as a classification criterion. These types, which include the *random ROSCA*, the *bidding ROSCA* and the *mixed ROSCA*, differ primarily in the ordering method used to determine which of the members receives each pot. Using Kovsted's (1999) classifications, we can categorise them into the following three types:

a. The random ROSCA: The order of obtaining the money pot is decided by lottery, either before the whole ROSCA starts or before each meeting.

b. The bidding ROSCA: The money pot is given to the person who gives the highest bid in that meeting.

c. The mixed ROSCA: The order of allocating the pool is decided by some pre-defined criterion, including the social influence of the leader(s) and/or members, degree of emergency, social network, and reputation.

In China, although the above three ROSCA types all exist, the random ROSCA has the longest history and is the most popular. In this thesis, the research objectives are focused on the rules of random ROSCA in China.

As has been discussed, joining a ROSCA is essentially establishing a borrowing-lending relationship. Because normally more than two people are needed to form a ROSCA group, some mechanism is needed to allocate the accumulated money pot to each participant. Under the common rotating rule in ROSCAs, all participants except the last order people will take the money pot earlier than if they had accumulated the funds on their own.

Besley et al. (1993) developed an economic model of ROSCA, which is considered one of the most profound frameworks for discussing ROSCA. The model depicts an individual's decision to participation in a ROSCA group using the preferences of choosing the type of ROSCA. The size of the ROSCA money pot is assumed constant throughout the whole process and specifically equal to the value of a durable good that the participant is complementary to purchase. Therefore, the benefit of participating in a ROSCA is located at the point of possibly obtaining the durable goods earlier than by autarky (saving by themslves). In their model, money discounting is not considered. Assuming a constant money pot is convenient for model construction but does not reflect real ROSCA rule situations in China. Thus, in order to discuss the benefit of participating, a more advanced model that allows for the consideration of discounting and a changing money pot is needed.

Kuo's (1993) model of ROSCA involves a bidding ROSCA and money discounting is considered as individual information which is assumed to be heterogenous and changing at each meeting. This model highlights the necessity of money discounting and individual heterogeneity; however, it is debatable whether frequent changes of individual information (preferences) are realistic.

In section 2.4, previous research on ROSCA participation motivations is reviewed; these motivations can be grouped into two types: *direct benefits* and *indirect benefits*. Direct benefits include: 1) the early pot motive (Besley et al., 1993; Anderson et al., 2009; Bisrat et al., 2012), i.e., that participants may be able to purchase durable goods or invest in a family business earlier; 2) extra interest income to compensate participants who obtain the money pot relatively late (Sandsør, 2010); 3) the insurance motive (Calomiris &

Rajaraman, 1998; Klonner, 2003); and 4) the commitment device model (Ashraf et al., 2006; Gugerty, 2007). As for *indirect benefits*, these are related to indirect reciprocity; Ambec and Treich (2007) describe it as a kind of social pressure. This may become a social mechanism that insures a person will be helped when he or she needs it; similarly, people may participate in a ROSCA because of indirect reciprocity.

Therefore, this thesis aims to provide a new model for analysing the benefits of participating in different ROSCA schemes, with reference to the above models. Specifically, as ROSCA rules in China have evolved to take on various forms (see more details in section 4.2), a more elaborate model is necessary to discuss the utility differences among ROSCA rules. At the same time, from the literature review it is clear that reciprocity should not be ignored as it is essential to both the evolution of cooperation and the original motivation for forming a ROSCA.

3.1.2 Evolutionary imitation game for rule choices

As stated in the research objectives in the introduction, this research aims to identify what determines an individual's choice of ROSCA participation based on the rules they prefer.

Evolutionary stability

The stability and robustness of a strategy in a population is one of the key issues discussed in evolutionary game theory. Maynard Smith and Price (1973) were the first to formulate the concept of evolutionary stability. An *evolutionary stability strategy* (ESS) describes a strategy that is immune to invasion by a minority of mutants playing a different strategy

(Szabo & Fath, 2007). Note that, as a dominant strategy on an evolutionary timescale within an infinite population (the situation of finite populations is discussed more in most recent literature), strategies observed in the real world can be considered as typical ESSs.

Imitative dynamics

Evolutionary game theory is completed by game dynamics, i.e., the model that defines the updating strategies in the population. Imitative dynamics describes a dynamic strategy distribution in a population in which each agent imitates the better strategies of other players. More specifically, when a player receives an updating opportunity, he or she randomly chooses an opponent in the population and observes the opponent's strategy and its payoff. Then, the player imitates the opponent's strategy with a probability depending on his or her payoff or preference (Hofbauer & Sigmund, 1998). As shown by Fudenberg and Imhof (2006), mutations can be introduced into the imitation dynamics.

In the classic ROSCA choice model, a simple mathematical setting is assumed in which the optimal strategy for decisions based on an analysis of costs and benefits is predicted. However, tackling more realistic research issues requires an agent-based model where the preferences of each individual can be modelled to determine decisions. As reviewed in Chapter 2.3, according to evolutionary game theory, players are not born to be rational; instead, successful strategies spread by being copied through imitation or learning. To be more specific, as an important part of game theory, evolutionary imitation game theory tries to explain how a new behaviour or a new rule is diffused among the whole society by assuming that people adopt new things when they encounter others who have already adopted them.

3.2 Field work

Although facilitating access to credit and formal financing among the poor has been high on the agenda for governments and institutions, success has been limited in most rural financial institutions in developing areas for a long period (Jain, 1996; Yaron, 1992a). Certain institutions, such as ROSCAs, have worked better in some areas, but failure has also been observed in other areas.

The second main research methodology in this research were field work and interviews. These were conducted in Chinese villages to directly measure economic factors among individuals belonging to ROSCAs, and to investigate how these parameters correlated with the participants' ROSCA rule preferences.

Site selection

As the first research objective shows, this thesis aims to discuss how different cooperation rules can emerge and be sustained; thus, it is essential to choose the field work site that allows us to track the developing history of this cooperative behaviour and investigate its current situation. Therefore, villages in China were chosen where ROSCA groups currently exist or once did, and which will be described in Chapter 6. The selected site used to be relatively closed, located in a less developed area that lacked formal financial services, and formed its own special culture, which can also be observed until today. However, with recent economic developments, formal financial institutions have become more accessible. Choices related to ROSCA rules show some new aspects in the study area.

Interview and Experiment

By contacting local government officials, interviewees were randomly chosen from villager lists and 60 households were selected for interview in each village. The fieldwork consisted of three parts. In the first part, basic individual and household information was collected. For the second part, questions related to ROSCA participation were asked, including the ROSCA rules, participation preferences, and comparison with formal finance. In each case, the whole conversation was recorded and transcribed in order to analyse the interviewee's attitude and rule preferences on ROSCA. The third part involved an experiment designed to elicit each individual's preferences for money discounting.

This chapter has provided a description of the research methodology used in this thesis work in order to tackle the research objectives and questions stated in Chapter I. In the following chapters, more detailed explanations of the model and methods will be provided.

Chapter 4 BASELINE MODEL OF ROSCA

4.1 Introduction

In the field, the random ROSCA is more common and the rules are more flexible; sometimes it appears with mixed types (in which the partial orders of obtaining the money pot can be negotiated, especially when someone is in urgent need). In this thesis, I focus on the random ROSCA. Based on the literature and fieldwork, under the category of random ROSCA there are observed rule disparities which can be categorised into several types. The details of each type are defined as follows.

The common rule for all types of random ROSCA is that the order of obtaining the money pot is decided by lottery before the ROSCA begins. The distinguishing characteristics of random ROSCA types are identified by the following rules:

1) Payment may or may not be consistent in every meeting for each order. The payments in each meeting are combined into the money pot that is given to one of the members. This may result in disparities among different ROSCA types in the total payment obtained by each participant.

2) It has been mentioned that the order of obtaining the money pot is decided by a one-off lottery before the start of the ROSCA. However, due to the special characteristics of ROSCAs, including self-organisation, flexibility, and reciprocity, partial orders can be negotiated among the participants. For example, a group leader

is responsible for organising the meetings and other issues. Thus, in some types, the leader can choose the order of obtaining the money pot, including for the reciprocal reason. In such cases, it can be arranged for an individual in urgent need to be moved earlier in the order.

In this chapter, the details of different ROSCA types in China that follow the above-mentioned rules will be described in section 4.2, in which ROSCA schemes are discussed and the types of random ROSCA are defined. In section 4.3, the pecuniary payoff equation of participating in a ROSCA group is proposed with the consideration of exponential time discounting factor δ; in section 4.4, reciprocal behaviour is defined and the reciprocal factor, θ, is adopted as the weight of caring about other people's utility.

4.2 ROSCA Types in China

A ROSCA usually happens among a group of relatively homogenous people who live close to each other and have similar consuming abilities or needs, with limited outside financial resources.

Let $X = \{1, 2, \ldots, m, \ldots, M\}$ denote a society with M individuals. Each individual m has the property θ_m, in which θ_m denotes the reciprocity factor for individual m. Let $s_i \in I \times F$ denote a ROSCA group information set, where s_i varies depending on the ROSCA type i and detailed parameter values in F. Let $F = \{\varphi_i\}_{i \in I}$ denote the set of ROSCA group alternatives, where $I = \{1, 2, 3, \ldots\}$ is the set of ROSCA types, which indicates different rules of different types, and let $\varphi_i \subseteq \Theta = \{w, \alpha, d, \eta\}$ denote the set of ROSCA rule parameters, which will be explained below in this section.

As mentioned above, ROSCAs have appeared all over the world for a long time; therefore, it is not possible to enumerate all types of ROSCA that exist. In this section, the four main types of ROSCA in China, including the calculating equations, are exhibited in 4.2.1 to 4.2.4. Based on these types, how evolution and coexistence occur in each model will be discussed in the next chapter.

The main difference among these four types of ROSCA is their way of deciding the payment of each player at each meeting. Here, let $a_i(k, n)$ denote the payment at the k^{th} meeting for the player who obtains the money pot at n^{th} order in one ROSCA group that belongs to type *i*. Therefore, for each type of ROSCA below, the formula to calculate $a_i(k, n)$ is shown. It is assumed that N is the number of people participating in the group. One of the characteristics of a ROSCA is to aid people in urgent need of money; this may be done by placing them earlier in the order (normally, first). In this way, a participant's savings target will be decided beforehand. Here, let w denote the target money pot under one ROSCA rule, which denotes how much money is collected and given to the first participant. Thus, w is decided by the members before each ROSCA begins.

Suppose all participants have different time-related preferences and are aware of it. At each meeting of one type, all the players contribute a pre-decided amount to form a money pot and one of the players takes all the funds collected at this meeting; the money pot thus becomes empty. At the next meeting, players refill the money pot in the same way and another player takes all the money away with them. After N meetings (i.e., all the players have taken the money once in turn), this round of ROSCA stops.

To show the rules more intuitively, real cases from the field are given for each type to

explain how much a participant needs to pay at every ROSCA meeting. All the schemes are budget balanced.

4.2.1 Type 1: Suojin ROSCA

The first type is the Suojin ROSCA and is characterised by φ_1, number of participants N, money pot w, and a parameter, α ($0 \leq \alpha \leq 1$), indicating the ratio between the payments of the player who receives the money pot at the last meeting and the payments of the player who receives it at the first meeting. The payment made by each member at each meeting keeps decreasing until the member obtains the pot; then, the amount of money in the payment changes into a fixed number (in the case of Table 4.1, the fixed number is 10,556 *yuan*). The Suojin ROSCA has been popular in the south eastern part of China since the Qing dynasty when informal financial institutions and small family businesses began and became prosperous. The rule for calculating the amount one member must pay at each meeting is much more complex than the traditional method described below and demands a higher education level of the participants (Wang, 1930). The payment at each meeting of each person $a_1(k,n)$ is calculated based on equation (1):

$$a_1(k,n) = \begin{cases} \frac{w-c(k-1)}{N-k+1}, & 1 \leq k \leq n \\ c, & n < k \leq N \end{cases} \quad (1)$$

where

$$c = \frac{w(1-\frac{\alpha}{N})}{N-1}$$

Table 4.1 Flow of Money in Suojin ROSCA

Meeting (k)/order (n)	1	2	3	4	5	6	7	8	9	10
1st meeting	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
2nd	10556	9938	9938	9938	9938	9938	9938	9938	9938	9938
3rd	10556	10556	9861	9861	9861	9861	9861	9861	9861	9861
4th	10556	10556	10556	9762	9762	9762	9762	9762	9762	9762
5th	10556	10556	10556	10556	9630	9630	9630	9630	9630	9630
6th	10556	10556	10556	10556	10556	9444	9444	9444	9444	9444
7th	10556	10556	10556	10556	10556	10556	9167	9167	9167	9167
8th	10556	10556	10556	10556	10556	10556	10556	8704	8704	8704
9th	10556	10556	10556	10556	10556	10556	10556	10556	7778	7778
10th	10556	10556	10556	10556	10556	10556	10556	10556	10556	5000
Total payment	105004	104386	103691	102897	101971	100859	99470	97618	94840	89284
Total income	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
Net income	-5004	-4386	-3691	-2897	-1971	-859	530	2382	5160	10716

In Table 4.1, $N = 10$, $w = 100{,}000$, and $\alpha = 0.5$.

4.2.2 Type 2: Shensuo ROSCA

The second type, Shensuo ROSCA, is characterised by φ_2, N participants, money pot w, and a parameter, d, which stands for a payment gap between each meeting for the first-order player. As the leader's premium, the leader obtains the money pot at the first order without paying extra interest. The payment made at each meeting by each person $a_2(k,n)$ is calculated based on equation (2). An example is given in Table 4.2 to show the flow of money in a Shensuo ROSCA for a group containing 10 members, aiming to collect 100,000 *yuan* as the money pot and with a payment gap fixed at 200 *yuan*.

$$a_2(k,n) = \begin{cases} 0, & k = n \\ h - d(n-2), & k \neq n \end{cases} \tag{2}$$

where

$$h = \frac{w}{N-1} + \frac{(N-2)d}{2}$$

Table 4.2 Flow of Money in Shensuo ROSCA

Meeting (k)/order (n)	1	2	3	4	5	6	7	8	9	10
1st meeting	0	11511	11411	11311	11211	11111	11011	10911	10811	10711
2nd	11511	0	11411	11311	11211	11111	11011	10911	10811	10711
3rd	11411	11511	0	11311	11211	11111	11011	10911	10811	10711
4th	11311	11511	11411	0	11211	11111	11011	10911	10811	10711
5th	11211	11511	11411	11311	0	11111	11011	10911	10811	10711
6th	11111	11511	11411	11311	11211	0	11011	10911	10811	10711
7th	11011	11511	11411	11311	11211	11111	0	10911	10811	10711
8th	10911	11511	11411	11311	11211	11111	11011	0	10811	10711
9th	10811	11511	11411	11311	11211	11111	11011	10911	0	10711
10th	10711	11511	11411	11311	11211	11111	11011	10911	10811	0
Total payment	100000	103600	102700	101800	100900	100000	99100	98200	97300	96400
Total income	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
Net income	0	-3600	-2700	-1800	-900	0	900	1800	2700	3600

In Table 4.2, $N = 10$, $w = 100{,}000$, and $d = 100$.

4.2.3 Type 3: Duiji ROSCA

The third type is the Duiji ROSCA, characterised by φ_3, number of participants N, money pot w, and a parameter, η (>1), which stands for an increased payment ratio for each player after they take the money. This type is popular due to its ease of handling and extra benefits that are used to compensate the later recipients. At the same time, the shortcoming of this type is obvious: the earlier recipients pay too much interest. The payment at each meeting made by each person $a_3(k,n)$ is calculated based on equation (3):

$$a_3(k,n) = \begin{cases} \frac{w}{N}, & 1 \le k \le n \\ \frac{\eta w}{N}, & n < k \le N \end{cases} \tag{3}$$

An example is given in Table 4.3 to show the flow of money in a Duiji ROSCA that has 10 group members, aims to collect 100,000 *yuan* for the first obtainer, and has a payment ratio of 1.1

Table 4.3 Flow of Money in Duiji ROSCA

Meeting (k)/order (n)	1	2	3	4	5	6	7	8	9	10
1st meeting	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
2nd	11000	10000	10000	10000	10000	10000	10000	10000	10000	10000
3rd	11000	11000	10000	10000	10000	10000	10000	10000	10000	10000
4th	11000	11000	11000	10000	10000	10000	10000	10000	10000	10000
5th	11000	11000	11000	11000	10000	10000	10000	10000	10000	10000
6th	11000	11000	11000	11000	11000	10000	10000	10000	10000	10000
7th	11000	11000	11000	11000	11000	11000	10000	10000	10000	10000
8th	11000	11000	11000	11000	11000	11000	11000	10000	10000	10000
9th	11000	11000	11000	11000	11000	11000	11000	11000	10000	10000
10th	11000	11000	11000	11000	11000	11000	11000	11000	11000	10000
Total payment	109000	108000	107000	106000	105000	104000	103000	102000	101000	100000
Total income	100000	101000	102000	103000	104000	105000	106000	107000	108000	109000
Net income	-9000	-7000	-5000	-3000	-1000	1000	3000	5000	7000	9000

In Table 4.3, $N = 10$, $w = 100{,}000$, and $\eta = 1.1$.

4.2.4 Type 4: Traditional ROSCA

Traditional ROSCA was a type that used to be popular in China. According to the interviews conducted in this research, the basic principle of this traditional type is that when there is someone in need of money (for example, in an emergency or for a big event), relatives and neighbors gather together and contribute to a money pot and one of them receives it in rotation; thus, in this type, no extra interest is required. In terms of motivation for the participants without emergency needs, their answer is, basically, "I help other people this time, and they will also help me next time." Therefore, even without the extra benefit of interest, people were still willing to join in. The organising rule of this type is the simplest one compared to the other three types, that is, all the members pay the same amount of money at every meeting. This is characterised by φ_4, number of participants N, and money pot w. The payment at each meeting made by each person $a_4(k,n)$ is calculated based on equation (4):

$$a_4(k,n) = \frac{w}{N} \tag{4}$$

An example is given in Table 4.4 to show the flow of money in a Traditional ROSCA, where the group contains 10 members and aims to collect 100,000 *yuan* for the money pot.

Table 4.4 Flow of Money in Traditional ROSCA

Meeting (k)/order (n)	1	2	3	4	5	6	7	8	9	10
1st meeting	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
2nd	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
3rd	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
4th	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
5th	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
6th	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
7th	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
8th	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
9th	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
10th	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Total payment	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
Total income	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
Net income	0	0	0	0	0	0	0	0	0	0

In Table 4.4, $N = 10$ and $w = 100{,}000$.

4.3 Pecuniary Payoff from a ROSCA

One of the main purposes of this thesis is to analyse participants' rule preferences among different random ROSCA rule choices (different ROSCA types). The model developed here closely depicts the different observed rules of a ROSCA. It is considered that those different rules appearing in a ROSCA reflect different levels of economic development, pecuniary needs, levels of reciprocity, and so on. These varieties show the high flexibility and rational responses of a random ROSCA, which allows maximising the expected utility of its members.

In any one round of ROSCA, the revenue of the player who receives the money pot at the n^{th} order, hereby denoted as $C_n(s_i)$, depends on the payment that each player makes at each meeting, which can be calculated by the following equation (5):

$$C_n(s_i) = \sum_{n'=1}^{N} a_i(n, n') \tag{5}$$

By definition, for ROSCA types 1, 2, and 4, $C_n(s_i)$ is constantly equal to the money pot w: i.e., $C_n(s_1) = C_n(s_2) = C_n(s_4) = w$ for $^{\forall}n$. For type 3, the revenue that each participant receives depends on the order, which is given by $C_n(s_3) = \frac{nw+(N-k)\eta w}{N}$. Thus, for simplicity of notation, $C_n(s_i)$ is used to denote the income for each participant.

Let $u(n|s_i)$ denote the net pecuniary payoff of a player who chooses group s_i. The pecuniary payoff is affected by the discount factor of the society δ, the ROSCA group (s)he participated in, and the order in which the player takes the money. This

relationship is described in the equation (6):

$$u(n|s_i) = C_n(s_i) \cdot \delta^{n-1} - \sum_{k=1}^{N} a_i(k,n) \cdot \delta^{k-1} \quad (6)$$

4.4 Reciprocal Behaviour in Participating in a ROSCA

An outstanding example of cooperation in human history, reciprocal behaviour in a ROSCA is widely known and discussed and is one of the main incentives encouraging people to participate. Therefore, it is straightforward to assume that rule preferences in a society with a higher level of reciprocity will be different from those in a society with a lower one.

Direct reciprocity relies on repeated encounters between the same two individuals, but often the interactions among humans are asymmetric. Helping someone by participating in a ROSCA establishes a good reputation, which may help in getting assistance from others in the future. The reputation-accumulating mechanism in a ROSCA is called indirect reciprocity and captured in the principle: "I help you this time, and when I need help, someone else will help me back" (Nowak and Sigmund, 2005).

Normally, a ROSCA is established for a person in urgent need who wants to obtain the money pot in the first order. In this sense, members in a ROSCA do not only care for their own monetary benefit, but also value the utility of another person who needs help. The basic postulate is that individuals' concerns toward others can be characterised by reciprocal utility functions. For the sake of simplicity, let us consider that the person who obtains the money pot at the first order is solely in urgent need of money. In this sense, the first order of obtaining the money pot has been decided in advance. For the

others, their order is decided randomly by a lottery. Therefore, the expectation of monetary benefit for those participants not receiving the money pot at the first order in this ROSCA (denoted with the suffix _1) is calculated by equation (7):

$$E_{\_1}(s_i) = \frac{1}{N-1}\sum_{n\neq 1} u(n|s_i) \tag{7}$$

The reciprocity characteristic of players is considered herein as one of the incentives to participate in a ROSCA. The expected utility of participant *m* (denoted as *v*) is thus affected by players' reciprocal parameters θ_m and the utility of the first order obtainment player denoted as $u(1|s_i)$, and expressed as in equation (8). Note that this expected utility no longer depends on the order in which the player *m* receives the money pot.

$$v_{\_1}(m|s_i) \;=\; (1-\theta_m)E_{\_1}(s_i) + \theta_m u(1|s_i) \tag{8}$$

Also, note that $\theta_m u(1|s_i)$ shows how much player *m* cares about the first recipient's benefit in his/her group with the weight of θ_m.

Chapter 5 ROSCA RULE CHOICES BASED ON EVOLUTIONARY IMITATION GAME

5.1 Introduction

This chapter focuses on the evolution of cooperation and rule choices based on the baseline ROSCA model described in Chapter IV. In this chapter, a social learning model of how individual reciprocity and time discounting level affects people's rule preferences is proposed. It is assumed that individuals change their choices through interactions with others, following an imitation rule which will be described in section 5.2. Section 5.3 describes the computer simulation procedure. Section 5.4 demonstrates the numerical results and Section 5.5 discusses the results and concludes the chapter.

This chapter aims to provide a new framework and insights to analyse the factors underlying the rule preferences and choices among different schemes of ROSCAs, and to show its evolutionary direction to contribute to the practical use of evolutionary cooperation theories.

5.2 ROSCA Participation on Evolutionary Imitation Game

In this chapter, we follow evolutionary game theory and an imitation game is proposed as an attempt to imagine the trajectory of rule preference changes, which allows participants to learn about new ROSCA types by encountering and learning from others.

Assuming each individual decides which ROSCA to join based on his/her reciprocal utility in equation (8), the evolutionary dynamism of human cooperation produced through ROSCA is very complex and of a nonlinear nature. In real human society, such behaviours also involve trial and error to find a more desirable ROSCA rule. The basic assumption is that when adopting a new ROSCA rule, each individual makes a rational choice of a ROSCA type that maximises his or her payoff as compared to the last choice and according to his/her degree of reciprocity. The imitation rule as to when and how each participant changes his/her actions in interacting with other participants is set as the following.

In the initial round, an individual m randomly joins a ROSCA group s_p of type p. He or she receives a revision opportunity when (s)he finishes one round of ROSCA and randomly encounters another member in the society who does not belong to the s_p group. He or she observes the encounter's ROSCA type information set (for example, group s_q) and its expected payoff. Then, the participant imitates the actions of someone (s)he met and considers joining one of their ROSCA groups from the next round if the expected utility of the s_q group is greater than that of the s_p group according to his or her personal preference, θ_m.

Ideally, a ROSCA group with a higher utility leads to a higher probability that it is chosen. However, as previously mentioned, a ROSCA is a cooperative behaviour in which a certain number of participants in the group is required and pre-determined (e.g., a ROSCA with a group size of 5 cannot be operated by only 3 players). Hence, in our simulation game, a player can join a group only when the exact number of people are willing to join in the same group in the next round; otherwise, players who fail to gather a group have to wait until the next round.

5.3 Computer simulation procedure

The initialization of this simulation is described as the following. Suppose there are M players in the society; they do not have any access to financial institutions except for participating in a ROSCA, and once they participate in a ROSCA group, no one will default. Personal information including reciprocity value and discounting value for each individual is generated; this does not change if there are no special requirements. Then, ROSCA groups are generated, within which group size in each type varies according to certain capacities; also, the amount of the money pot ranges within a reasonable scale. Therefore, a ROSCA group contains the ROSCA rules, a certain number of group members, and a fixed money pot. In the initial round, all players in the society are allocated in equal proportions into the four ROSCA types, and each of them only belongs to one ROSCA group in each round. Accordingly, the player m's expecting utility $v_{\_1}(m|s_i)$ is calculated.

The random encounter happens when the first round of a ROSCA is finished. Each player encounters one other player in the society and obtains information about a "new" (different) ROSCA type only from the newly encountered person. The player then decides whether to change group or not, and another round of ROSCA starts.

At the end of each round, new ROSCA groups are formed since each individual's preference has changed. In this process, the rule for forming a new ROSCA group is as the following. First, one counts the members who have their hands up for each ROSCA group in the society after they have finished the above encounter; Second,

i) If an exact number of members in the society wants to join a certain ROSCA

group from the next round, then the group is established in the next round.

ii) If more players prefer a certain ROSCA group exceeding the group capacity from the next round, then members will be randomly chosen to form the preferred group(s).

iii) If there are players left, these players go back to their previous groups; however, if there are not enough members to form their previous group, then the players left will not join any ROSCA group in the next round, and their expected utility is zero. They will start to raise their hands for the preferred group(s), since the next round is finished.

Lastly, the above process continues until the proportion of the population joining each type converges to a stable value. The final ratios of the four main types are based on the total numbers of each subtype.

5.4 Results of Numerical Simulation

In this section, the numerical simulation results based on the above framework described in sections 5.2 and 5.3 and programmed on MATLAB (2014b) are presented. Following the aforementioned updating principles, in this chapter I attempt to provide an understanding of how different distributions of reciprocity and time discounting value influence participants' preferences for the four types of ROSCA through numerical simulation.

In this section, I suppose there are 7,200 players in the society. In the initial round, all

players in the society are allocated in equal proportions into the four ROSCA types, in which there are 1,800 players in each ROSCA type and at least one group can be formed for each ROSCA group. For each ROSCA type, 10 different money pot values are considered, ranging from 10,000 to 100,000, with an interval of 10,000. Similarly, group capacity varies from 5 to 40 with intervals of 5. As a result, 80 subtypes are generated within each of the four types, through combining different group sizes and money pot values. A flowchart of this imitation game procedure is given in Figure 5.1.

The numerical simulation results are presented for homogeneous and heterogenous societies in terms of the reciprocity and time discounting values in sections 5.4.1 to 5.4.4. The results for simulations of social changes are presented in section 5.4.3.

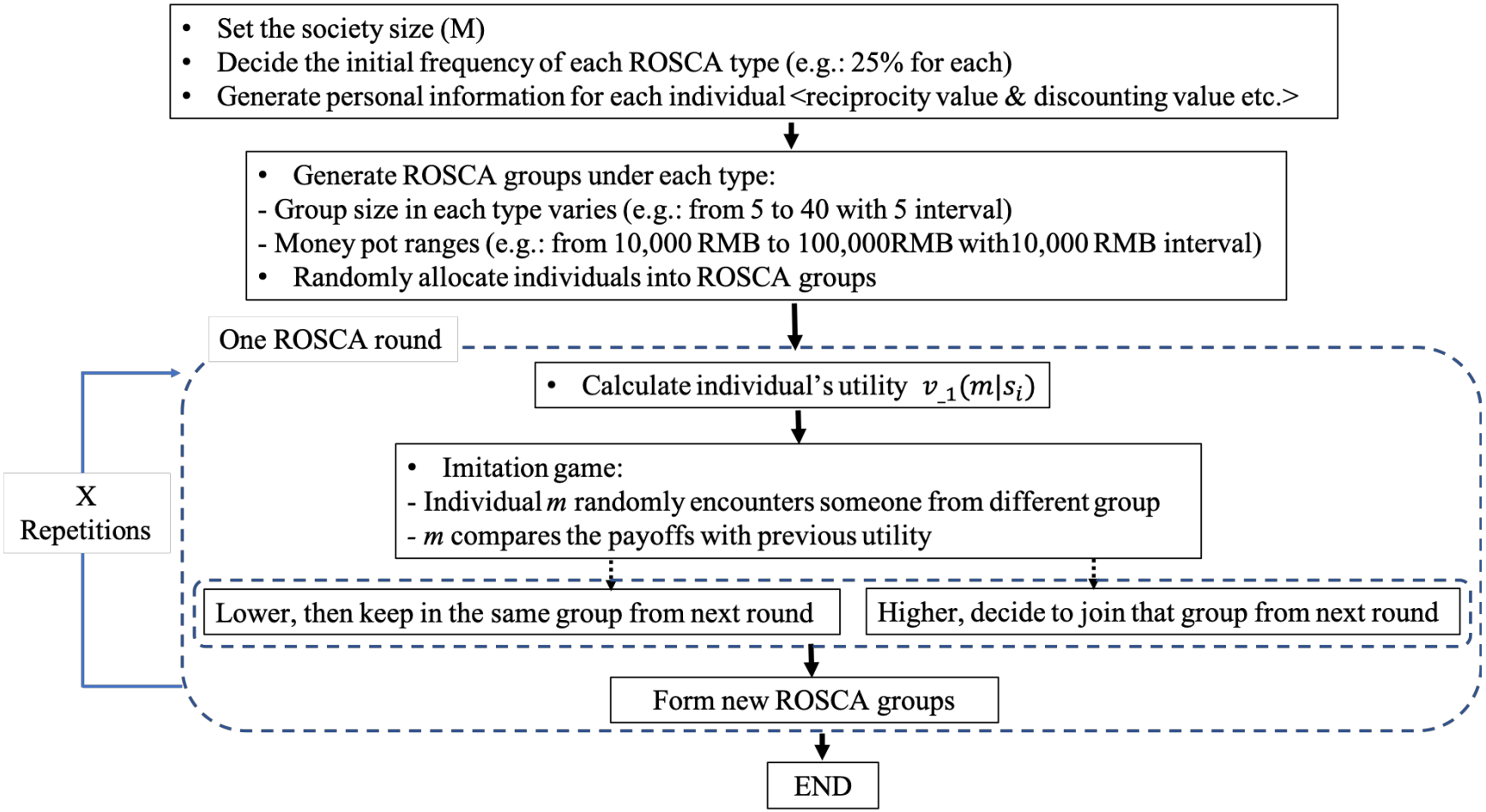

Figure 5.1 Flowchart of imitation game on ROSCA rule choice

5.4.1 Homogeneous society

To show a more detailed picture of the relationship between reciprocity and rule preferences in a ROSCA game, the value of θ is divided into 10 partitions with an interval of 0.1, ranging from 0 to 1 as shown in Figure 5.2. Each portion represents the mean converged share of its corresponding ROSCA type (out of 100×1,000 trials) in which the reciprocity parameter θ is uniformly distributed across each interval. Within an interval, the results in Figure 5.2 show a homogeneous society where all players share the similar reciprocity value.

In a more homogeneous society, the share of type 1 reaches a peak where the value of θ in the society is distributed at both 0.2 to 0.3 and 0.3 to 0.4 on the reciprocity scale. The portion of type 2 is comparatively bigger in both selfish (0.0-0.2) and altruistic (0.8-1.0) societies, whereas type 3 attracts more people only in a selfish society (especially around 0 to 0.2 on the reciprocity scale) and loses its advantage when the society becomes more reciprocal. Type 4 gradually attracts more people as the society becomes more altruistic and becomes the dominant type when θ exceeds 0.5. These results help to explain why, in a specific society, there always exists a dominant type of cooperation. At the same time, it is worth noting that although different reciprocity settings produce different equilibria, there is no setting under which any of the rules completely disappeared during the simulated evolutionary processes. According to standard deviation showing in Table 5.1 and frequency distribution of Type 1 to 4's ratio where the reciprocity parameter θ is uniformly distributed on (0, 0.1), it is found that this is a no-linear dynamic process which the results are relying on the initial value and individual stochastic encountering. Since it is quite similar process and to save the

space, only standard deviations will be shown in Section 5.4.2 Heterogeneous society.

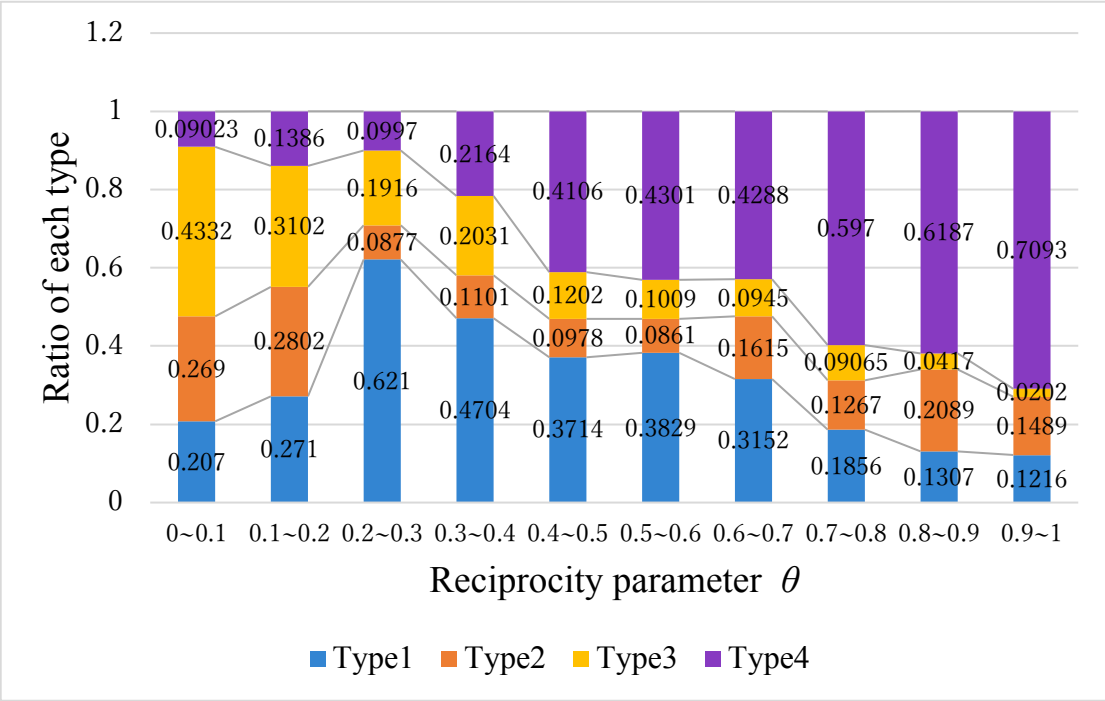

Figure 5.2 Ratio of four ROSCA types on different θ partitions (intervals of 0.1)

Table 5.1 Standard deviation of frequency distribution for ROSCA Type 1~4 on different θ partitions (interval=0.1)

θ / Type	0~0.1	0.1~0.2	0.2~0.3	0.3~0.4	0.4~0.5	0.5~0.6	0.6~0.7	0.7~0.8	0.8~0.9	0.9~1.0
Type 1	0.1007	0.1411	0.1614	0.2504	0.1325	0.1949	0.2005	0.2243	0.1328	0.2541
Type 2	0.1268	0.0331	0.2436	0.1268	0.2060	0.0226	0.1095	0.0394	0.0853	0.0233
Type 3	0.0945	0.1019	0.0437	0.1733	0.1192	0.1301	0.1771	0.1554	0.0310	0.2248
Type 4	0.1344	0.1663	0.3080	0.0726	0.2611	0.2567	0.1082	0.0063	0.1864	0.0156

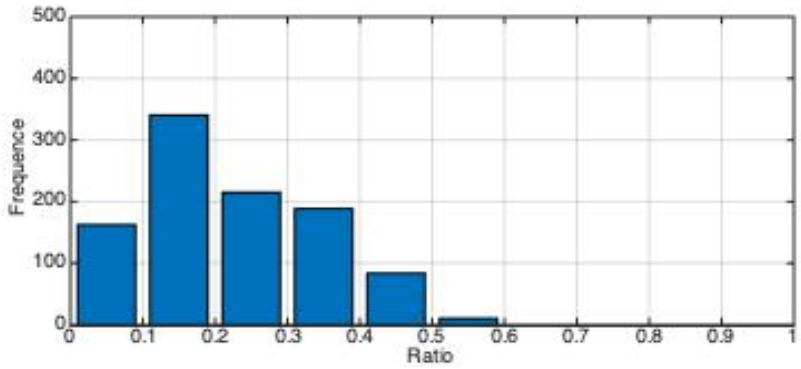

Figure 5.3 Frequency distribution of Type 1's ratio where the reciprocity parameter θ is uniformly distributed on (0, 0.1)

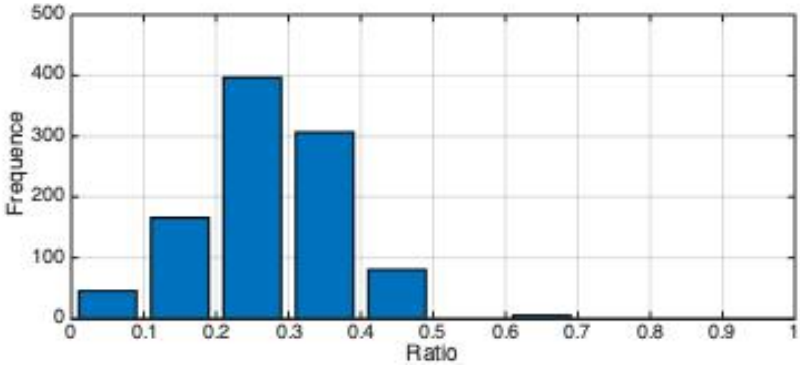

Figure 5.4 Frequency distribution of Type 2's ratio where the reciprocity parameter θ is uniformly distributed on (0, 0.1)

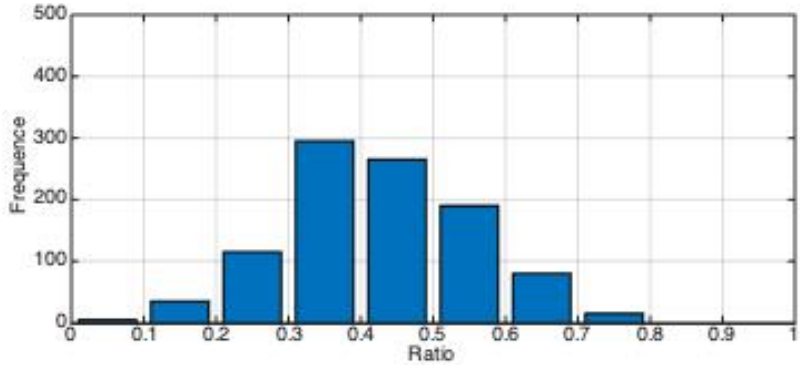

Figure 5.5 Frequency distribution of Type 3's ratio where the reciprocity parameter θ is uniformly distributed on (0, 0.1)

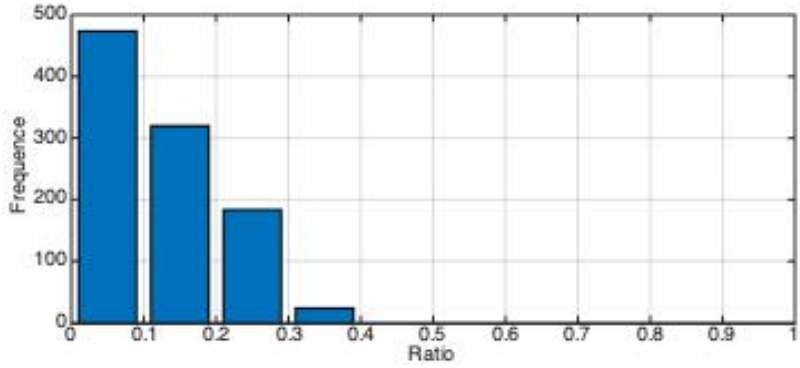

Figure 5.6 Frequency distribution of Type 4's ratio where the reciprocity parameter θ is uniformly distributed on (0, 0.1)

To show this process more clearly, the results for 100 rounds of ROSCA are given for different societies with different reciprocal value representatively. Figure 5.7 and Figure 5.8 illustrate typical simulation outcomes in a *selfish* society where the reciprocity parameter θ distributes uniformly on (0, 0.1) and (0.2, 0.3). Note that the type 3 ROSCA dominates in the selfish society with around 90% of the population when social reciprocity value distributing on (0, 0.1), and the type 1 ROSCA dominants in the relative selfish society where reciprocity value distributing on (0.2,0.3).

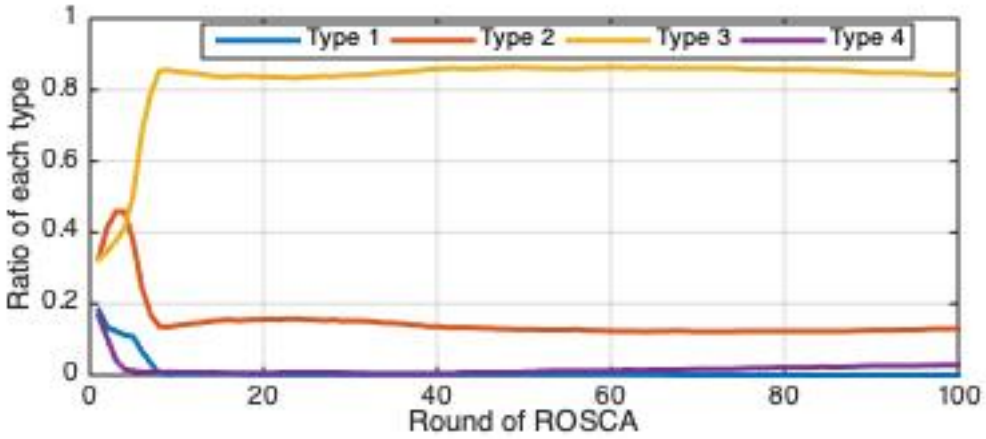

Figure 5.7 Selfish society where the reciprocity parameter θ is uniformly distributed on (0, 0.1)

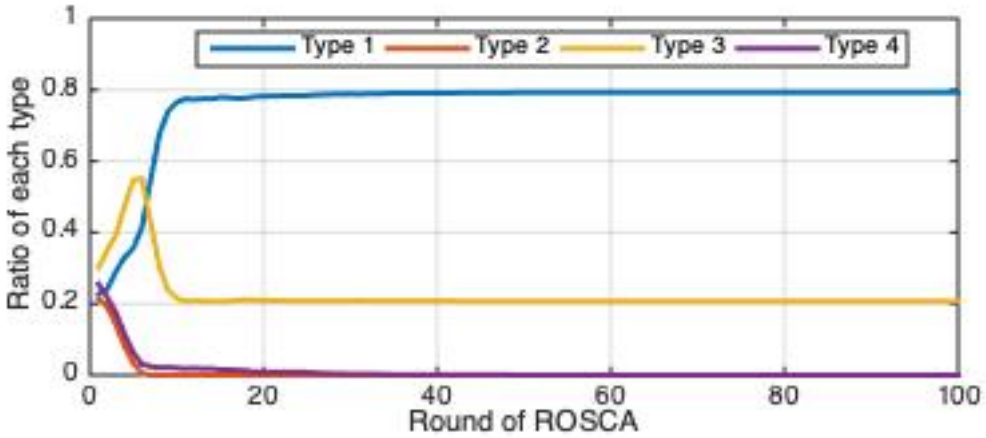

Figure 5.8 Selfish society where the reciprocity parameter θ is uniformly distributed on (0.2, 0.3)

In contrast, in an *altruistic* society, where the reciprocity parameter θ distributes uniformly on (0.5, 0.6) and (0.9, 1), the type 4 is the most popular ROSCA in the both societies, chosen by 90% of the population, as shown in Figure 5.9 and Figure 5.10. Observations from an altruistic society are similar to that in the selfish society when reciprocity value distribute on a relatively small interval (here 0.1 interval), which in a typical snapshot of one hundred runs, a ROSCA type becomes the dominant and most popular choice in the certain society, and this type usually attracts more than 80% people of the whole society.

The four types of ROSCA may coexist, but in the end, there is often a most popular choice in the whole society which occurs with the highest probability. This is also a widely observed phenomenon in the field especially in the relatively homogenous societies.

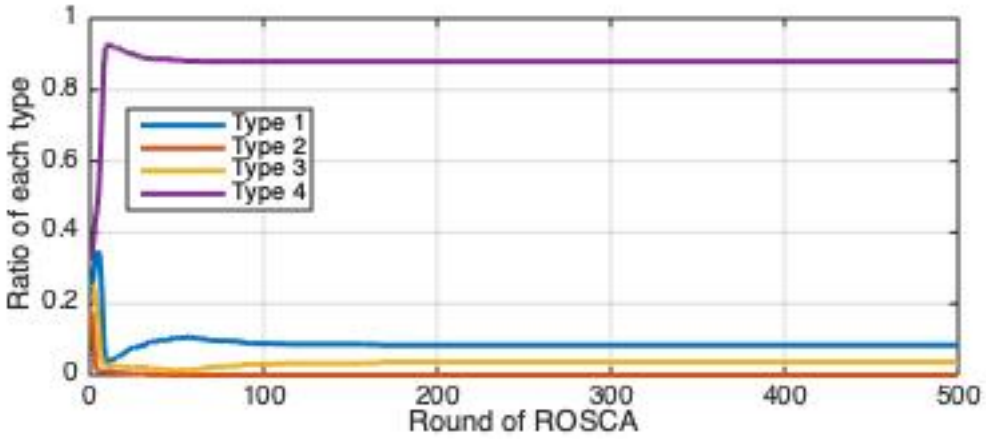

Figure 5.9 Altruistic society where the reciprocity parameter θ is uniformly distributed on (0.5, 0.6)

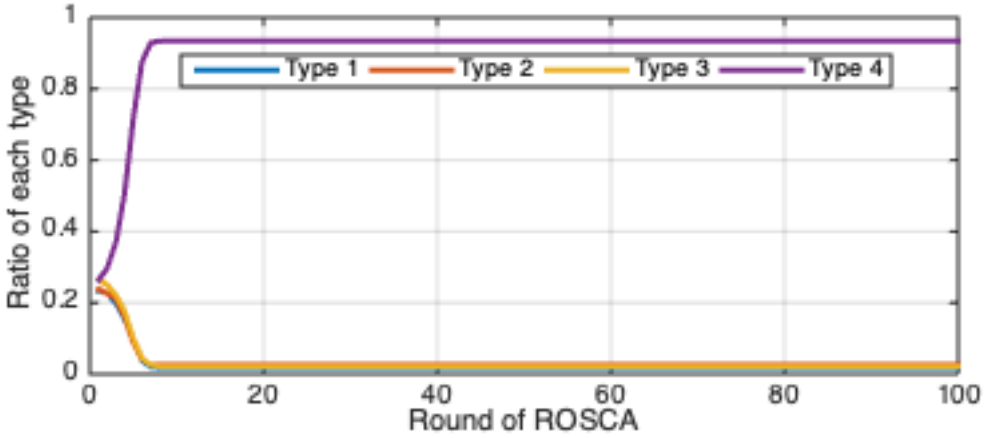

Figure 5.10 Altruistic society where the reciprocity parameter θ is uniformly distributed on (0.9, 1)

Due to the simulation parameter settings and group capacity limitation used in this framework, there are two different reasons for the disappearance of some ROSCA types: i) no individual prefers the groups of this type and successfully joins other types; therefore, the dismissing of the ROSCA type happens quickly; ii) even the disappearing ROSCA type is not the worst choice and, still, some individuals may prefer it in a

society. However, unfortunately, if those individuals who preferred this type were not allocated in it, and people in this type left the group before they shared the information with the potential members, then, as a result, this type would lose its popularity before the proper individuals can join it.

At the same time, some ROSCA types coexist and remain within a quite low ratio to the end even if they are not the dominant ROSCA type in a homogeneous society. There are two reasons for this coexistence. First, even within a relatively small reciprocity interval, slight differences on reciprocity value may also lead to the low coexistence of some ROSCA types. Second, due to the group capacity limitation used in this framework, the individuals who are not selected by their preferred ROSCA groups are labelled with their previous group. Normally, this number is quite small.

5.4.2 Heterogeneous society

In this section, the numerical simulation results are given for a society with heterogeneous reciprocity values. Figure 5.11 shows the situation where θ varies with 0.2 interval, and Figure 5.12 shows the typical snapshot in a *selfish* society where the reciprocity parameter θ distributes uniformly on (0, 0.2). It shows that type 3 ROSCA is dominant in this society with around 50%; at the same time, the rest three types coexist in the end. However, unlike the results showing in homogenous society, where a dominant type normally attracts more than 80% population in the society, the snapshot of a heterogenous society shows that the ROSCA types can coexist with different ratio. The mechanism of coexistence is different from homogenous society, that in a more heterogenous society, there are more varieties of preferences, thus different ROSCA types are preferred accordingly.

Figure Figure 5.13, Figure 5.14, Figure 5.15, Figure 5.17, Figure 5.18, Figure 5.19, Figure 5.20, and Figure 5.21 show the situations where θ varies with 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1 interval, respectively. The trends observed in a more heterogeneous society (compared with Figure 5.2) are similar to the results found in homogenous societies. Within different reciprocity value intervals, different types become dominant among the four rules. From the following results, we observe that the trend is for the proportion of type 4 to increase and the proportion of type 3 to gradually decrease as the reciprocity value becomes bigger. When θ varies with an interval of more than 0.2, types 1 and 4 are always the first or second most dominant type in each θ interval. Figure 5.12 and Figure 5.16 shows the typical snapshot in different social situations where the reciprocity parameter θ distributes uniformly on (0, 0.5) and (0,1).

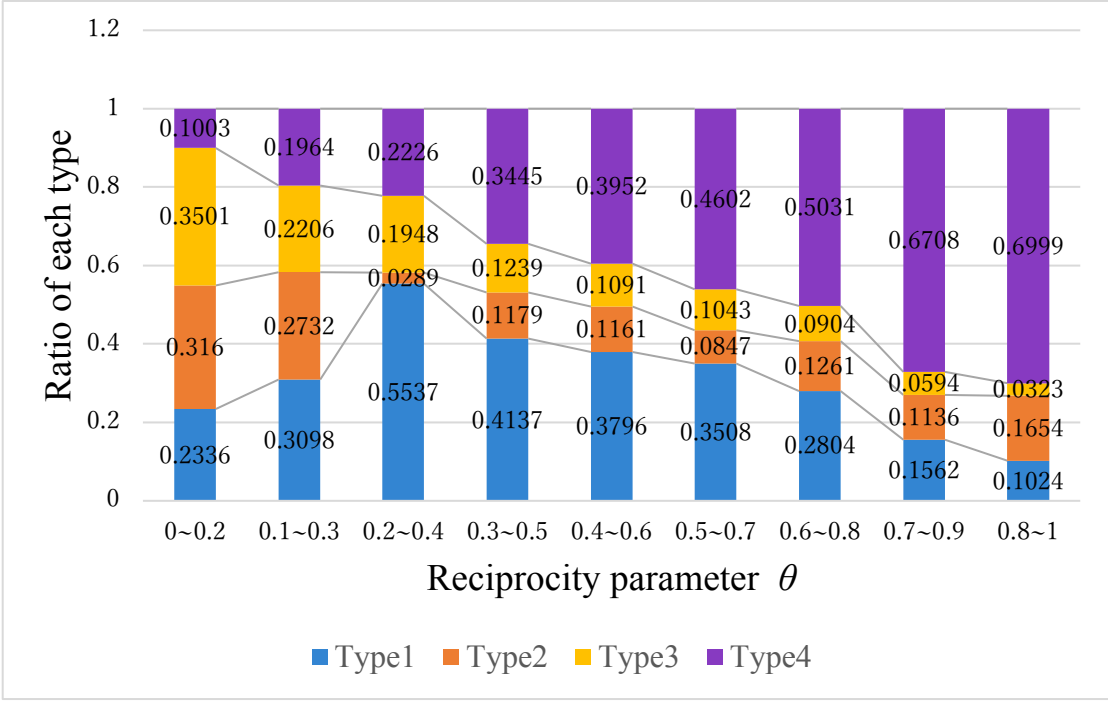

Figure 5.11 Ratio of four ROSCA types on different θ partitions (interval=0.2)

Table 5.2 Standard deviation of frequency distribution for ROSCA Type 1~4 on different θ partitions (interval=0.2)

θ / Type	0~0.2	0.1~0.3	0.2~0.4	0.3~0.5	0.4~0.6	0.5~0.7	0.6~0.8	0.7~0.9	0.8~1
Type 1	0.2206	0.1678	0.2928	0.2680	0.1271	0.1810	0.2028	0.1531	0.0387
Type 2	0.2378	0.0538	0.1425	0.0967	0.2045	0.0753	0.1683	0.0160	0.0028
Type 3	0.0476	0.0808	0.0413	0.1782	0.1709	0.1836	0.1047	0.0862	0.0752
Type 4	0.1984	0.1399	0.2560	0.0503	0.2653	0.2704	0.1414	0.0802	0.2848

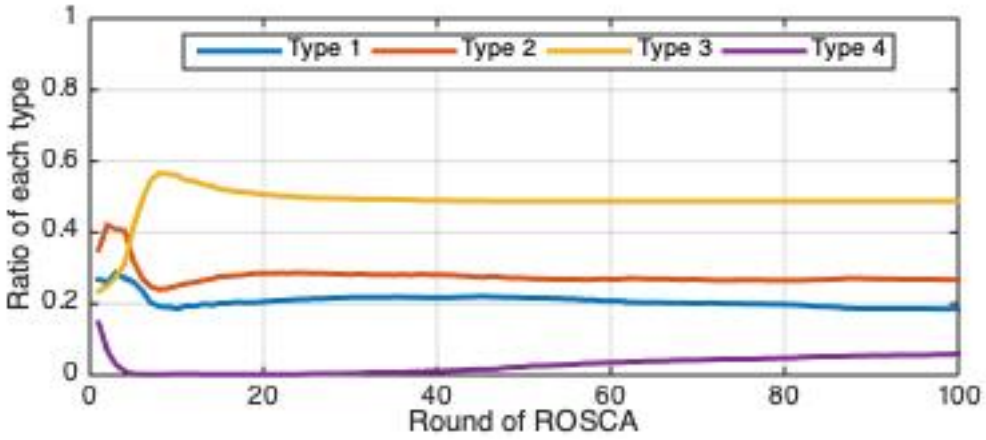

Figure 5.12 A typical simulation outcome in a selfish society where the reciprocity parameter θ distributes uniformly on (0, 0.2)

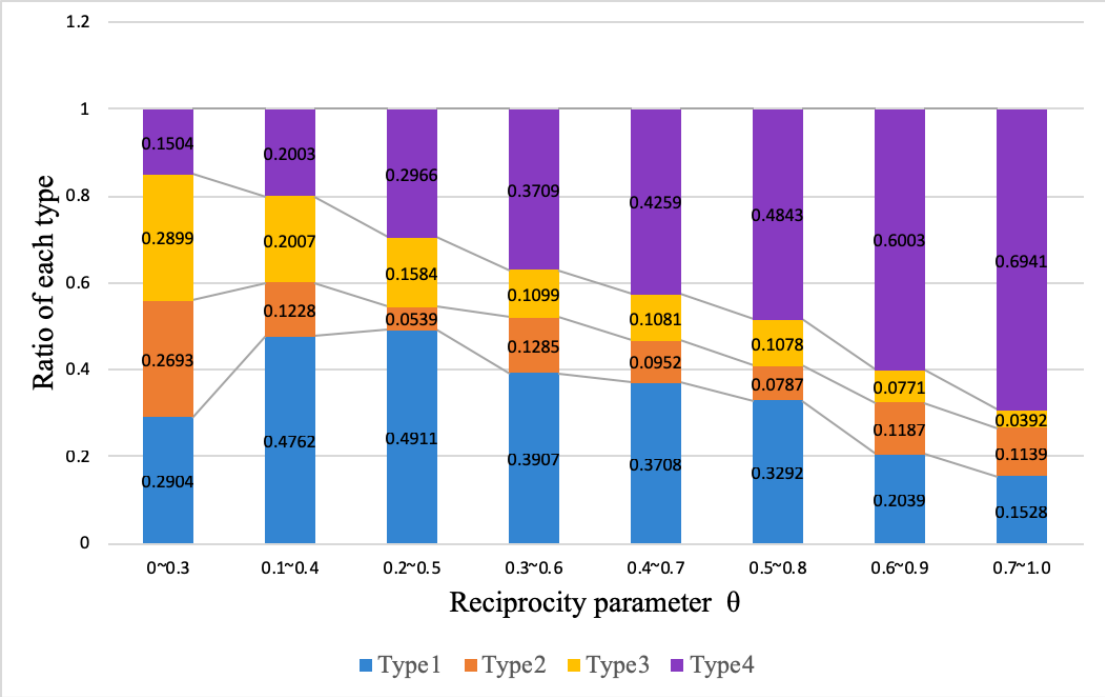

Figure 5.13 Ratio of four ROSCA types on different θ partitions (interval=0.3)

Table 5.3 Standard deviation of frequency distribution for ROSCA Type 1~4 on different θ partitions (interval=0.3)

θ / Type	0~0.3	0.1~0.4	0.2~0.5	0.3~0.6	0.4~0.7	0.5~0.8	0.6~0.9	0.7~1.0
Type 1	0.2104	0.1484	0.0876	0.2015	0.1843	0.2537	0.1941	0.2112
Type 2	0.1078	0.0723	0.0301	0.1683	0.0402	0.0003	0.0390	0.2147
Type 3	0.2746	0.1965	0.1010	0.0411	0.0009	0.1183	0.0410	0.0402
Type 4	0.0054	0.2039	0.2004	0.1905	0.1545	0.0957	0.2359	0.1112

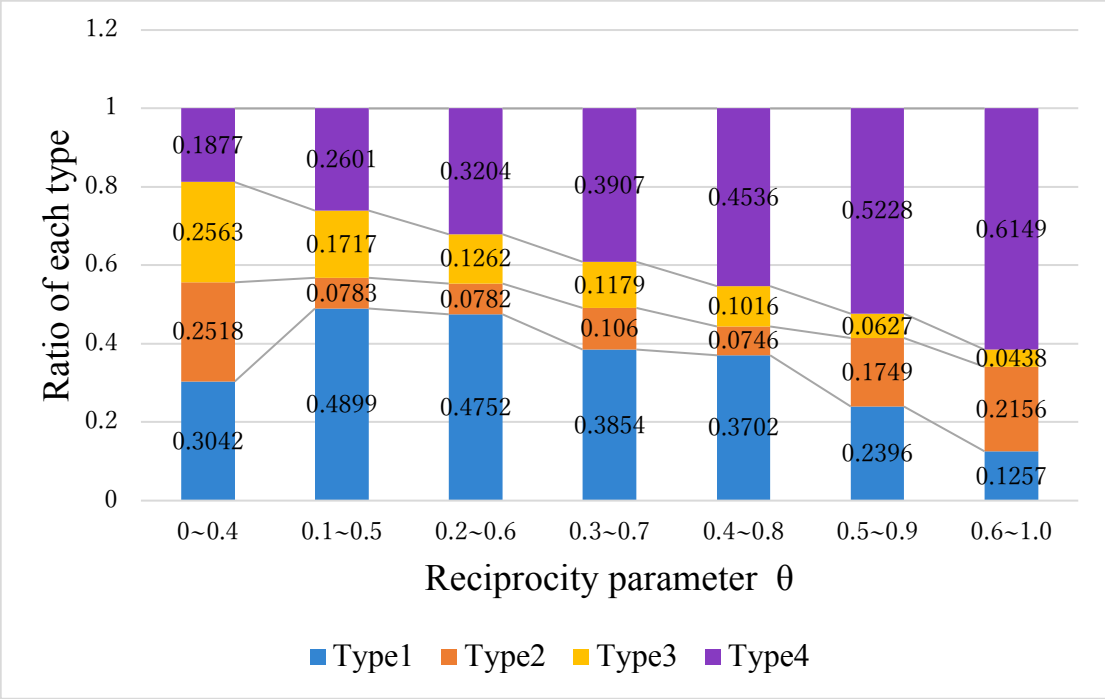

Figure 5.14 Ratio of four ROSCA types on different θ partitions (interval=0.4)

Table 5.4 Standard deviation of frequency distribution for ROSCA Type 1~4 on different θ partitions (interval=0.4)

θ / Type	0~0.4	0.1~0.5	0.2~0.6	0.3~0.7	0.4~0.8	0.5~0.9	0.6~1.0
Type 1	0.0451	0.2455	0.0872	0.1104	0.2503	0.1132	0.1109
Type 2	0.0866	0.0248	0.0229	0.1796	0.0152	0.1376	0.2052
Type 3	0.2351	0.2276	0.1326	0.1219	0.1595	0.0716	0.1391
Type 4	0.0631	0.1128	0.1296	0.1613	0.2238	0.0597	0.0950

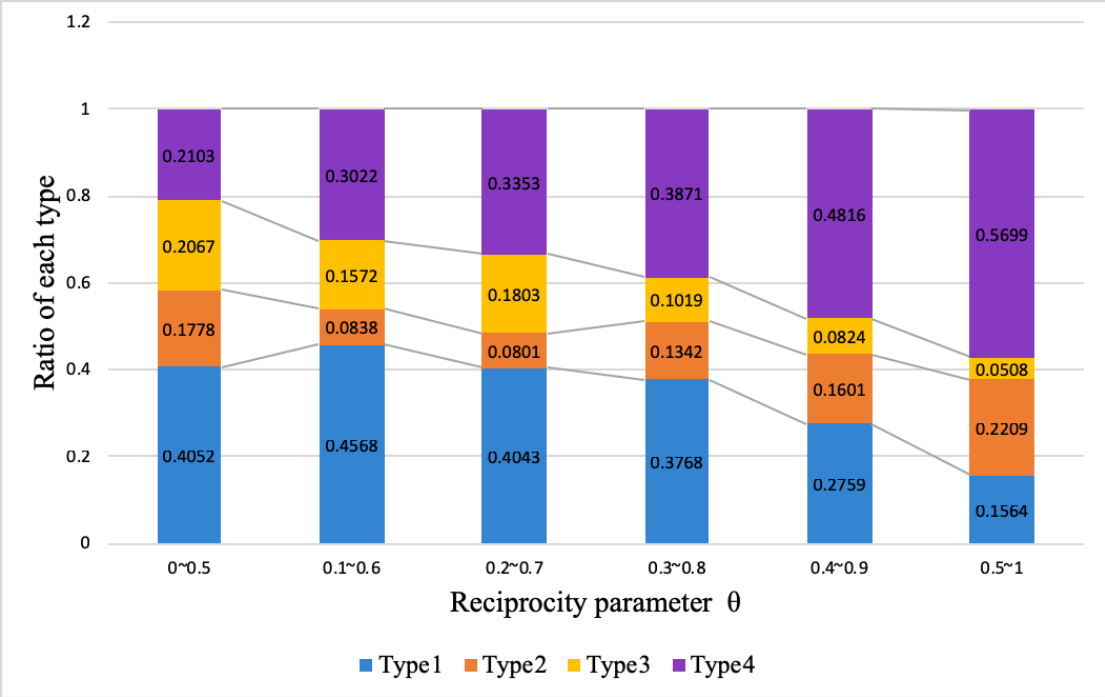

Figure 5.15 Ratio of four ROSCA types on different θ partitions (interval=0.5)

Table 5.5 Standard deviation of frequency distribution for ROSCA Type 1~4 on different θ partitions (interval=0.5)

θ / Type	0~0.5	0.1~0.6	0.2~0.7	0.3~0.8	0.4~0.9	0.5~1.0
Type 1	0.1686	0.0753	0.0669	0.1940	0.0879	0.1237
Type 2	0.1138	0.1156	0.0661	0.1687	0.2195	0.2618
Type 3	0.0088	0.0667	0.0627	0.0823	0.0466	0.0746
Type 4	0.0920	0.1403	0.1778	0.0432	0.2469	0.1659

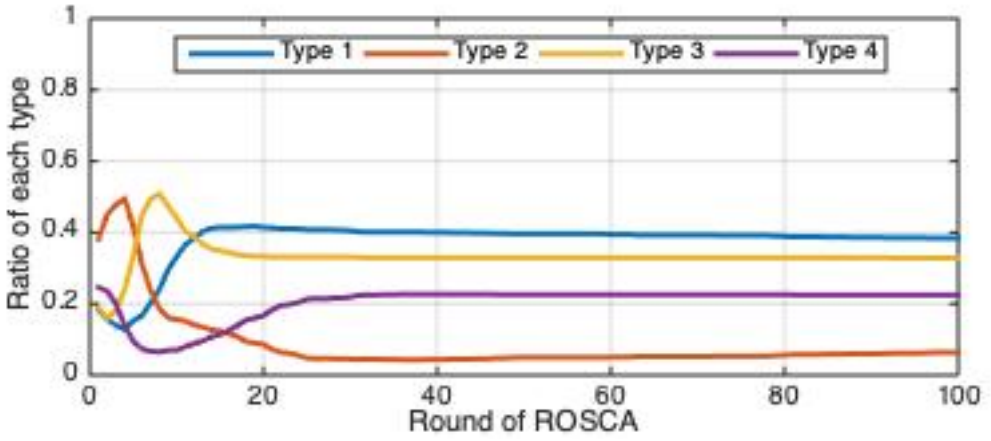

Figure 5.16 A typical simulation outcome in a selfish society where the reciprocity parameter θ distributes uniformly on (0, 0.5)

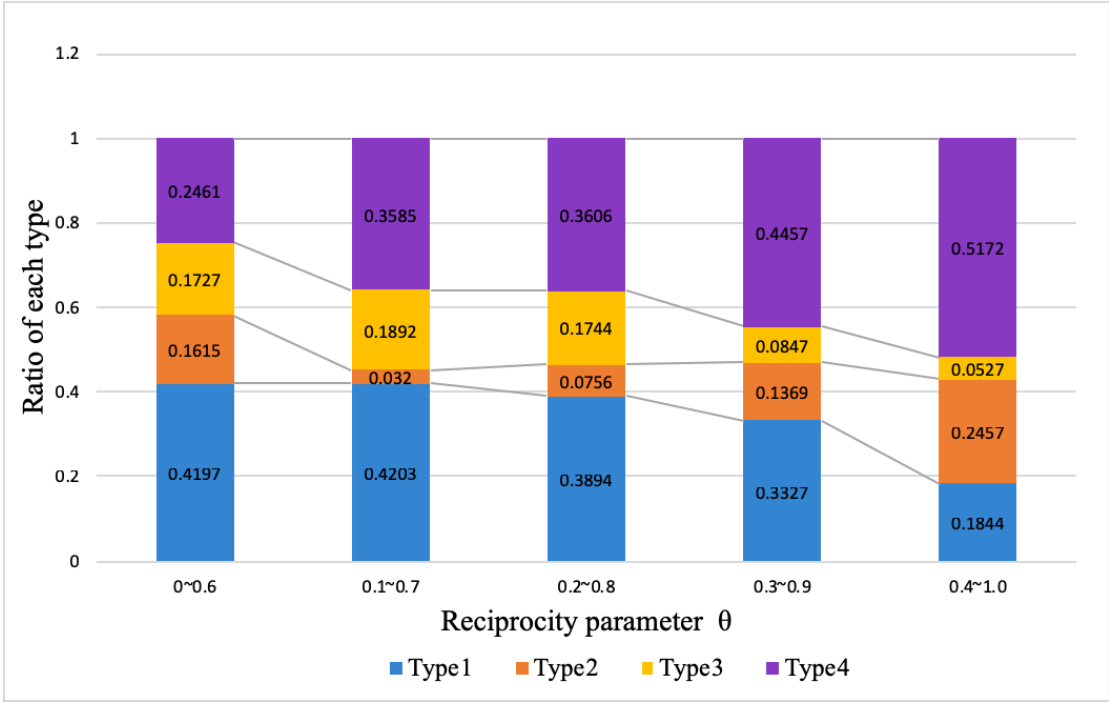

Figure 5.17 Ratio of four ROSCA types on different θ partitions (interval=0.6)

Table 5.6 Standard deviation of frequency distribution for ROSCA Type 1~4 on different θ partitions (interval=0.6)

θ / Type	0~0.6	0.1~0.7	0.2~0.8	0.3~0.9	0.4~1.0
Type 1	0.0547	0.2339	0.0880	0.0583	0.2169
Type 2	0.2322	0.1191	0.1147	0.0476	0.1656
Type 3	0.0051	0.0209	0.1031	0.0476	0.0449
Type 4	0.2149	0.1178	0.2469	0.0667	0.0816

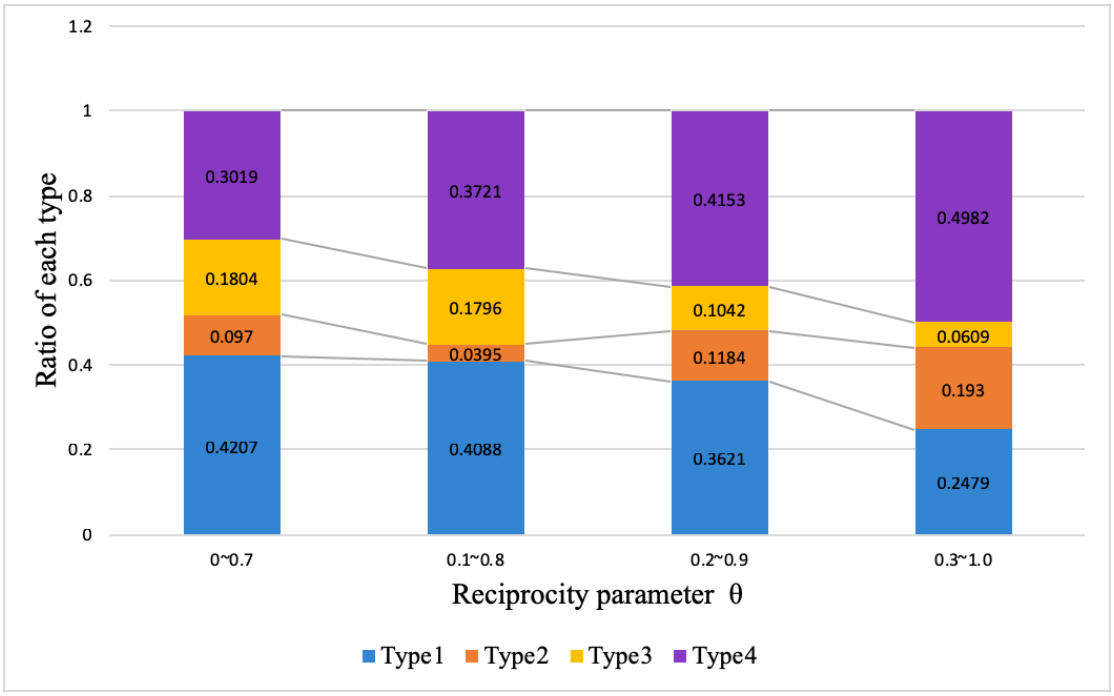

Figure 5.18 Ratio of four ROSCA types on different θ partitions (interval=0.7)

Table 5.7 Standard deviation of frequency distribution for ROSCA Type 1~4 on different θ partitions (interval=0.7)

θ / Type	0~0.7	0.1~0.8	0.2~0.9	0.3~1.0
Type 1	0.2430	0.1272	0.0640	0.2478
Type 2	0.0761	0.0784	0.0351	0.2390
Type 3	0.0849	0.0566	0.0747	0.0324
Type 4	0.1364	0.0505	0.0396	0.1650

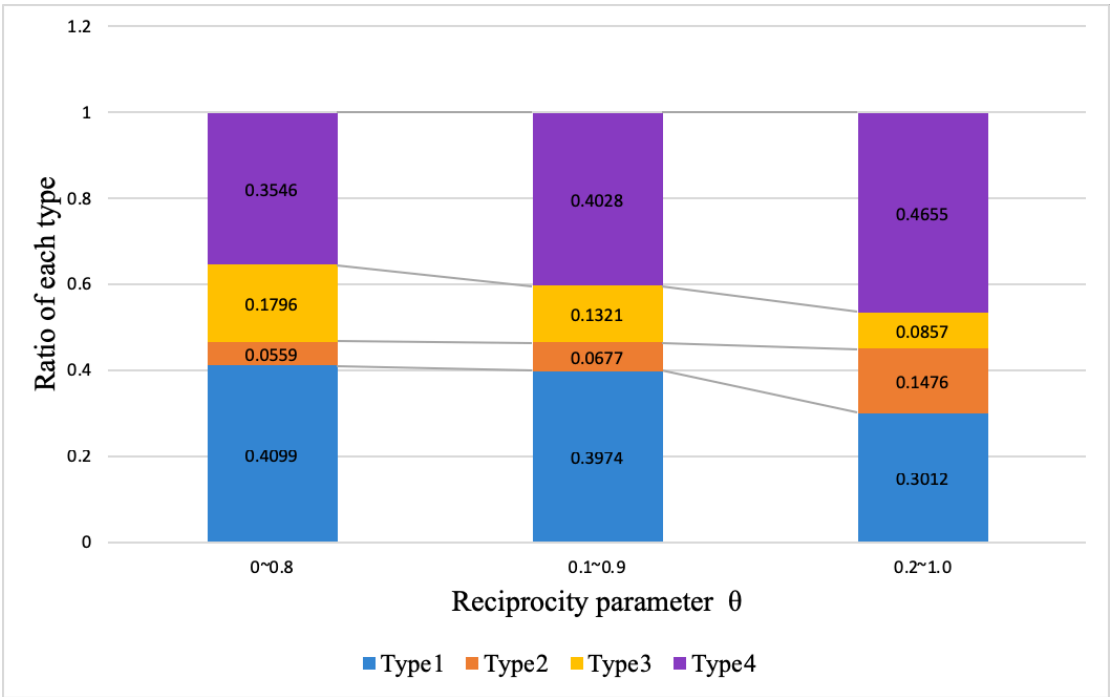

Figure 5.19 Ratio of four ROSCA types on different θ partitions (interval=0.8)

Table 5.8 Standard deviation of frequency distribution for ROSCA Type 1~4 on different θ partitions (interval=0.8)

θ / Type	0~0.8	0.1~0.9	0.2~1.0
Type 1	0.1112	0.2206	0.0313
Type 2	0.1341	0.0089	0.0182
Type 3	0.0892	0.0403	0.1534
Type 4	0.0444	0.1267	0.2769

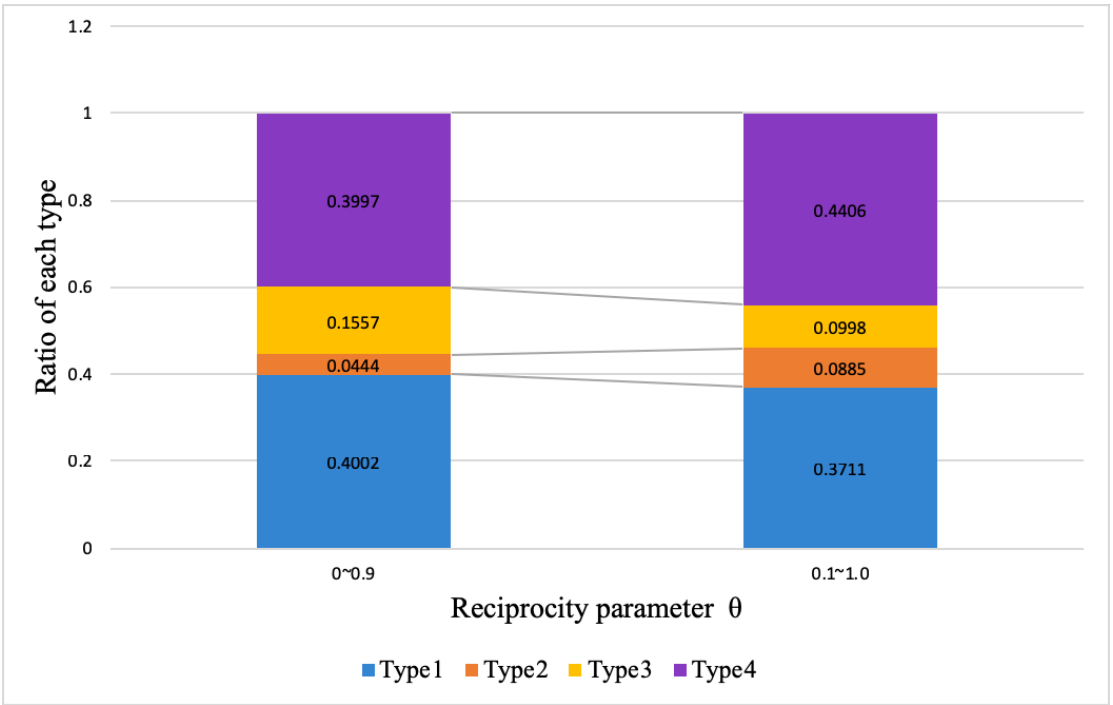

Figure 5.20 Ratio of four ROSCA types on different θ partitions (interval=0.9)

Table 5.9 Standard deviation of frequency distribution for ROSCA Type 1~4 on different θ partitions (interval=0.9)

θ / Type	0~0.9	0.1~1.0
Type 1	0.1694	0.2262
Type 2	0.0811	0.0793
Type 3	0.0469	0.0690
Type 4	0.1133	0.0741

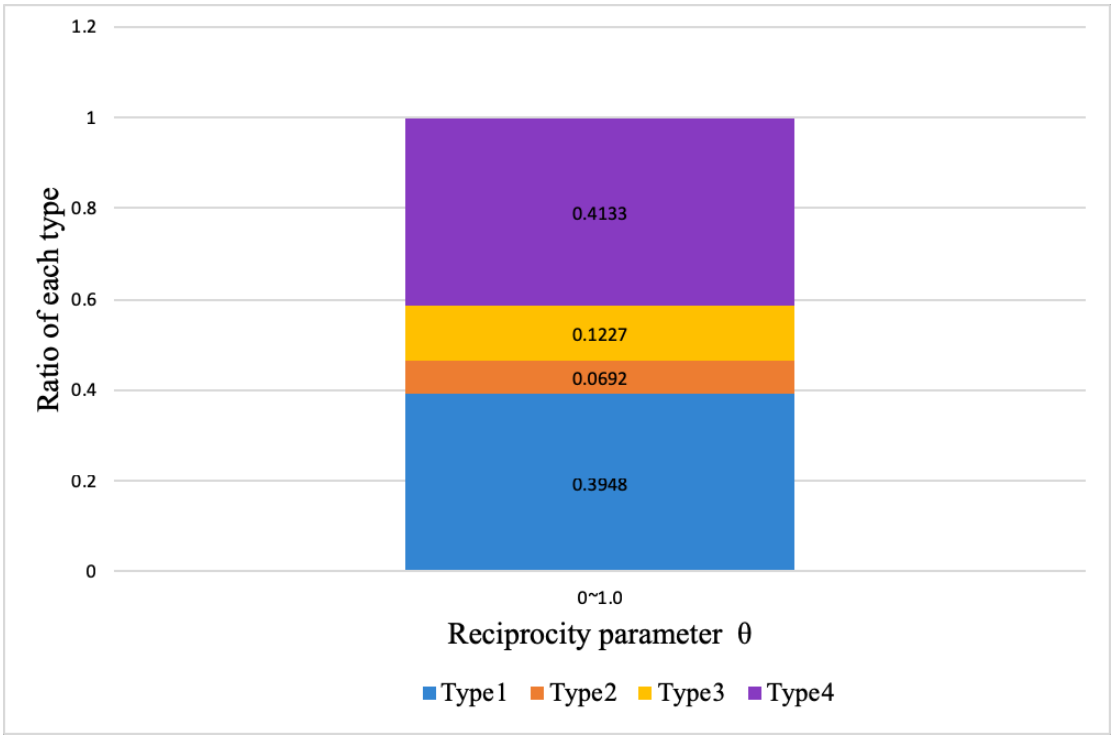

Figure 5.21 Ratio of four ROSCA types on different θ partitions (interval=1.0)

Table 5.10 Standard deviation of frequency distribution for ROSCA Type 1~4 on different θ partitions (interval=1.0)

θ / Type	0~1.0
Type 1	0.1870
Type 2	0.0955
Type 3	0.1393
Type 4	0.1404

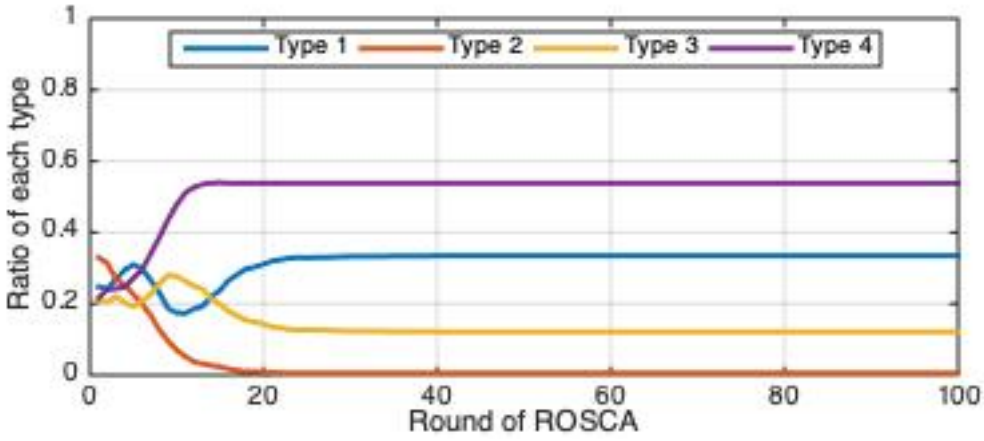

Figure 5.22 A typical simulation outcome in a selfish society where the reciprocity parameter θ distributes uniformly on (0, 1)

In this section, the results are presented for 100 rounds of ROSCA in *selfish* and *heterogeneous* societies. Figure 5.16 illustrates a typical simulation outcome in a *selfish* society where the reciprocity parameter θ distributes uniformly on (0, 0.5). Note that,

as compared to the typical snapshot from section 5.3.1, four ROSCA types coexist in the society, where type 1 is the dominant type with no more than 40% of the population. This coexistence occurs because, in this kind of society, heterogeneity of reciprocity leads to the coexistence of different types. In a relatively *more heterogeneous* society, a similar finding is shown in Figure 5.22, where the reciprocity parameter θ distributes uniformly on (0, 1). In this social setting, the type 4 ROSCA dominates in the society with around 50% of the population, while type 1 holds more than 30% of the population, and the rest of the people go to type 3. Type 2 is dismissed in this snapshot.

Dynamic turbulence is sometimes observed, especially in the typical snapshot of a more heterogeneous society as Figure 5.23 and Figure 5.24 show, where the reciprocity parameter θ distributes uniformly on (0, 0.5) and (0.5, 1), respectively. This phenomenon is caused by the group capacity limitation and dynamic group selection process. In Figure 5.23, type 1 is the dominant ROSCA type, attracting around 80% of the people in this society; at the same time, around 15% choose to join type 4. The percentage of both are fluctuating all the time. Although ROSCA types 1 and 4 coexist within reciprocity values distributed uniformly on (0, 0.5), a dynamic equilibrium is observed between types 1 and 4, but not on types 2 and 3. For example, a small number of people in this society are currently in type 2 (although they prefer type 4 more), but only some of them acquire the information from type 4 in this round. Some of them decide to join type 4 from the next round, which may or may not be selected by it. For the individuals who are not selected by type 4, they can either go back to type 2 or out of game in the next round, following the previous rules outlined in section 5.3. Whether a new group is formed successfully depends on if there are enough members with hands up in that round.

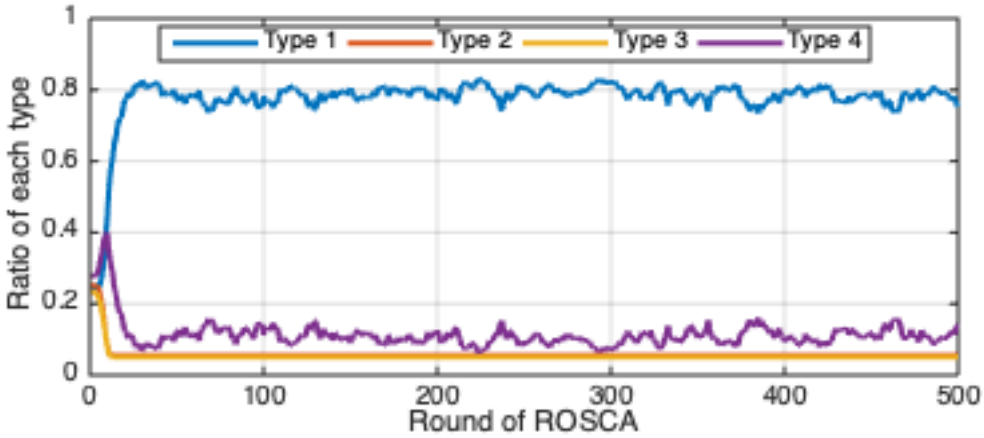

Figure 5.23 A typical simulation outcome in a selfish society where the reciprocity parameter θ distributes uniformly on (0, 0.5)

Figure 5.24 A typical simulation outcome in an altruistic society where the reciprocity parameter θ distributes uniformly on (0.5, 1)

5.4.3 Social changes in reciprocity values

In sections 5.4.1 and 5.4.2, unchanged reciprocity values were set. However, whether in reality or in the computer simulation, a long-time scale is being considered. Therefore, it is necessary to discuss how the society's preferences and rule choices may be altered when social changes happen. In the following Figure 5.25, a typical snapshot is

presented with the reciprocity parameter distributed on (0, 0.1) and the time discounting value fixed at 0.98, in which case type 3 becomes the dominant type soon after the beginning.

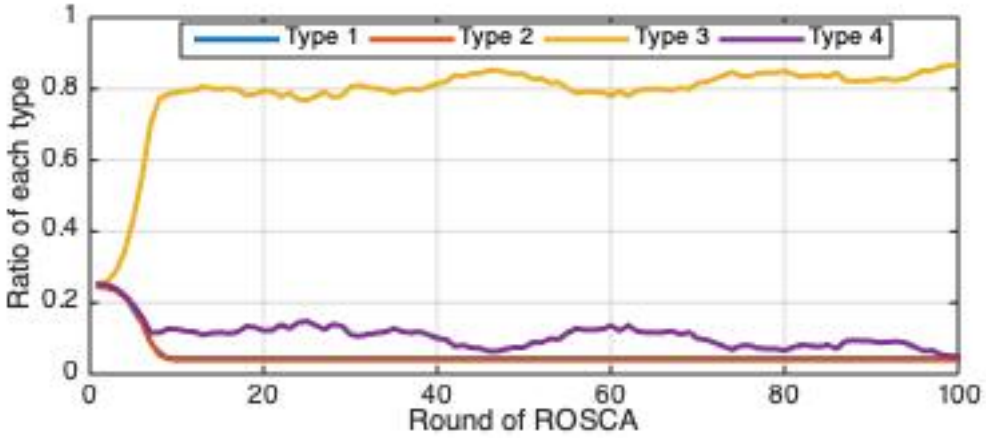

Figure 5.25 A typical simulation outcome in a society with reciprocity parameter θ distributing uniformly on (0, 0.1)

Then, the simulation is modified to enable a social change in reciprocity value to occur in the middle of the simulation to check whether social changes affect society choices. In this section, the results are presented for the simulations of the situation where the distribution of θ changes from (0,0.1) to (0.9,1). Figures 5.26 to 5.28 show the simulation results that happen with the change occurring in the 5^{th}, 10^{th} and 20^{th} rounds, respectively. The results show that when social changes that are related to the process of rule choosing happen, the dominant ROSCA type also changes. Without social change, type 3 is always the main choice of type (or rule) in the society as Figure 5.25 shows. However, when social change happens so that altruism increases, as shown in figures 5.26 to 5.28, type 3 loses its dominance and type 4 becomes the most popular one in the society.

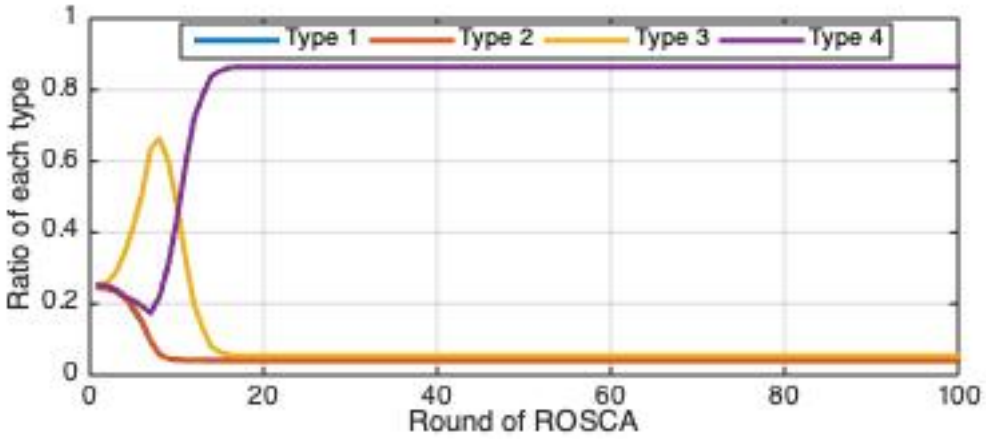

Figure 5.26 A typical simulation outcome in a society with reciprocity parameter θ that mutates in the 5th round from (0,0.1) into (0.9,1)

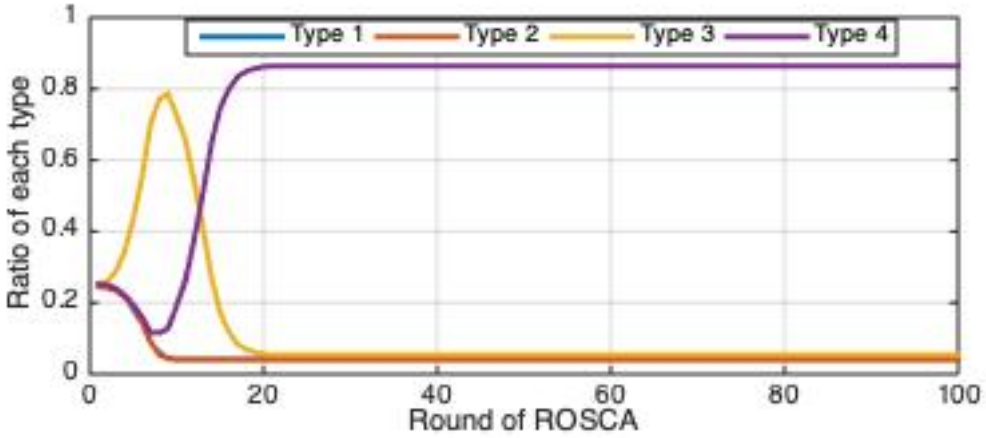

Figure 5.27 A typical simulation outcome in a society with reciprocity parameter θ that mutates in the 10th round from (0,0.1) into (0.9,1)

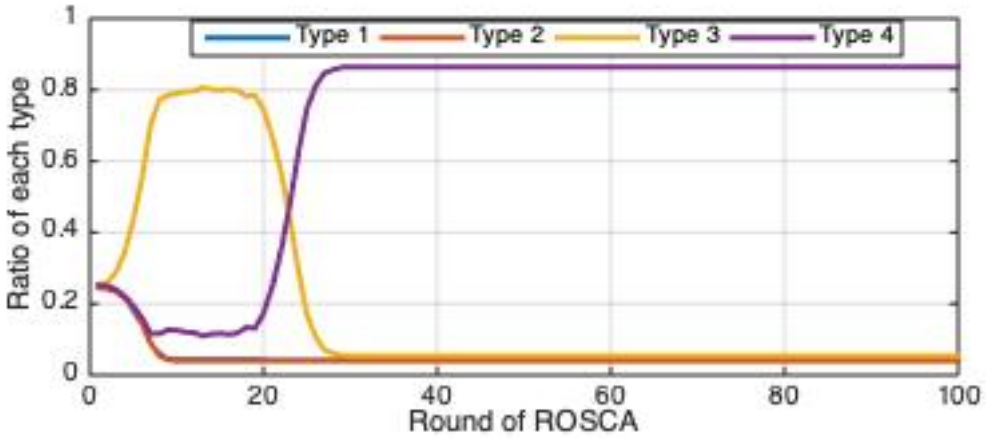

Figure 5.28 A typical simulation outcome in a society with reciprocity parameter θ that mutates in the 20th round from (0,0.1) into (0.9,1)

As frequently discussed in evolutionary game theory, mutation and social changes may lead to different rule choices. In this subsection, with the consideration of individual parameter mutation in the imitative dynamics, it is observed that a previously dominant rule can be overtaken by another rule which had been in the minority because the social situation changes. These results provide a plausible explanation for how rule choices may change in a society, and empirical data is needed to examine whether the explanations hold true in a real-world situation.

5.4.4 Rule preference - time discounting

In this section, the influences of time discounting value on ROSCA rule choices are discussed. To be more realistic, the scale of time discounting δ is limited to range from 0.8 to 1. In Figure 5.29, the value of δ is uniformly distributed from 0.8 to 0.9, and the reciprocity parameter θ is distributed uniformly on (0,1). Each portion in Figure 5.29 represents the mean converged share of its corresponding ROSCA type (out of 100×1,000 trials) in which δ is uniformly distributed across each interval. In Figure

5.30 the value of δ is uniformly distributed from 0.9 to 1, and the reciprocity parameter θ is unchanged from Figure 5.29. The results of Figures 5.29 and 5.30 show that ROSCA type 4 is always the most popular type in both societies. Interestingly, this result is highly consistent with the situation in the real world, in which type 4 ROSCA (without any charging of extra interest) is the most common and popular in many areas.

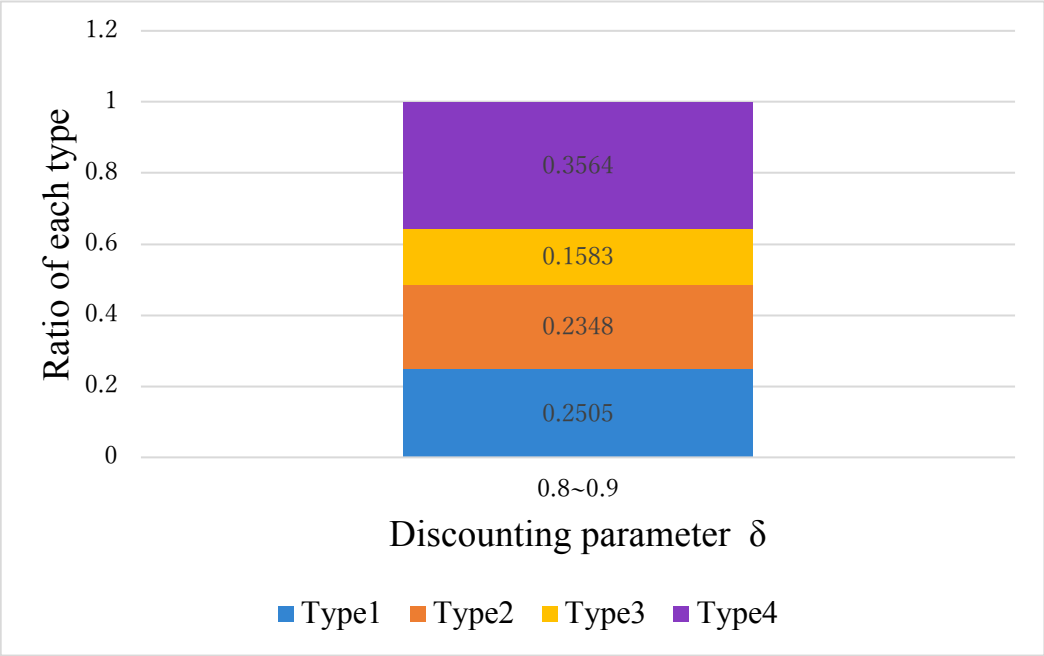

Figure 5.29 Ratio of four ROSCA types on 0.8 ~ 0.9 δ partitions (interval=0.1), reciprocity parameter θ distributed uniformly on (0,1)

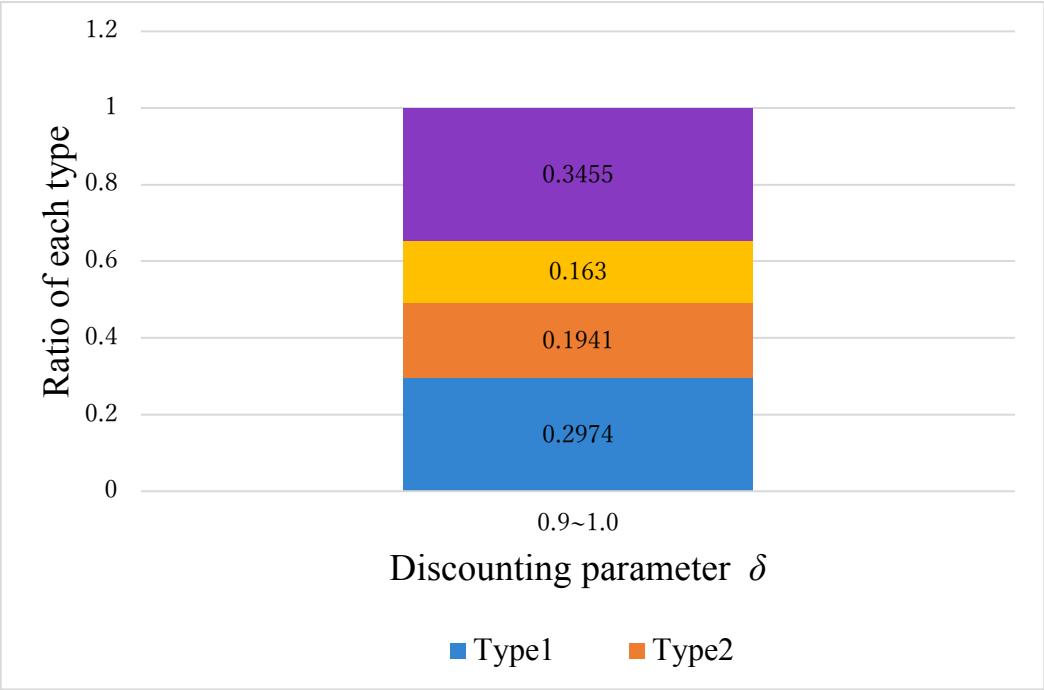

Figure 5.30 Ratio of four ROSCA types on 0.9 ~ 1 δ partitions (0.1 interval), reciprocity parameter θ distributed uniformly on (0,1)

Next, some extreme social situations are considered. Figure 5.31 and Figure 5.32 show the simulation results of a no-time-discounting society (δ = 1). Figure 5.31 gives a typical simulation outcome in an extremely selfish society where the reciprocity parameter θ = 0. In this social situation, type 3 is always the dominant rule. However, as Figure 5.32 shows, in an extremely altruistic society where the reciprocity parameter θ = 1, type 4 becomes the most popular. As has been noted in previous sections, among the four ROSCA types, type 3 charges the highest interest for the members who receive the money pot in one of the first half orders (especially for the first-order member). In contrast, type 4 is the most altruistic type, in which the recipients in the first half are not charged any interest. The results shown in figures 5.31 and 5.32 enable us to understand what people's choices would be without the influence of time discounting.

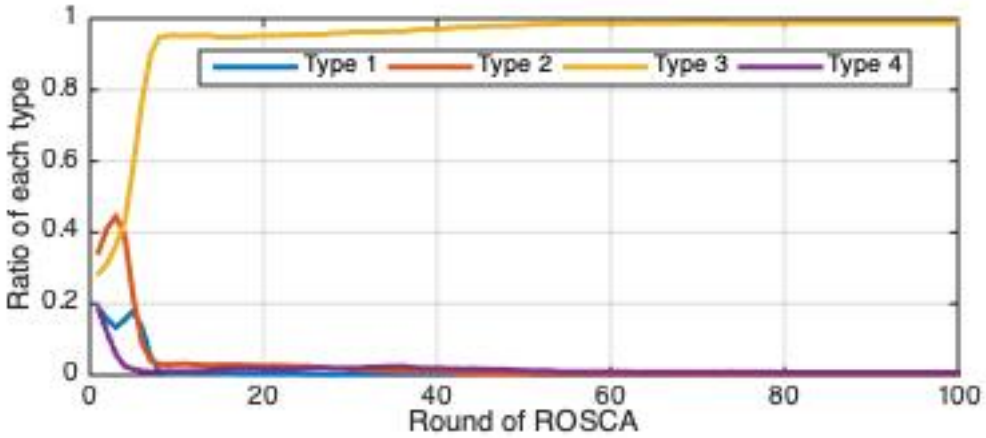

Figure 5.31 A typical simulation outcome in a selfish society (reciprocity parameter θ = 0) where the time discounting parameter δ = 1

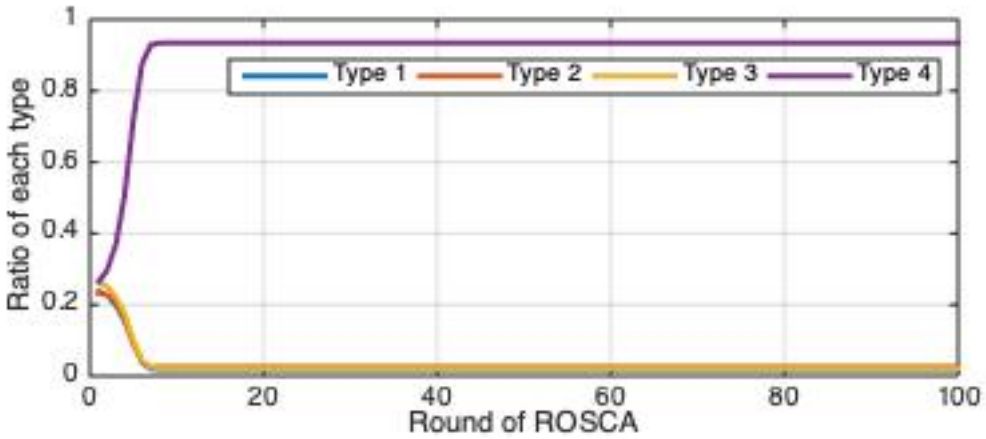

Figure 5.32 A typical simulation outcome in an altruistic society (reciprocity parameter θ = 1) where the time discounting parameter δ = 1

5.5 Discussion and Conclusion

Four types of ROSCA in China were modelled with the consideration of individual investment ability and a time discounting parameter. Although these equations and parameters are largely specific to the Chinese context, rules can be extended into different countries and conclusions can be drawn based on this model. The reciprocity

function was proposed and a numerical analysis was conducted to confirm whether rule preferences related to participation in a ROSCA correlate with reciprocity levels. I argue that the evolution of ROSCA is an indicative exemplar for understanding the evolution of cooperation. The following conclusions are drawn:

(1) In different societal settings there is a dominant ROSCA type, but other types may coexist. These results can explain some aspects of the current ROSCA situation in China. The four types of ROSCA have a long history in China; however, even with the passage of time, these types still coexist in different areas (societies).

(2) Different ROSCA rules directly influence participants' monetary benefit. Simulation results show that the value placed on reciprocity has a significant effect on people's rule preferences. In different social settings, there is always a dominant ROSCA type, although other types may coexist in the numerical simulation. However, the reasons for coexistence are different. In a homogenous society, group capacity limitation is the main reason; in a more heterogenous society, heterogeneity of the value placed on reciprocity leads to the coexistence of different types.

(3) In social transition processes, it is crucial to study individual rule preferences, which may influence the evolutionary direction of social norms. These results suggest that financial institutions require some knowledge about the private information and preferences of potential participants, and that such knowledge can provide insights into the theory of collective rule choice that triggers the evolution of cooperation.

Note that, in addition to the factors discussed here, there are still many other factors which can also affect people's rule preferences. Simulations and mathematical models are effective for exploring possible dynamisms of social interactions when a large number of people are involved. Future work may include providing feedback on experiments and empirical research by presenting this causal relationship. Although the specific results from this study may not extend directly to all social contexts, they help to better understand how the reciprocity level in a society influences people's rule preferences.

Some empirical investigations reveal that social rules keep evolving and people share rules by learning from each other. In the field, disparities in the rules are observed not only in China, but also in other regions where ROSCAs are popular. Similarly, some traditional rules, such as the type 4 examined in this study, are still widely used. However, new types that demand extra interest payments have also emerged and are considered as evidence that participants are realising that the value of time and money is decreasing. Therefore, even when the primary incentive to participate in a ROSCA is still to help other people, the helpers also do not want to lose their monetary benefit. Findings from both the fieldwork and the simulation in this paper supply concrete support for arguing that participants' rule preferences for a ROSCA are related to the level of reciprocity and net benefit gained by joining a ROSCA group. Although no prior empirical studies have so far succeeded in specifying a mechanism as to how members' interactions promote cooperation, our simulations do explain how this dynamism can be produced under various conditions.

Chapter 6 RULE PREFERENCES FOR ROSCA: Household Survey Evidence from China

6.1 Introduction

In the previous literature, ROSCAs have mainly been discussed along three dimensions. First, ROSCAs work as a substitute for insurance, especially in developing countries where markets for insurance do not function well (Ambec, 2007; Klonner, 2003). Second, ROSCAs enable the purchase of durable goods. The model of Besley, Coate, and Loury (1993) shows that, as compared to autarky, ROSCAs enable participants to buy durable goods sooner. Third, ROSCAs can help people to cope with their self-control problems and serve as a commitment device (Ambec, 2007; Anderson & Baland, 2002). However, limited research has focused on temporal and geographical differences in ROSCA rules. Research on how ROSCAs are organised, in terms of underlying individual preferences, and how different group compositions and rules influence default risk, may provide a clearer picture of the role of rural informal finance and help to increasethe diversity of financial institutions. In this chapter, the results of an empirical study of ROSCAs in China, are provided.

ROSCAs have a long history in China. Although they have disappeared in some developed areas, they are still a popular informal mutual aid financial institution in rural areas. The features of China's *Hui* have much in common with those of other countries. That *Hui* have survived until today suggests that they serve an economically useful function. There are several reasons why a study of *Hui* may be attractive. First, *Hui* are

still considered an important informal financial mechanism in rural China. There is continued, intense interest in the design of financial institutions that can attract the accumulated wealth of the small rural saver (Hamada, 2000) and despite the emergence of modern financial institutions, *Hui* continue to be popular in rural China. Second, *Hui* are an example of how human societies form cooperative institutions or mechanisms. Third, *Hui* are closely related to economics, society, and culture. My hypothesis is that the characteristics of the *Hui* are correlated with local situations and people's preferences. In this chapter, I particularly focus on rule disparities between different villages. Interviews were conducted in five Chinese villages to directly measure economic factors among individuals who were members of a ROSCA and to investigate how these parameters correlate with their ROSCA rule preferences. In particular, I focus on the role of financial behaviours and rule choices. Basic household information was collected in the field. Through narrative analysis of the recorded interviews, this chapter tries to illustrate local peoples' preferences related to ROSCAs and to determine potential reasons for such preferences. The particular characteristics of each ROSCA probably respond in some way to the needs of the population living in the area.

This chapter is organised as follows. Section 6.2 introduces the background of local mutual aid organizations in the fieldwork site. In section 6.3, I show the investigation results in terms of ROSCA rule disparities based on narrative analysis and summarise the rules of the ROSCA in each village where interviews were conducted. Section 6.4 describes the procedure of the time discounting experiment conducted in the field and using regression analysis, the relationship between the time discounting value and individual characteristics is estimated. Section 6.5 concludes the chapter and discusses the results.

6.2 Fieldwork in China

6.2.1 Background

The fieldwork site, Tunbao, is an area located in the center of Guizhou Province（貴州省）in China as shown on the map (Figure 6.1). The Tunbao（屯堡）culture originated from the southern expedition of the troops of Emperor Zhu Yuanzhang（朱元璋）, the founder and first emperor of the Ming dynasty（明朝） (1368–1644). After the troops suppressed rebellion and conquered southern China, Emperor Zhu ordered troops to be stationed there and to farm the wastelands in order to stabilise the south. He also forcefully moved craftsmen, civilians, and officials from central China to this area. Before the arrival of Zhu's troops, the area was occupied by minorities whose cultures were different from those of the troops. Thus, the troops lived in this enclosed area, surrounded by mountains, and refused to communicate with those outside for a very long period. After hundreds of years, a unique Tunbao culture formed including the wide establishment of mutual aid organisations. This area supplies this research an ideal spot to track the historical development of a ROSCA and discuss how it has evolved to the current period. Based on the information from a pre-investigation conducted in August 2017, we concluded that there were three mutual aid organisations in the region at the time of the pre-investigation.

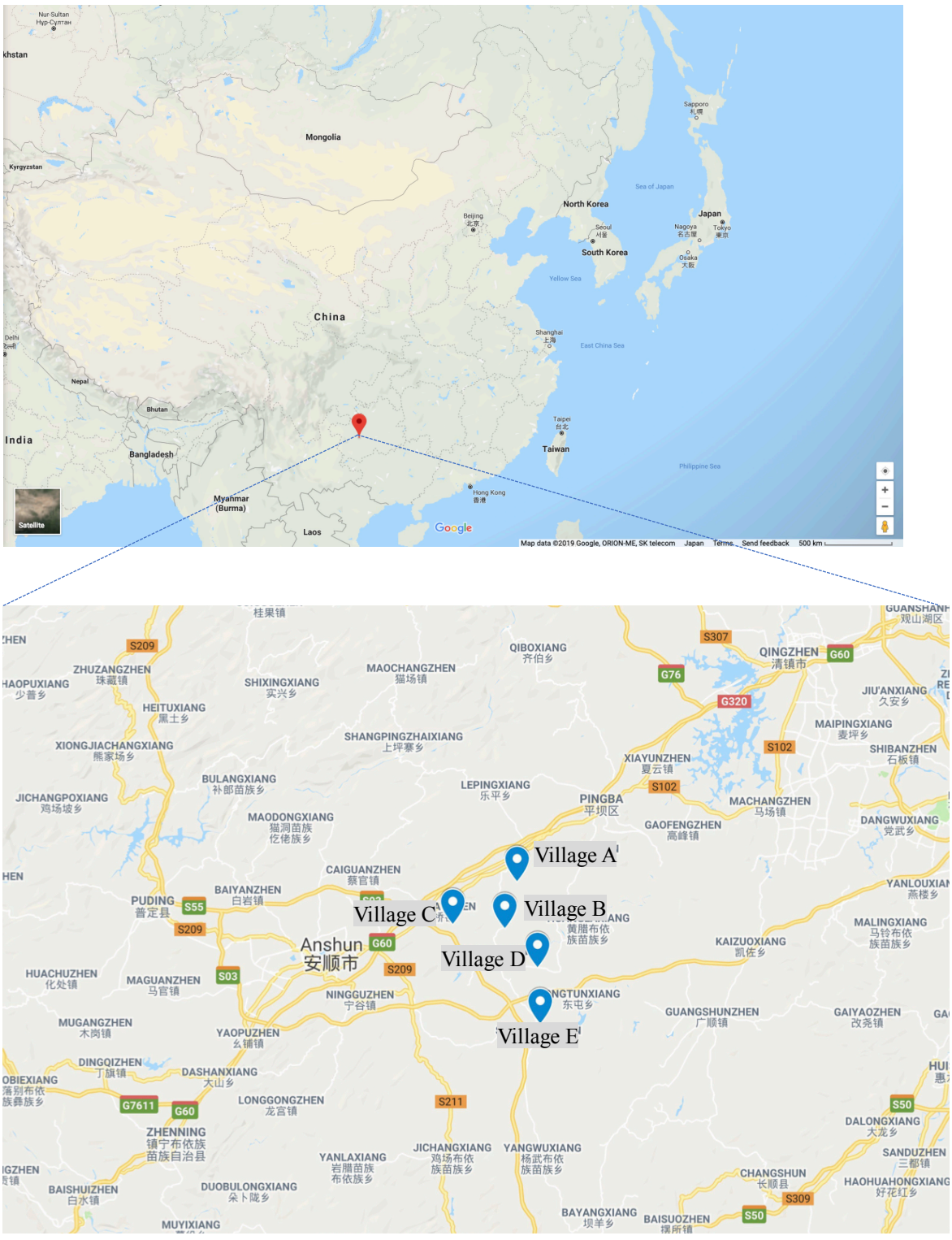

Figure 6.1 Location of Field Work in China

1) The exchange of labour force – Huanqi（换気）

In the busy farming season, there is a deficit of labour in almost all households. Instead of asking their husbands to help by stepping away from the family business, women in these villages usually form into eight-person groups which share the labour and rotate to help each household during the busy period. Normally, groups are composed of relatives or friends. The basic rule of the group is that the labour recipient should serve the group members with lunches during their service.

2) Buddhist organizations – Fotou Hui （仏頭会）

In the 1940s, Tunbao women started to join local Buddhist organisations. Their regular activities included prayer and eating vegetarian food in the temple. The organisations collected funds used for the pilgrimage travelling fee and the betterment of temples. Compared to the Buddhist spirit of the women, the men tended to believe in God Wang（汪公）, who was a successful bureaucrat and businessman. Despite the pragmatic nature of the men's beliefs, they supported the women's Buddhist activities by paying the necessary fees and allowing their absence from home for several days each year.

Figure 6.2　A Female Buddhist Group in Tunbao Village

3)　ROSCA – Hehui （合会）

ROSCAs are called Hehui（合会）in this area and have developed over hundreds of years. As observed in real cases and related research, one important characteristic of ROSCAs is that they originally emerged among people who lived in isolated areas and who had limited access to formal financial institutions. In the Tunbao area, almost all households are involved with at least one Hehui group. Although accessibility of formal finance and contacts with outsiders have increased, the Tunbao people are still keen to participate in Hehui to solve their money problems.

Seibel (2001) reports the trend of informal institutions evolving “from labour, in-kind or pre-monetary currency, to cash; from non-financial to financial groups; from short-lived to permanent groups”. In our fieldwork, a similar phenomenon was observed in

terms of ROSCA organisation and rule varieties.

6.2.2 Investigation and descriptive data

In January and February 2019, interviews were conducted in five villages of the Tunbao area where ROSCA groups currently exist or once did. With the help of local government officials and leaders of each villages, subjects were randomly chosen from villager lists and 60 households from each village were selected for interviews. Around 80% of the questionnaires were completed in each village. Some descriptive statistics about the five fieldwork villages, identified as villages A to E, are given in Table 6.1.

In the interviews, there was a special focus on the villagers' financial activities, including main income source, the use of bank accounts, bank loans, and Alipay Finance, and, most importantly, ROSCA participation. According to the Chinese government, rural per capita disposable annual income was 13,066 yuan in 2018; the average income of the interviewees (shown in Table 6.1) was higher than the national level. The main income sources were agriculture and related industries, such as tea and sugar factory work. A new phenomenon is that, since the Tunbao area was listed among conservation districts of historic sites in China, the tourism industry has become another pillar of the local economy. A nine-year compulsory education policy started in China in the 1990s. However, as shown in Table 1, the average number of years of education among the study subjects in each village is less than nine years in all villages but one (village D).

Table 6.1 Descriptive Data of the Five Fieldwork Villages

	A	B	C	D	E
Total number of villagers	1,531	1,692	1,461	2,023	2,350
Total number of respondents	50	46	48	50	50
Main income sources	Tea factory Agriculture	Retail Store Tourism Agriculture	Tourism Agriculture	Business Tourism Agriculture	Sugar factory Agriculture
Monthly household income (*yuan*) (mean)	6,980	6,554	7,510	10,120	6,794
Age (mean)	44.9	44.5	38	42.2	42.3
Gender (mean)	0.58	0.50	0.43	0.62	0.62
Years of education (mean)	7.5	5.5	7.5	9.4	6.5
Household number (mean)	5	7	5	5	6
<18 yrs	1	1	1	0.76	1
>60 yrs	0.9	1	0.7	0.74	0.7
Bank account (1=yes)	0.9	0.87	0.97	0.94	0.88
Bank loan (1=yes)	0.54	0.22	0.48	0.58	0.22
Alipay Finance (1=yes)	0.6	0.67	0.86	0.8	0.68

6.3 ROSCA Rule Preferences at the Village Level and Conversation Analysis

As a widely used method of cooperation, ROSCAs comprise various schemes with temporal and geographical disparities. In the interviews, the focus was on the factors that influenced people's rule preferences, the mechanism for sustaining the group, and the group's operating history. Details of the ROSCA rules reported in the five villages are presented in this section.

6.3.1 Two main ROSCA types in Tunbao

Two main ROSCA types were observed in the Tunbao area. These are the same as the types shown in Chapter IV, Table 4.3 and Table 4.4; the payments and number of group members vary depending on group needs. The two types are illustrated in the tables below. The first row in each table demonstrates the order in which the members obtain the money pot, and the first column is the index of regular meetings. The amount in the money pot at each meeting is indicated as the total income, and the amount of money paid by each participant by the end of the round of meetings is shown as the total payment.

In the Traditional ROSCA type shown in Table 6.2, each member pays the same amount at each meeting, whereas in the Interest ROSCA type shown in Table 6.3, the payment structure is different, with members needing to pay extra money after obtaining the money pot.

Table 6.2 Traditional ROSCA Type Without Interest in Tunbao Area

Meeting (k)/order (n)	1	2	3	4	5	6	7	8	9	10
1st meeting	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
2nd	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
3rd	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
4th	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
5th	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
6th	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
7th	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
8th	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
9th	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
10th	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Total payment	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
Total income	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
Net income	0	0	0	0	0	0	0	0	0	0

Table 6.3 Interest ROSCA Type in Tunbao Area

Meeting (k)/order (n)	1	2	3	4	5	6	7	8	9	10
1st meeting	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
2nd	11000	10000	10000	10000	10000	10000	10000	10000	10000	10000
3rd	11000	11000	10000	10000	10000	10000	10000	10000	10000	10000
4th	11000	11000	11000	10000	10000	10000	10000	10000	10000	10000
5th	11000	11000	11000	11000	10000	10000	10000	10000	10000	10000
6th	11000	11000	11000	11000	11000	10000	10000	10000	10000	10000
7th	11000	11000	11000	11000	11000	11000	10000	10000	10000	10000
8th	11000	11000	11000	11000	11000	11000	11000	10000	10000	10000
9th	11000	11000	11000	11000	11000	11000	11000	11000	10000	10000
10th	11000	11000	11000	11000	11000	11000	11000	11000	11000	10000
Total payment	109000	108000	107000	106000	105000	104000	103000	102000	101000	100000
Total income	100000	101000	102000	103000	104000	105000	106000	107000	108000	109000
Net income	-9000	-7000	-5000	-3000	-1000	1000	3000	5000	7000	9000

According to my investigation, the Interest ROSCA type illustrated in Table 6.3 is currently more popular, even though earlier obtainers are charged extra money as a compensation for later obtainers. The Traditional ROSCA type shown in Table 6.2 remains active only for a limited number of people. And Table 6.4 show the number of interviewees who choose to join Interest ROSCA type in Village A~E, which Interest ROSCA type is the most popular type in each village but a small number of villagers choose to participant in No-interest type.

Table 6.4 Number of Interviewees Who Join Interest ROSCA Type in Village A~E

Village	Number of interviewees in Interest ROSCA type
A	42/50
B	43/46
C	39/48
D	46/50
E	33/50

In the interview, we inquired of each interviewee which ROSCA he or she once experienced or currently belongs to, and the following open answer question was asked: *Why did you join that ROSCA*? Table 6.5 summarises the main motivations in Villages A~E. The results suggest that *Saving money* is considered as a quite important motivation for participating in a ROSCA group, which is consistent with the literature review outlined in section 2.4. *Mutual help*, at the same time, is considered as essential for them.

Table 6.5 Motivation for Participating in a ROSCA in Village A~E

Motivation	Village A	Village B	Village C	Village D	Village E
Mutual Help	13/50	7/46	5/48	11/50	16/50
Build House	5/50	10/46	13/48	12/50	9/50
Wedding	9/50	4/46	7/48	8/50	2/50
Save money	17/50	14/46	13/48	10/50	14/50
Emergency	6/50	11/46	10/48	9/50	9/50

Several participants who belong to the above two ROSCA types were interviewed. The following answers show their potential motivations in choosing between the different types.

Interviewer: Which kind of Hehui types have you joined and why?

Interviewee 1 (male, 65 years old): "I'm in the type where everyone pays the same money until the end, no matter what the order is [Traditional type shown in Table 6.2]. Our group has been more than 20 years with the same members. No matter what age you are, you always need lumpy money…money for building a house, for a son's wedding, or for a parent's funeral …recently, young people prefer the type with interest; it's difficult for our older people to calculate. We've already gotten used to this system. In our lives, there is always some time when you need

this help. It's not necessary to charge extra interest."

Interviewee 2 (male, 40 years old): "Now I'm in two *Hehui* groups. In both of them, you need to pay extra money after obtaining the money pot [Interest type shown in Table 6.3]. I'm in the first and twelfth orders of the groups. I think *Hehui* is quite good because it can help us to solve the urgent need for money. Yes, even if we have to pay extra interest. I think it's natural because it is the same as when other people lend you money. I wouldn't join if I was in a late order without extra money; then I'd rather save the money in Alipay."

The above conversations reveal different considerations when participating in a ROSCA. Although all agree the existence of ROSCAs are necessary for mutual financial aid, Interviewee 1 considers that, because everyone has money problems in their lifetime, it is not necessary to charge extra interest to an earlier obtainer in a ROSCA. However, Interviewee 2 thinks that even if it is for the purpose of helping others, the helpers should not suffer the loss; thus, extra interest payments can motivate people to join.

Despite the rule differences, the capacity of any one ROSCA group normally ranges from 10 to 50 persons. The money pot is flexible and changes with the numbers of members and their needs; the frequency of meetings is usually once a month. In each ROSCA group, at least one leader exists and is responsible for organising and collecting money. These rules are based on common sense and are similar in every village.

6.3.2 Rules for deciding ROSCA orders

Generally, the order of obtaining the money pot is decided by lottery before the whole ROSCA starts or before each meeting (random ROSCA), given to the person who gives the highest bid in that meeting (bidding ROSCA), or decided by negotiation before beginning (negotiation ROSCA). In the field, it was observed that random ROSCA and negotiation ROSCA are adopted in different villages. In villages B and D, ROSCA groups tended to decide the obtainment order by ex-ante negotiating, whereas villages A, C, and E preferred the more random method of throwing dice in advance. In either case, the leaders are responsible for organising the meetings. The detailed ROSCA rules in villages D and E are shown in Table 6.6 and Table 6.7, and two answers from group leaders in villages D and E are provided to explain how the obtaining rules are decided.

Table 6.6 ROSCA Rules and Situation in Village D

Item	Village D
Money pot obtaining order	Negotiate the order depending on needs
Timing of deciding order	At first meeting
Money collection	All members gather at leader's house every time
Frequency of meeting	Every two months
Punishment for free-rider	Take household property of free-rider; 10% fine for latecomers
Sign contract or not	Yes
Operating history	Operates well; free-riders appear sometimes

Table 6.7 ROSCA Rules and Situation in Village E

Item	Village E
Money pot obtaining order	Throwing dice
Timing of deciding order	At every meeting among people in need
Money collection	All members gather at leader's house every time
Frequency of meeting	Every month
Punishment for free-rider	Take household property of free-rider
Sign contract or not	Yes
Operating history	Operates well; no free-rider case reported

Interviewer: How does the group decide the obtaining order and why this rule?

Interviewee in village D: "Of course, the order will be negotiated and decided in advance. Only when everyone is satisfied with the order can a ROSCA start operating. This is natural; otherwise, no one would join a ROSCA if the obtaining point couldn't satisfy their needs because some join it for extra interest and some for earlier money use."

Interviewee in village E: "We decide the order by rolling dice. Yes, sometimes participants can exchange the order between themselves; but still, rolling dice is fair for everyone. It's acceptable, even if we can't get the most desirable order. We can use the money pot earlier if we get an earlier order and obtain extra interest when we get a later order."

Based on the above quotes, it can be seen that the patience of the participants affects the obtaining order rule significantly. In the villages where participants are less patient, the ROSCA rule tended to include negotiation-oriented elements in deciding the order

of obtaining the money pot. On the other hand, where people are more patient, the order tended to be decided randomly.

6.3.3 Contract and punishment mechanisms in ROSCA

As the previous literature shows, ROSCAs rely heavily on a community monitoring system enforced by local networks. As the ROSCAs become larger, moral problems inevitably arise. Thus, ROSCA groups may end with success or failure, depending on the mechanism adopted. A special aspect which needs to be mentioned here is that, in Tunbao villages, ROSCA activities are limited among the members geographically living in the same village. This means that individuals outside of the village are not allowed to participate, unless he or she has direct relatives originally from this village who can guarantee their reliability

ROSCA operating situations in the Tunbao area vary across the villages. For example, village B once experienced failure in the ROSCA process due to the appearance of defectors who obtained the money pot and then left without paying money in. However, because the villagers considered cooperation in a ROSCA was important and helpful for their households, a mechanism of contract and punishment was designed. Since then, all members have needed to sign a contract which documents all their personal information and punishment rules for defectors. In addition, money is collected at regular face-to-face meetings.

Similar rules were found in villages A, D, and E, where the ROSCA situations are well managed. However, for village C, I refer only to the past rule because the villagers do not organise ROSCA any more due to frequent defections that happened 10 years ago.

Group members in village C (who had been members years ago) and village B were consulted on this issue. Table 6.8 and Table 6.9 show the detailed rules in villages B and C.

Table 6.8 ROSCA Rules and Situation in Village B

Item	Village B
Money pot obtaining order	Negotiate the order depending on needs
Timing of deciding order	Before the ROSCA opens; if the order cannot meet their needs, they will refuse to participate
Money collection	All members gather at leader's house every time
Frequency of meeting	Every month
Punishment for free-rider	Take household property of free-rider
Sign contract or not	Yes
Operating history	There was a period when cooperating in a ROSCA almost crushed this village; the villagers estimated that the value of the ROSCA was high, therefore, they adopted various measures such as signing contracts; currently the situation has improved

Table 6.9 ROSCA Rules and Situation in Village C

Item	Village C
Money pot obtaining order	Throwing dice
Timing of deciding order	At first meeting
Money collection	Leader collects separately; no meeting
Frequency of meeting	No meeting; payment every month
Punishment for free-rider	Vague (common sense is to take household property of free-rider, but in reality, barely punish them)
Sign contract or not	Orally decide the rules; leader has the member list
Operating history	Due to large-scale defections 10 years ago, this village

lost mutual trust and suspended all ROSCAs

To understand how these situations happened, conversations with people from villages B and C were analysed. Parts of two such interviews are shown below. Different considerations were observed.

Interviewer: Could you introduce the ROSCA operating situation in your village?

Interviewee from village B: "ROSCA is still very popular and the main mutual way in our village. Normally, defection barely happens…actually, around 20 years ago, defection sometimes happened. It would ruin the mutual trust…we villagers thought mechanisms were needed to solve this emerging defection problem….You see, since then we started to sign this contract. Also, we hold meetings every month. It's important to see each other's face every month to confirm each member's household situation. Also, a group leader chooses members based on reputation. If you ever defected once, you will never be accepted by any group in future."

Interviewee from village C: "Yes, ROSCA was quite popular in our village about 10 years ago. At that time, whenever you needed some money, you could rely on the leader and join a ROSCA to solve your problem…almost everyone belonged to more than one ROSCA group, and the money pots were getting bigger…then defectors started emerging…they took the money pot and escaped to the downtown; it was impossible to find them…yes, we didn't sign any punishment contract…I think even if we signed, it wouldn't work, right? Then we gradually gave up on ROSCAs. It's too risky and time-consuming…"

The detailed rules used by village A are presented in Table 6.10. Special attention is paid to punishment rules in the narrative that follows that was provided by a group leader in the village.

Table 6.10 ROSCA Rules and Situation in Village A

Item	Village A
Money pot obtaining order	Throwing dice
Timing of deciding order	At first meeting
Money collection	All members gather at leader's house every time
Frequency of meeting	Every month
Punishment for free-rider	Take household property of free-rider
Sign contract or not	Yes
Operating history	Operated well (according to the interviewees, there were almost no free-riders)

Interviewer: What's the punishment for defectors in your village?

Interviewee from village A: "I can show you the contract. The contract is the common version used in our village, which stipulates the punishment rule for defectors and people late for regular meetings. If you defect, the other members will take away your household belongings or land as a punishment. Also, if you are late for a regular meeting, you'll be fined 200 yuan. Being punctual is the most important rule."

The statement above helps us to understand which mechanisms may work in informal financial institutions such as ROSCAs. Signing a contract with punishment for defectors appears significantly related to the sustainability of a ROSCA.

One relevant item of background information is that rural lands in China are owned by a village committee, which has the power to decide the allocation and usage of land for each household. This makes the punishment of forfeiture of the defector's land possible. If the group leader is relatively powerful in the village, there is a high probability that the village committee's decision can be influenced and punishment rules implemented. When defection happens in one group, the rest of the members could sue the village committee and ask for the reallocation of the defector's land. However, before doing so, group leaders normally fulfill the defector's overdues and wait to see if the situation changes.

6.3.4 Attitude to bank loans

Almost all the interviewees in the five villages have bank accounts because of government subsidies paid via the bank. However, their experience in borrowing money from banks is relatively limited. Based on the local bank regulations, farmers can use their land or house as collateral for loans. The procedures look simple and should not be a barrier for farmers. Interviewees were asked about borrowing and loans, to explore the possible reason for the low rate of usage of bank loans; a typical answer from an interviewee follows.

> *Interviewer: Have you ever borrowed money from a bank? Do you know the annual loan interest of that bank?*
>
> Interviewee: "I have never borrowed money from the bank because I heard that without some special network or connection, it would be impossible to get a loan from the bank for a farmer like me. Yes, I know the rate; it's 5.6% per year, but I

think it's too high."

Interviewer: Then, when you have an urgent use for money or some business investment, what would you do?

Interviewee: "Normally, we organise a ROSCA group. Yes, joining a ROSCA is much easier than loaning from the bank…because we are all familiar with ROSCA…and the interest rates of ROSCAs are quite fair and not high."

However, according to the ROSCA rule in Table 6.3, the earliest obtainer would pay 9% of the total income as extra interest, which is much higher than the rate on a bank loan. This answer shows that local people are more reliant on traditional mutual aid organizations and social networks, rather than sophisticated calculation. Another interesting finding is that the usage rate of Alipay Finance is high. Smart phones are quite popular in rural areas and local people rely heavily on the chatting applications. The Alipay Finance service is part of these applications, which enables users to save or borrow money through them. At the same time, small loans from Alipay Finance do not require collateral, which allows villagers more flexibility in borrowing money so long as they keep good credit online. Similar to joining ROSCAs, the popularity of online finance services is also rooted in social networks. The above result may supply new insights for designing rural financial mechanisms.

6.3.5 ROSCA group Leader's responsibility

In the Tunbao area, normally there is at least one (or more than one) group leader in one ROSCA group. As Figure 6.3 shows, the group leader is called Head, and the

member is called Foot. Leaders' responsibility and premium in A~E Village are concluded in Table 6.11.

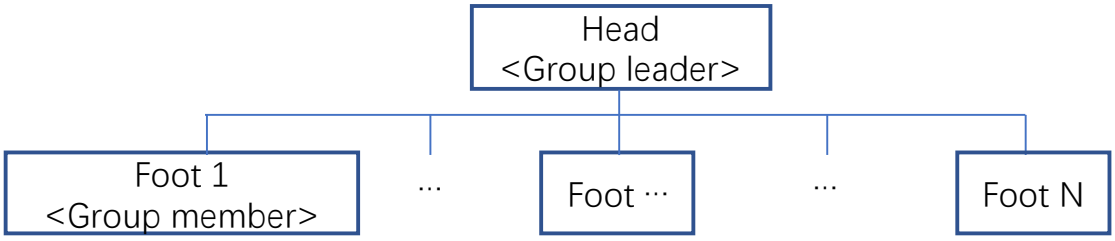

Figure 6.3 ROSCA Organising Mechanism in Tunbao Area.

Table 6.11 The Leader's Responsibility and Premium of Village A~E

Village	Leader's responsibility	Leader's premium
Village A	Operate meetings; collect money; guarantee success	Obtain at first meeting without extra interest
Village B	Operate meetings; collect money; guarantee success	Obtain at first meeting without extra interest
Village C	Collect money; guarantee success (sometimes pay for the defector's part instead)	Obtain at first meeting without extra interest
Village D	Operate meetings (including supplying location and food); collect money; guarantee success (pay money on behalf	Obtain at first meeting without extra interest, and at last meeting
Village E	Operate meetings (including supplying location and food); collect money; guarantee success	Obtain at first meeting without extra interest

Basically, the leaders are responsible for organising the meetings. Especially in Villages D and E, leaders hold the regular meetings to collect the funds at their homes and supply

the dinner. However, since there is no face-to-face meeting in Village C, the leader needs to collect the funds house by house before every rotation. As according to the leader's premium, leaders can obtain the money pot without interest at the first meeting or in any order they want. At the same time, the leaders' responsibilities include member selection beforehand. Therefore, a leader's ability and responsibility are indispensable to the group

6.4 Time Discounting and Rule Choices

There is extensive previous literature demonstrating that ROSCA participants' discounting preferences have an influence on ROSCA rule and order preferences. To my knowledge, the empirical literature has not yet shown a direct link between elicited time discounting preferences and ROSCA preferences at an individual level. Most of the previous research has focused on the aspect that participants tend to prefer to obtain the money pot earlier because they want to purchase indivisible lumpy goods as soon as possible, or they have emergency (or urgent) needs. As described previously, ROSCAs may have originated from private borrowing arrangements. However, as they evolved into more organised and larger institutions, it would have become harder to forecast the coming of emergency situations. When the order is determined in a negotiation-oriented way, later obtainers can instead be motivated by gaining extra interest as the compensation for waiting. Hence different ROSCA rules emerged and can be observed in the field.

In this section, individuals' time discounting rates are evaluated by eliciting preferences for various alternative rewards obtained at different times.

6.4.1 Elicitation of time discounting preferences

The experiment to elicit time discounting preferences was conducted using hypothetical rewards that could be obtained by participating in a ROSCA. Consider a ROSCA participant's preferences over monetary rewards and times, denoted as the pair (y, t), to be interpreted as y yuan obtained at time t. Assume subjects' preferences over monetary rewards are exponential. The discount function D (y, t) is defined as follows.

$$D(y,t;\lambda) = exp\{-\lambda t\},\ t > 0 \quad (9)$$

The relationship between choosing the immediate reward of x over the delayed reward of y in period t is given by the following function.

$$x = y\ exp\{-\lambda t\},\quad t > 0 \quad (10)$$

6.4.2 Experimental design

In the time discounting experiment, a total of 194 ROSCA-experienced subjects participated. Each interviewee completed the experiment after finishing the interview to provide basic information and information about the ROSCA situation in their village. During the experiment, they were asked to reply to a set of 36 questions to elicit their money discounting rates. The questions were of the following form:

If x RMB is paid to you today, what would make you indifferent to y RMB paid to you in t months?

Table 6.12 and Table 6.13 show a brief form of the questionnaire (see Appendix for a

complete version). The questionnaire consists of two parts. In the first session, *x* RMB equals 1,000 RMB and the amount of *y* varies from 1,200 to 2,200 RMB in increments of 200, while *t* varies among 1 month, 3 months, and 6 months. In the second part, *t* varies in the same way while the amounts of money today and in the future are greatly increased, so that *x* equals 5,000 RMB, and *y* varies from 6,000 to 8,500 RMB in increments of 500. The genetic algorithm (GA) is used to identify λ in Equation (10) and time discounting factor $\delta = exp\{-\lambda\}$. Figure 6.4~6.8 shows the results of the raw data of λ and its Probability density distribution in Village A~E.

Table 6.12 First scenario in questionnaire on time discounting

	Plan A	Plan B
1	receive 1200 RMB in 1/3/6 month	receive 1000 RMB today
2	receive 1400 RMB in 1/3/6 month	receive 1000 RMB today
3	receive 1600 RMB in 1/3/6 month	receive 1000 RMB today
4	receive 1800 RMB in 1/3/6 month	receive 1000 RMB today
5	receive 2000 RMB in 1/3/6 month	receive 1000 RMB today
6	receive 2200 RMB in 1/3/6 month	receive 1000 RMB today

Table 6.13 Second scenario in questionnaire on time discounting

	Plan A	Plan B
19	receive 6000 RMB in 1/3/6 month	receive 5000 RMB today
20	receive 6500 RMB in 1/3/6 month	receive 5000 RMB today
21	receive 7000 RMB in 1/3/6 month	receive 5000 RMB today
22	receive 7500 RMB in 1/3/6 month	receive 5000 RMB today
23	receive 8000 RMB in 1/3/6 month	receive 5000 RMB today
24	receive 8500 RMB in 1/3/6 month	receive 5000 RMB today

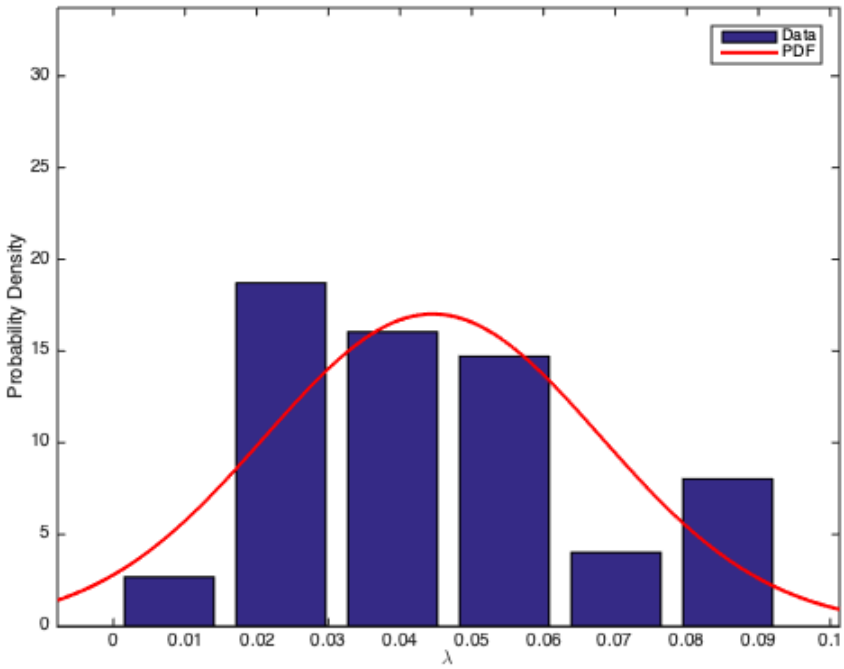

Figure 6.4 Probability density distributions of λ of Village A

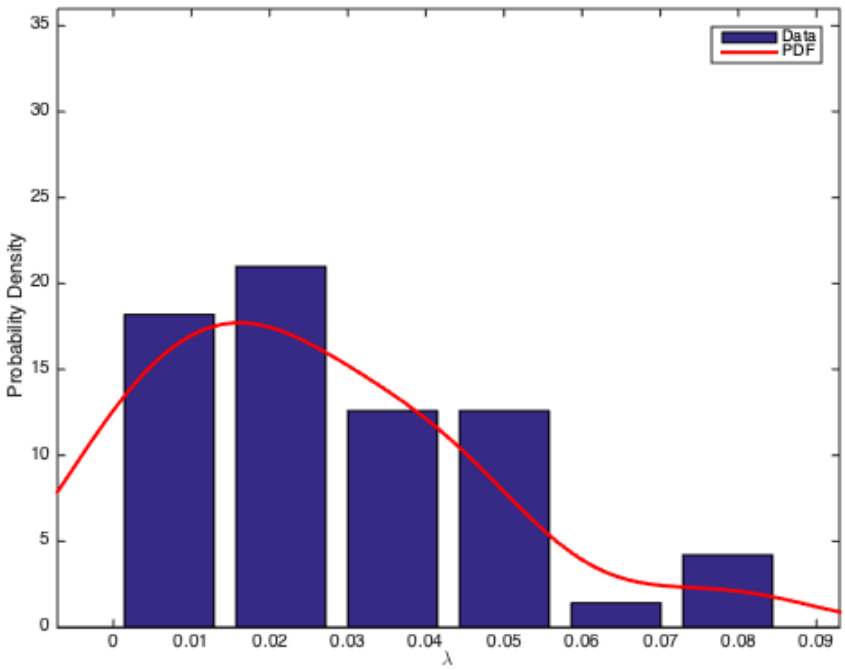

Figure 6.5 Probability density distributions of λ of Village B

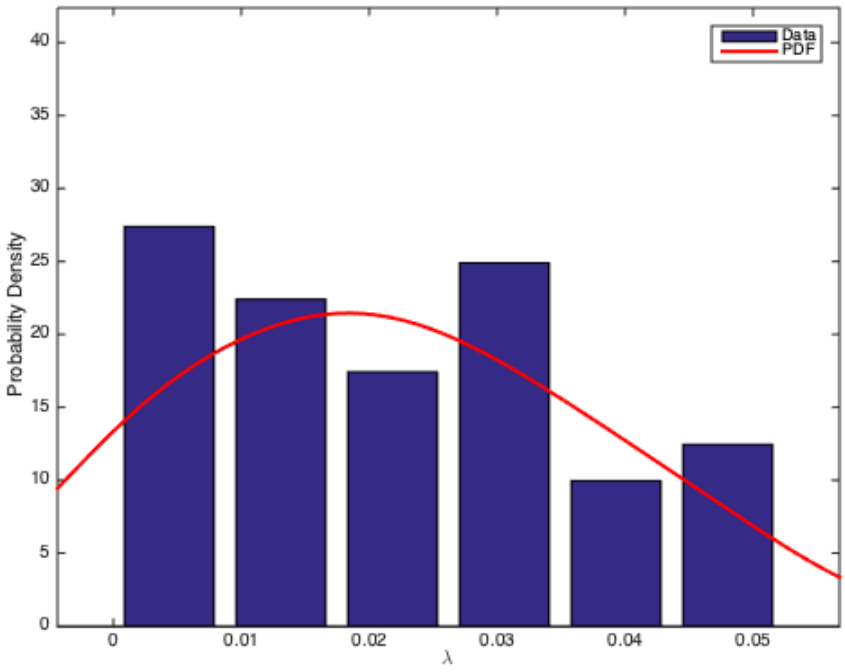

Figure 6.6 Probability density distributions of $\boldsymbol{\lambda}$ of Village C

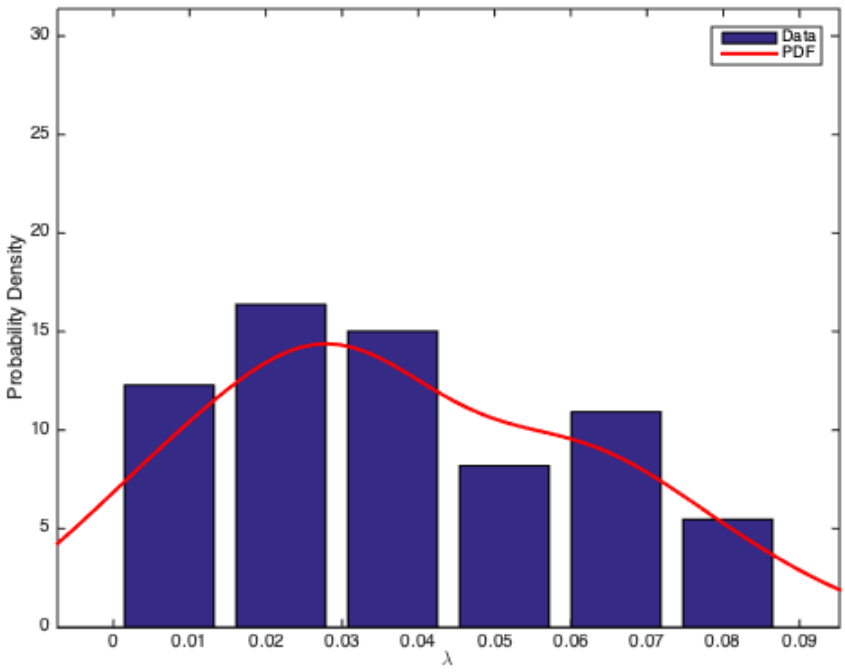

Figure 6.7 Probability density distributions of λ of Village D

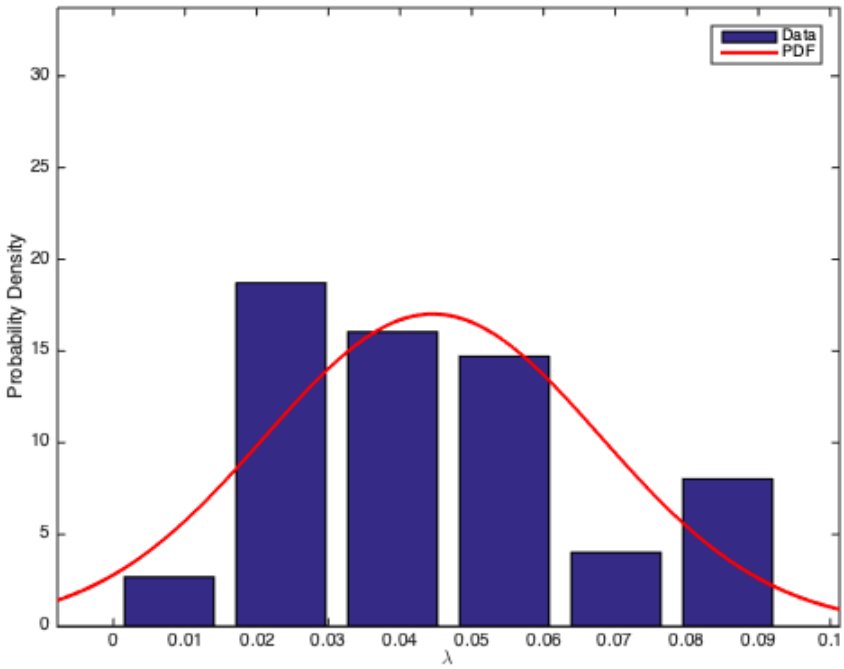

Figure 6.8 Probability density distributions of λ of Village E

The probability density distributions of the time discounting rates δ in villages A to E are given in Figure 6.9. As reported in section 6.3, village C is where large defections from ROSCA activities once happened and where ROSCAs have now been suspended. The time discounting results show that δ values in this village are relatively lower than in the other four villages. In Figure 6.9, a dashed line means the village mainly adopts the ROSCA rule that the order is decided by negotiation and a solid line means the ROSCA rule in the village is that order is decided by a random dice roll. In the next section, the relationship between time discounting and ROSCA rule preferences will be discussed.

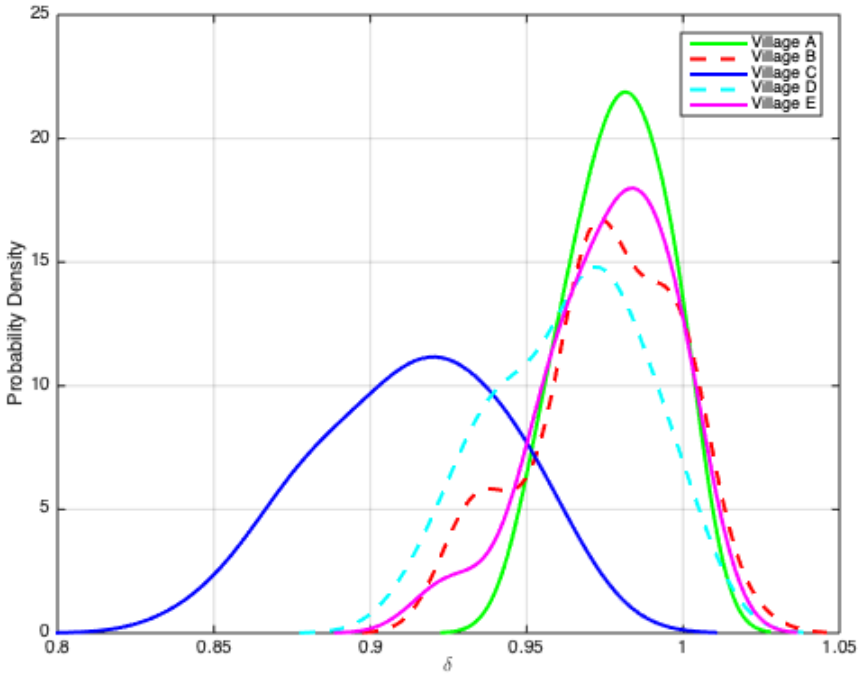

Figure 6.9 Probability density distributions of the time discounting rates δ of the five villages

6.4.3 Time discounting and order-deciding rules and interest types

According to the interview results presented in section 6.3.1, it was found that in the same village, two main ROSCA types—the interest and no-interest types—may be adopted by members who differ in individual characteristics. In this section, I present the method and results of a probit regression conducted to elucidate the relationship between time discounting and ROSCA rule preferences, especially the choices on the Interest and No-interest types. Table 6.14 presents the estimation results. The regression is based on the following:

$$Interest_i^* = \beta X_i + \varepsilon \quad (11)$$

$$Interest_i = 1 \; if Interest_i^* > 0$$

$$= 0 \; otherwise$$

where i denotes the interviewee index, Xi contains individual characteristics such as time discounting rate, age, household size, years of education, monthly income, and whether or not the individual owns a bank account, has ever taken a loan from a bank, and uses Alipay.

The main finding from the probit regression is that the choices of the interest type or no-interest type are significantly related to the time discounting rate. Members who choose the interest-type ROSCA show a relatively lower time discounting level than the people who chooses the no-interest type, which refers that members in the interest-type ROSCA is relatively more patient and willing to wait longer for higher payback.

Table 6.14 Probit regression results for time discounting rate and ROSCA rule choices in the field

VARIABLES	Interest
Delta	0.1574***
	(0.0459)
Age	0.0108
	(0.0106)
Sex (Male = 0)	-0.0779
	(0.19)
Household number	0.0253
	(0.0451)
Education years	0.0372
	(0.0293)
Household Income / Per month	-2.51e-05
	(1.64e-05)
Bank account (yes = 1)	0.162
	(0.399)
Bank loan (yes = 1)	-0.261
	(0.208)
Alipay (yes = 1)	0.116
	(0.287)
Constant	-16.07***
	(4.604)
Observations	194
Standard errors in parentheses in column interest *** p<0.01 ** p<0.05, * p<0.1 The log-likelihood value of probit estimation is -125.67 R^2: 0.0654	

6.5 Results and Discussion

The results of the empirical investigation show that ROSCA members in villages B and D prefer to include negotiation-oriented elements when deciding the order of obtaining a money pot. In these villages, it was found that the participants' levels of patience are relatively low. On the other hand, in villages A, C, and E, people show more patience and, therefore, when joining a ROSCA group they prefer a more random method of deciding the obtaining rule, such as throwing dice. This result can be also interpreted intuitively. When people are impatient, they will decide to join a ROSCA group only when the obtaining order satisfies their needs, thus when the order is determined according to negotiation. When group members are more patient, they can accept the random orders as more fair to everyone.

By comparing ROSCA operating situations in villages A, D, and E, it was found that signing a contract in advance and holding face-to-face meetings are essential to sustain cooperation. Although sanctions in the contract are sometimes difficult to enforce, social connections (deepened by regular meetings) and the fear of punishment are important factors influencing people's cooperative behaviours.

Another interesting finding is that people have concerns about bank loans and keep their distance from them to some extent. However, online finance systems such as Alipay are more accessible to them. Important implications can be derived from this finding, including that online finance systems can be new and innovative tools in building more inclusive financing in developing areas.

Understanding the decision-making rationale underlying informal financial institutions

such as ROSCAs in developing countries is critical to economic development because there is a great deal of evidence implying that financial markets are highly imperfect. An abundance of previous research shows that various motivations stimulate people to choose ROSCAs instead of formal institutions. In this thesis, I have analysed the culture in which ROSCAs are rooted and tried to reveal how different ROSCA rules were formed in various groups and areas. In the Tunbao area, ROSCAs act as a financial intermediary and show a good ability to adapt to people's different needs and preferences. At the same time, ROSCAs are not flawless, as observed in village B where defection happened frequently and, finally, cooperation collapsed. This research demonstrates possibilities in understanding how to design better financial instruments available to the rural economy.

1) Reciprocal person prefers no-interest ROSCA type;

2) Signing a contract, holding regular meetings and explicit statement of the punishment rule can help sustain ROSCA cooperation;

3) Regarding the choices about ROSCAs with interest or not, there is a statistically significant relationship with more patient (higher δ value) individuals tending to choose the ROSCA rule with interest.

Chapter 7 CONCLUSION

This chapter contains a summary of both the research process and the main findings of this thesis. The implications of this research for future work are also included. The research supplies a framework for choosing rules for cooperation by using ROSCA as a case study. It is argued that some future applications could be based on the current model.

7.1 Summary of the Research Process

This thesis has focused on the choice of ROSCA rules for cooperation and their evolution using a simulation-based imitation game and fieldwork in China to study the topic. First, a review of cooperation and evolutionary game theory was conducted; this highlighted the necessity of applying the theory to real cases of human cooperation. Then ROSCA was introduced as an indicative exemplar to be used for understanding the evolution of cooperation. The concept and basic rules of a ROSCA were defined based on the previous literature. In the review of the history of the development of ROSCA in China, it was found that there were huge rule disparities temporally and geographically. Accordingly, four types of ROSCA found in China were modelled in such a way as to include consideration of a discounting parameter.

An agent-based model of the evolutionary imitation game was established which enabled modelling of individual participant choices of different ROSCA groups or rules based on

his or her own utility function and the information obtained from the society. At the same time, because ROSCA has been considered as a mutual aid behaviour based on strict cooperation, reciprocal behaviour was included in the model as an essential weighting of each individual's utility function. Numerical simulations were conducted to illustrate the dynamic process of ROSCA rule choosing on an agent-based level. Using the simulation approach, some extreme social situations (e.g. a no-discounting society) were also modelled and discussed.

To explore how ROSCA rule choices happen in the real world, the fieldwork site was selected for investigating ROSCA rules in China because ROSCA has been adopted as the main informal financing method in the locale, where it has a relatively long history. The interviews focussed on rule disparities in different villages. Interviews were conducted in five Chinese villages to directly measure economic characteristics among individuals who were members of a ROSCA and to investigate how these parameters correlate with their ROSCA rule preferences. The investigation was conducted with narrative analysis of recorded interviews. Experiments to measure time discounting preferences were also conducted. The fieldwork was designed to identify local peoples' preferences related to ROSCAs and to understand potential reasons for such preferences.

7.2 Main Research Findings

ROSCA has been practiced as a useful informal financial institution for several hundred years all around the world. Previous research has barely demonstrated that the evolution of cooperation can be explained as a series of outcomes of microscopic interactions

between altruistic, but also self-motivated, individuals.

In this thesis research, I have developed a framework for simulating and discussing human rule choices in a cooperative behaviour ROSCA in order to understand how a new rule or behaviour diffuses through a whole society. One of the purposes of this thesis was to discuss the relationship between rule choices and individual preferences (i.e. reciprocity level) when people choose among different ROSCA types. In the computer simulation, I proposed an efficient framework and evolutionary cooperation model to simulate the ROSCA rule evolution process under different social situations. In identifying an agent's preference, learning behaviour was modelled and considered as the principal rule for updating rule choices. The value placed on reciprocity is a key factor that affects an individual's choice. In each societal setting, there is a dominant ROSCA type, but other types may coexist, and mutation on reciprocity may cause significant social change. This framework enables a discussion exploring possible dynamisms of social interactions when there are a large number of people involved.

In the field, it was found that several ROSCA rules can coexist but normally only one rule is the dominant scheme in that area. This result is consistent with the simulation conclusions: the order ranking rules are related to people's time discounting rates. According to the narrative analysis, it was found that individuals with higher reciprocity levels tend to participate in a ROSCA group that does not charge extra interest for any orders. At the same time, in the villages where the levels of participants' patience were relatively high, the ROSCA order was decided with a random method and, conversely, the order was decided by negotiation where participants had relatively lower patience.

To answer the question on the sustainability of ROSCA, the operation of the ROSCAs in different villages were compared. These results show that upfront signing of a contract that includes sanctions on defaulting behaviour and holding face-to-face meetings are essential for sustaining cooperation. Although defections are difficult to avoid completely, social connections and the fear of punishment are important factors influencing people's cooperative behaviours. As an outside option for financing, formal banks were found in all interview areas. However, consistent with the findings in some previous research, local people have concerns about bank loans and keep their distance from them to some extent. Instead, they consider that ROSCA is a convenient way to solve financing issues, which indicates that ROSCA may keep its vitality for some time. Therefore, this research demonstrates possibilities for designing better financial instruments available to the rural economy.

It can be concluded that the evolutionary fitness of a given ROSCA rule can be rationally explained by needs, patience, reciprocity and their distributive compositions. This conclusion in supported by the results of the computer simulation and surveys in the field. Different situations and factors are considered and discussed in numerical simulation and fieldwork, therefore, different models are adopted respectively. Nonetheless, in addition to the factors discussed here, there are still many other factors which can affect people's rule preferences. The work in this research demonstrate a potential way to illustrate society's rule choices under various situations.

7.3 Future Work

In this thesis, I attempt to explain ROSCA rule choices in terms of a dynamic process using a framework developed for this purpose. This proposed framework has raised many possibilities for further research studies.

First, a study could be carried out to examine the topology of networks in a given society when discussing imitative behaviour and rule choosing. In the current framework, a global situation on the whole population is considered and there is no weight placed on the social links. By combining simulation results with real situations, it is possible to discuss how a society's rule preferences change in various network topologies, for example, a small world network. A global equilibrium has been found in current settings, but a local rule choosing equilibrium might be observed in some specific local social networks.

Second, in this thesis I introduced the use of reciprocal behaviour in modelling the process of rule choosing and considered it as information about an individual. The baseline model shows the potential for extending the framework and involving more factors in this dynamic process. More empirical data would supply a better understanding of individual information and preference modelling. The framework and methodology adopted for the fieldwork could supply a guideline for such research.

Third, in this thesis, I constructed an imitation game on ROSCA rule choices. This could be applied not only to ROSCA, but also some other collective behaviours. Different cooperative behaviours or institutions display different levels of focus on imitation rules,

reciprocity levels, and other limitations. Technically, this model is open and adjustable for use in the study of other cooperative behaviours and evolutionary games.In the study of the development of human cooperation, a lot of research questions have been raised including, but not limited to, the emergence of cooperation, the effect of individual preferences on social transitions, and the sustainability of cooperation. As was introduced at the beginning of this dissertation, humans tend to cooperate and make rules according to different demands and social situations. As observed in ROSCAs, temporal and geographic rule differences exist and preferences on the individual level should not be ignored. Even when there are outside options for financing and loans, such as banks, many people around the world still choose to join ROSCA groups and the rules of these groups keep evolving in a self-motivated way. The discussion on human cooperation and the evolution of rules for informal financial institutions (such as ROSCAs) will likely continue in future research.

Appendix AROSCA CINTRACT OF VILLAGE A

互 助 会 规

会首：鲍英明 （头会不乍利息）

此会为互助会，互相帮助，解决困难。我使本会圆满成功，特定会规如下：

一、本会于2017年农历十月初一起乍第一会，每月一会（润月、正月照乍，备注：正月推到初六乍会），每会人民币1000元，重会乍1100元，每月初一晚19:03---10:90准时摇会；不准迟到，如迟到，轻会罚款100元还要取消摇会资格，重会罚款200元。

二、本会实行摇会制，同点以前面的点为主。

三、在中途如有会员故意退出，轻会将作“后银不跟，前银不算”，重会如有滥会，会首带领众会友到其家中拿物资折价抵押。

四、不准使用假币，如发现一张，按数目的10倍罚款。

五、会员在接会时，由夫妻二人签字，由轻会担保人签字，须有房屋、田地抵押，并按手印。如摇得会者不需要此会可卖会。

六、望各会员必须遵守以上条款，履行义务。

七、备注：外地人员接会时，由当地亲戚负责担保签字，外地人员方可接会。

会 员 名 单

姓 名	会数	电 话	姓 名	会数	电 话	姓 名	会数	电 话
姜兴国	1		红 妹	1	18224698558	才多平	1	18224785821
王艳霞	1	630166	江 红	1	538673	会 方	1	15902632916
翠 秀	1	18785363894	艳青安胜子	1		悟 空	1	14785839993
江文平	1	18934437862	老 珍	1	18286353837	才金连	1	15185389191
润 华	1		中 祥	1	671592	星 星	1	13086908090
汪 林	1		润 红	1	13985730864	正 元	2	18785378881
安 安	2	18722784291	小 菊	1		汪贵兰	1	13765376496
优 华	1		汪艳青	1	15008539828	贵 祥	1	13721533686
刚 兵	1		林 波	1	18285305303	林 林	2	13765338831
安 祥	1	18083393900	凤 召	1	13885302694	光 荣	1	15185438155
路 路	1		贵 香	1	537438	良 成	1	
菊 英	1	638593	小进红平子	1	18224715205	云 平	1	
平 忠	1		老幺送水	2	13708534920			
明 明	2		新 艳	1	658886			
百 胜	1		润 三	1				
春 成	2	632079	小进润三子	1				
红 香	5	532984	凤 珍	1	519593			

2017年农历十月初一乍第一 全会共56会

Figure A.1 A copy of ROSCA contract in Village A

Mutual Help Group Regulation (rule) (Translation)

Leader: XX

We establish this group to aid mutually and solve members' financial difficulties. To ensure the success, group regulation is as follows:

This group opens its first meeting on 1 October, 2017 and holds a regular meeting every month (in the month of the Lunar New Year, the meeting is held on the 6th). Each member pays 1,000 yuan at each meeting before obtaining the money pot; after obtaining, the payment is 1,100 yuan. The monthly meeting starts at 19:00 on the first day of that month. Please be punctual. A 100 yuan penalty is applied for people arriving late, and this could be considered as disqualification from further participation.

The money pot obtaining orders are decided by rolling dice at each meeting. The highest point value wins the money pot.

When any member wants to quit this group before obtaining the money pot, we follow the principle of 'exempting the later payments, no return of the previous payments' (后银不跟，前银不算). However, if the member already withdrew the money pot, the group leader will organise the others to take away this member's personal belongings or estate.

Do not use counterfeit money; once discovered, a ten-times penalty will be charged.

Members are allowed to sell their order to others. When obtaining the money pot, husband and wife should both attend to sign and allow their estate and land to be held as collateral.

Every member should obey the above terms and fulfill his or her obligations.

Note: People from other villages must have local relatives to provide a guarantee if they want to buy an order.

Member list

Name	Chance of withdrawing pot[1)]	Phone number

Members can choose how many times they want to obtain the money pot. The payment at each meeting increases as more chances are chosen.

Appendix B QUESTIONNAIRE OF FIELD WORK IN CHINA

Anshun Tunpu（安顺屯堡） Village ROSCA Survey

2019.1-2019.2

A1	Village name	
A2	Respondent Name	
A3	Mobile phone number	
A4	Gender: 1=Male, 2=Female	
A5	Age	
A6	Date interviewed	
A7	Interviewed by	

Household Information

B8	How many years have you lived in the village?	
B9	Total number of household members besides you	
B10	Married or not, if yes, B11; if not, B12	
B11	Number of kids under 18 yrs old	
B12	Number of members above 60 yrs old (excluding yourself)	
B13	Years of education completed	
B14	Occupation/ main income source	
B15	The average monthly income of whole family	

ROSCA Information (about the latest ROSCA you joined)

C16	Have you ever joined a ROSCA? If not, why, -F42	
C17	When was your latest joined ROSCA	
C18	Why did you join that ROSCA (motivation)	
C19	Why that ROSCA was organized	
C20	How many members inside?	
C21	How long did it last?	
C22	How did the obtainment order be decided	
C23	How much money you need to pay at each meeting (what are the payment rules)	
C24	How did the rules be decided?	
C25	how did you finally use the money pot	
C26	Any free riders?	

Network information in the ROSCA

D27	Who organized that ROSCA? (name, M/F?)	
D28	Who did you invited to join this group?	
D29	Who invited you to join this group?	
D30	Did you know all the members before gathering	
D31	Did you know all the members after finishing?	
D32	How many relatives in the members?	
D33	How many closed neighbors in the members?	
D34	If you were the leader, would you invite the same members again?	

Evaluation of ROSCA

E35	How many times did you join ROSCA?	
E36	Did you join all voluntarily?	
E37	Do you think social relationship getting better after joining	

	a group?	
E38	Did your financial problem solved after joining a ROSCA	
E39	Do you prefer join a ROSCA or borrowing?	
E40	Do you think ROSCA will be sustained?	
E41	Do you think there may be free rider?	

Evaluation of formal financial institution

F42	Do you have a bank account? Yes-F43 , No-F44	
F43	Do you save money in the account?	
F44	Why do you not use bank account?	
F45	Have you ever loan money from the bank? Yes-F46 , No-F47	
F46	Why did you borrow from the bank? (why not ROSCA)	
F47	Why never loan from the bank?	
F48	Are you using Alipay or wechat wallet?	

Time preferences test

(First Part)

	Plan A	Plan B
1	A: receive 1200 RMB in 1 month	B: receive 1000 RMB today
2	A: receive 1400 RMB in 1 month	B: receive 1000 RMB today
3	A: receive 1600 RMB in 1 month	B: receive 1000 RMB today
4	A: receive 1800 RMB in 1 month	B: receive 1000 RMB today
5	A: receive 2000 RMB in 1 month	B: receive 1000 RMB today
6	A: receive 2200 RMB in 1 month	B: receive 1000 RMB today

I choose A for 1 - I choose B for 1 -

	Plan A	Plan B

7	A: receive 1200 RMB in 3 months	B: receive 1000 RMB today
8	A: receive 1400 RMB in 3 months	B: receive 1000 RMB today
9	A: receive 1600 RMB in 3 months	B: receive 1000 RMB today
10	A: receive 1800 RMB in 3 months	B: receive 1000 RMB today
11	A: receive 2000 RMB in 3 months	B: receive 1000 RMB today
12	A: receive 2200 RMB in 3 months	B: receive 1000 RMB today

I choose A for 1 - I choose B for 1 -

	Plan A	Plan B
13	A: receive 1200 RMB in 6 months	B: receive 1000 RMB today
14	A: receive 1400 RMB in 6 months	B: receive 1000 RMB today
15	A: receive 1600 RMB in 6 months	B: receive 1000 RMB today
16	A: receive 1800 RMB in 6 months	B: receive 1000 RMB today
17	A: receive 2000 RMB in 6 months	B: receive 1000 RMB today
18	A: receive 2200 RMB in 6 months	B: receive 1000 RMB today

I choose A for 1 - I choose B for 1 -

(Second Part)

	Plan A	Plan B
19	A: receive 6000 RMB in 1 month	B: receive 5000 RMB today
20	A: receive 6500 RMB in 1 month	B: receive 5000 RMB today
21	A: receive 7000 RMB in 1 month	B: receive 5000 RMB today
22	A: receive 7500 RMB in 1 month	B: receive 5000 RMB today
23	A: receive 8000 RMB in 1 month	B: receive 5000 RMB today
24	A: receive 8500 RMB in 1 month	B: receive 5000 RMB today

I choose A for 1 - I choose B for 1 -

	Plan A	Plan B

25	A: receive 6000 RMB in 3 month	B: receive 5000 RMB today
26	A: receive 6500 RMB in 3 month	B: receive 5000 RMB today
27	A: receive 7000 RMB in 3 month	B: receive 5000 RMB today
28	A: receive 7500 RMB in 3 month	B: receive 5000 RMB today
29	A: receive 8000 RMB in 3 month	B: receive 5000 RMB today
30	A: receive 8500 RMB in 3 month	B: receive 5000 RMB today

I choose A for 1 - I choose B for 1 -

	Plan A	Plan B
31	A: receive 6000 RMB in 6 month	B: receive 5000 RMB today
32	A: receive 6500 RMB in 6 month	B: receive 5000 RMB today
33	A: receive 7000 RMB in 6 month	B: receive 5000 RMB today
34	A: receive 7500 RMB in 6 month	B: receive 5000 RMB today
35	A: receive 8000 RMB in 6 month	B: receive 5000 RMB today
36	A: receive 8500 RMB in 6 month	B: receive 5000 RMB today

I choose A for 1 - I choose B for 1 -

References

Adams, D. W., & Von Pischke, J. D. (1992). Microenterprise credit programs: Deja vu. *World development*, 20(10), 1463-1470.

Adams, D.W. (1984). "*Are the Arguments for Cheap Agricultural Credit Sound?*" in D.W. Adams, D.H. Graham and J.D. Von Pischke, eds., Undermining Rural Development with Cheap Credit. Boulder, Colorado: Westview Press

Ambec, S., & Treich, N. (2007). Roscas as financial agreements to cope with self-control problems. *Journal of Development Economics*, 82(1), 120-137.

Anderson S, Baland J M., (2002). The economics of roscas and intrahousehold resource allocation, *The Quarterly Journal of Economics*, 117(3): 963-995

Anderson, C., & Kilduff, G. J. (2009). The pursuit of status in social groups. *Current Directions in Psychological Science*, 18(5), 295-298.

Anderson, S., Baland, J. M., & Moene, K. O. (2009). Enforcement in informal saving groups. *Journal of development Economics*, 90(1), 14-23.

Ashraf, N., Bohnet, I., & Piankov, N. (2006). *Decomposing trust and trustworthiness. Experimental Economics*, 9(3), 193-208. Fleming Revell, 1st Edition.

Axelrod, R., & Hamilton, W. D. (1981). The evolution of cooperation. *Science*, 211(4489), 1390-1396.

Bauchet J, Larsen V., (2018). ROSCA composition and repayment: Evidence from Taiwanese bidding ROSCAs, *The Journal of Development Studies*, 54(9): 1483-1495

Besley, T., Coate, S., & Loury, G. (1993). The economics of rotating savings and credit associations. *The American Economic Review*, 792-810.

Bisrat, A., Kostas, K., & Feng, L. (2012). Are there financial benefits to join RoSCAs? Empirical evidence from Equb in Ethiopia. *Procedia Economics and Finance*, 1, 229-238.

Bonan, J., LeMay-Boucher, P., McNabb, K., & Tomavo, C. C. (2019). Time preferences and commitment devices: evidence from ROSCAs and funeral groups in Benin. *Oxford Development Studies*, 1-17.

Bouman, F. J. A. (1995). Rotating and accumulating savings and credit associations: A development perspective. *World Development*, 23(3), 371-384.

Brandt, H., & Sigmund, K. (2004). The logic of reprobation: Assessment and action rules for indirect reciprocation. *Journal of Theoretical Biology*, 231(4), 475–486.

Brandt, H., & Sigmund, K. (2005). Indirect reciprocity, image scoring, and moral hazard. *Proceedings of the National Academy of Sciences of the United States of*

*Americ*a, 102(7), 2666–2670.

Bromley, D. W., Mckean, M. A., Gilles, J. L., Oakerson, R. J., & Runge, C. F. (1992). *Making the Commons Work: theory, practice and policy* (No. 307.72 M3).

Calomiris, C. W., & Rajaraman, I. (1998). The role of ROSCAs: Lumpy durables or event insurance?. *Journal of Development Economics*, 56(1), 207-216.

Chaudhuri, A. (2011). Sustaining cooperation in laboratory public goods experiments: a selective survey of the literature. *Experimental Economics*, 14(1), 47-83.

Conning, J., & Udry, C. (2007). Rural financial markets in developing countries. *Handbook of agricultural economics*, 3, 2857-2908.

Cull R, Morduch J., (2017). Microfinance and economic development, Policy Research Working Paper , Washington, DC: World Bank.

Dagnelie, O., & Lemay‐Boucher, P. (2012). Rosca participation in Benin: A commitment issue. *Oxford Bulletin of Economics and Statistics*, 74(2), 235-252.

Dekle R, Hamada K., (2000). On the development of rotating credit associations in Japan. Economic *Development and Cultural Change*, 49(1): 77-90

Falk, A., & Fischbacher, U. (2006). A theory of reciprocity. *Games and economic behavior*, 54(2), 293-315.

Fehr, E., & Fischbacher, U. (2003). The nature of human altruism. *Nature*, 425(6960),

785.

Fudenberg, D., & Imhof, L. A. (2006). Imitation processes with small mutations. *Journal of Economic Theor*y, 131(1), 251-262.

Geertz, C. (1962). The rotating credit association: A “middle rung” in development. *Economic* Development and Cultural Change, 10(3), 241-263.

Gugerty, M. K. (2007). You can’t save alone: Commitment in rotating savings and credit associations in Kenya. *Economic Development and Cultural Change*, 55(2): 251-282.

Hamilton, W. D. (1964). The genetical evolution of social behaviour. II. *Journal of theoretical biology*, 7(1), 17-52.

Hauert, C., Holmes, M., & Doebeli, M. (2006). Evolutionary games and population dynamics: maintenance of cooperation in public goods games. *Proceedings of the Royal Society B: Biological Sciences*, 273(1600), 2565-2571.

Hofbauer, J., & Sigmund, K. (1998). *Evolutionary games and population dynamics*. Cambridge university press.

Inoue Ryuzaburo (1979). *健保の源流"筑前宗像の定礼*. The Nishinippon Shimbun Press.

Izumida Yoichi (2003). *Rural Development Finance: Asian Experiences and Economic Growth* (農村開発金融論―アジアの経験と経済発展). Univ of Tokyo Press.

Jain P S., (1996). Managing credit for the rural poor: lessons from the Grameen Bank. *World development*, 24(1): 79-89

Jordan, J. J., Hoffman, M., Nowak, M. A., & Rand, D. G. (2016). Uncalculating cooperation is used to signal trustworthiness. *Proceedings of the National Academy of Sciences*, 113(31), 8658-8663.

Klonner, S. (2003). Rotating savings and credit associations when participants are risk averse. *International Economic Review*, 44(3), 979-1005.

Koike, S., Nakamaru, M., & Tsujimoto, M. (2010). Evolution of cooperation in rotating indivisible goods game. *Journal of Theoretical Biology*, 264(1), 143-153.

Kovsted, J., & Lyk-Jensen, P. (1999). Rotating savings and credit associations: The choice between random and bidding allocation of funds. *Journal of Development Economics*, 60(1), 143-172.

Kuo, P. S. (1993). Loans, bidding strategies and equilibrium in the discount-bid rotating credit association. Institute of Economics, Academia Sinica.

Leimar, O., & Hammerstein, P. (2001). Evolution of cooperation through indirect reciprocity. *Proceedings of the Royal Society of London B: Biological Sciences*, 268(1468), 745–753.

Madestam, A. (2014). Informal finance: A theory of moneylenders. *Journal of Development Economics*, 107, 157-174.

Masclet, D., Noussair, C., Tucker, S., & Villeval, M. C. (2003). Monetary and nonmonetary punishment in the voluntary contributions mechanism. *American Economic Review*, 93(1), 366-380.

Najita, T. (2009). *Ordinary economies in Japan: a historical perspective*, 1750-1950 (Vol. 18). Univ of California Press.

Nowak, M. A. (2006). Five rules for the evolution of cooperation. *Science*, 314(5805), 1560-1563.

Nowak, M. A. (2012). Evolving cooperation. *Journal of theoretical biology*, 299(0), 1-8.

Nowak, M. A., & Sigmund, K. (1998). Evolution of indirect reciprocity by image scoring. *Nature*, 393(6685), 573.

Nowak, M. A., & Sigmund, K. (2005). Evolution of indirect reciprocity. *Nature*, 437(7063), 1291.

Ohtsuki, H., Iwasa, Y., & Nowak, M. A. (2009). Indirect reciprocity provides only a narrow margin of efficiency for costly punishment. *Nature*, 457(7225), 79.

Platteau, J. P. (2000). *Institutions, social norms, and economic development* (Vol. 1). Psychology Press.

Rapoport, A., Chammah, A. M., & Orwant, C. J. (1965). *Prisoner's dilemma: A study in conflict and cooperation* (Vol. 165). University of Michigan press.

Sandsør, A. M. J. (2010). The rotating savings and credit association: An economic, social and cultural Institution, 2010.

Seibel H D., (2001). Mainstreaming informal financial institutions. Working Paper, University of Cologne

Sijia Z, Horita M., (2019). Reciprocity and Rule Preferences of a Rotating Savings and Credit Association (ROSCA) in China: Evolutionary Simulation in Imitation Games, *International Conference on Group Decision and Negotiation*. Springer, 43-56

Smith, A. H. (1899). *Village Life in China: A Study in Sociology*, New York, Fleming H. Revell Company, 54.

Smith, J. M., & Price, G. R. (1973). The logic of animal conflict. *Natur*e, 246(5427), 15.

Szabó, G., & Fath, G. (2007). Evolutionary games on graphs. *Physics reports*, 446(4-6), 97-216.

Tanaka, T., Camerer, C. F., & Nguyen, Q. (2010). Risk and time preferences: Linking experimental and household survey data from Vietnam. *American Economic Review*, 100(1), 557-71.

Trivers, R. L. (1971). The evolution of reciprocal altruism. *The Quarterly Review of Biology*, 46(1), 35-57.

Wang. (1930). *The history of Chinese Hehui*. Zhongguo Hezuo Xueshe.

World Bank Brief. (2017). UFA2020 Overview: Universal Financial Access by 2020. Accessed at 1 September 2019 https://www.worldbank.org/en/topic/financialinclusion/brief/achieving-universal-financial-access-by-2020

Xiaotong Fei. (1939). Peasant Life in China: A Field Study of Country Life in the Yangtze Valley. Routledge & K. Paul.

Yang, L. S. (1952). *Money and credit in China: a short history* (Vol. 12). Harvard University Press.

Yaron J., (1992). Assessing development finance institutions: a public interest analysis. Washington, DC: World Bank