Interaction of ROSCA with Mobile Money

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Abstract

This paper analyses the choice between two savings technologies, Rotating Savings and Credit Associations (ROSCA) and Mobile Money. Details on state contingent ROSCA contributions obtained from a focus group is used to model ROSCA savings. A theoretical approach in which individuals save to acquire an indivisible durable good, is used to analyse the impact that one's likelihood of incurring a bad shock has on their choice of savings mechanism. It is shown that there exist a threshold of likelihood of bad shock above which it is optimal to save in a ROSCA, otherwise savings is done independently. Mobile Money is modelled as independent savings with a higher interest rate than independent savings at home. We show that interest rate has a positive relationship with the threshold indicating that the introduction of mobile money could result in a reduction in ROSCA participation.

1 Introduction

According to the 2017 financial inclusion report by the World Bank, about 2 billion people are unbanked globally, almost all of whom are from developing economies.[1] In place of formal banking institutions, there is a significant prevalence of endogenous informal financial institutions amongst the poor in developing economies. Poor people who have little to no access to formal institutions, rely heavily on informal financial institutions. This reliance reveals a demand by

[1]See Demirguc-Kunt et al. (2018). Unbanked is defined as not having an account with a financial institution.

the poor for instruments to manage their finances. Access to some financial instruments is especially valuable to the poor, because their income and welfare tend to be highly susceptible to bad shocks and these instruments allow them to smooth their consumption. Thus, the informal financial institutions serve various functions ranging from savings and credit to insurance.

Given the limited access to formal financial institutions amongst the poor, there has been much interest in the potential impact of introducing formal financial institutions in such environments. For instance, Mobarak and Rosenzweig (2012) studied the effect of the introduction of index based rainfall insurance in an environment where informal risk sharing networks were the primary source of insurance. Their main concern was that introducing formal insurance into an environment with existing informal networks may crowd out of one of these insurance mechanisms. They found that, when informal networks only indemnify against individual specific losses, these two structures, in fact, complement each other.

Banerjee et al. (2016) found in their study of households in 75 villages in India that informal credit networks that were exposed to microfinance experienced a greater loss of linkage than those that were not exposed to microfinance. Amongst those exposed to the microfinance, they document that both those likely and those unlikely to receive credit from the microfinance lost informal credit relationships as a result of the exposure. So while introducing the villages to mircofinance may have been good for those likely to obtain credit from the formal institution, the introduction was actually detrimental to those unlikely to obtain credit from the microfinance institution.

This paper seeks to understand the impact of introducing a formal financial institution on an informal financial institution amongst the poor in Ghana. The focus is on the specific informal institution Rotating Savings and Credit Associations (ROSCAs), and the formal institution Mobile Money. On one hand, ROSCAs are one of the most common informal savings institutions prevalent in Latin America, Sub-Saharan Africa and Asia (Bouman, 1995). On the other hand, Mobile Money is a relatively new formal saving mechanism, that has become increasingly popular in Sub-Saharan Africa and especially so in Ghana since it was first introduced in 2009.

A ROSCA is an association of a small group of people who know each other and who have the same objective of accumulating a significant amount of money over time. The members are people who either work together, live close to each other, are friends or are relatives. The details of the operations of this association vary, but the basic principle is the same. All members agree to have periodic meetings at which each member makes a contribution. The total contribution, usually referred to as the pot, is then allocated to one of its members who has not received the pot in previous meetings. Contributions are made until each member has had a turn at receiving the pot, and then the group is dissolved, or another round is initiated.

Mobile money is technically a savings and payment system that is rendered via mobile phones by mobile network operators. It was first introduced in Kenya as MPESA and has since gained popularity across various countries in Sub-Saharan Africa. There has been massive growths in the adoption of this payment system due to accessibility of mobile phones in the region. The adoption of mobile money across the continent has been commended in facilitating financial inclusion amongst the poor. It is therefore of interest to understand how this growing financial service might impact existing financial institutions and the welfare of its adopters.[2]

The general interest of this paper is in examining if the introduction of mobile money could result in the abandonment of ROSCAs by its users, making them incapable of serving their purpose in an economy. To think about what might happen with the introduction of a new savings mechanism, consider a ROSCA of 12 members, composed of mothers. Suppose their objective for joining is to save towards schooling expenses. According to the Ghana living standard survey, rural households have an average of 6 members, 2 of which are school-aged children. These families earn an average monthly income of GhC 547 ($120 at the 2017 nominal exchange rate.) and spend an average of GhC 454 ($99.88) a term on the schooling of both

[2]For details about mobile money and financial inclusion see Donovan (2012),Demirgüç-Kunt and Klapper (2012),Etim (2014),and Hughes and Lonie (2007).

children.[3] To save up for their schooling expenses suppose these members agree to contribute GHC 38 (\$8.36) monthly with an insurance component. Whenever one is unable to make their contribution due to a bad shock say illness, the other members equally cover their contribution.[4]

Consider an alternative for these individuals to accumulate their savings in a formal institution which has a minimum deposit requirement such that, only the top 3 richest members of this ROSCA can afford to use this formal institution. What would be the overall effect of this ROSCA being exposed to this institution? The top 3 richest members could be made better of by leaving the association to join this financial institution, but what happens if they do? What becomes of the remaining 9? The expectation is that the introduction of the formal financial institution will result in a new equilibrium, but the question is, will this new equilibrium be a potential pareto improvement? Who will the winners be, who will the losers be, and how much will they lose?

In this paper, I examine theoretically the impact of mobile money on ROSCA participation. The objective is to understand if ROSCAs will exist with the introduction of mobile money, and if so, who joins. The environment is set up such that individuals have no access to credit, the only means of accumulating large sums of money is by saving. Savings can be done in one of two ways, saving together as a ROSCA, or saving independently. The choice between these two options is thus determined by their ex-ante expected utilities.

To understand the possible impact of Mobile Money on ROSCA participation in Ghana, it is important to understand why people join ROSCAs and how various features of the association affects one's payoff. By forming a focus group of 14 current members from 4 different ROSCAs and 8 former ROSCA participants, information is collected on the motives for joining a ROSCA and on the rules of operation. The important features of ROSCAs ascertained are incorporated into a model that explains the choice between a ROSCA and saving independently.

[3] Refer to the Ghana Living Survey report by the Ghana Statistical Service (2017)

[4] GhC is the symbol of the Ghana cedi which is the unit currency of Ghana. According to the world bank data, the GDP per capita of the country stands at US\$ 2046 . The nominal exchange rate as of the December 2019 is 1 GHC to 0.22 USD

The model is then used to explore the possible impact of mobile money.

The existing literature of ROSCAs outlines different reasons for joining a ROSCA. Women participate in ROSCAs to prevent their spouses from claiming their savings.[5] This role of ROSCAs is especially essential when women have little bargaining power (Anderson and Baland, 2002). Another motivation explored in the literature is the limited self-control hypothesis. Ambec and Treich (2007) argue that due to the constant and low contribution scheduled in advance, the high remuneration, and the strong limitations on withdrawals associated with ROSCAs, members are more efficient at reaching their savings goals. Insurance motives have also been explored in the study of ROSCAs. Calomiris and Rajaraman (1998),Kovsted and Lyk-Jensen (1999) and Klonner (2003) have studied bidding ROSCAs as substitutes for insurance among the poor in developing economies where formal insurance is limited.

Though ROSCAs are associated with various benefits, they are also associated with some problems, the most apparent one being defaulting. It is usually assumed that ROSCAs rely on social sanctions as enforcement.[6] While this usually works, there is still a high concern among ROSCA participants for defaults as shown by Anderson et al. (2003). While social sanctions mostly ensure that earlier recipients of the pot do not default, sometimes members are simply unable to make their contribution due to bad shocks. By understanding how such defaults are dealt with within ROSCAs, the utility of participating in a ROSCA can be better compared to the utility of participating in an outside savings option.

I use a two goods model to make precise how possible bad shocks affects one's decision to participate in a ROSCA. Each agent in the model can experience a good shock or a bad shock. Before their choice of savings mechanism each individual has some belief of their own chance of experiencing a bad shock which is common knowledge amongst all individuals. I show that equilibrium is determined by a threshold of perceived possibility of experiencing a bad shock.

[5] For more details on this savings hypothesis refer to Anderson and Baland (2002) and Mayoux and Anand (1995).

[6] See Anderson et al. (2003) and Besley et al. (1993).

Individuals below the threshold find themselves ex-ante better of saving independently as opposed to saving in a ROSCA. This threshold is shown to be larger for risk neutral individuals in comparison to risk averse individuals, making them more likely to save independently than in a ROSCA. I further show that, under the assumption that pot values remain the same, in equilibrium, either everyone saves together in a ROSCA or they each save independently.

To understand the impact of mobile money on ROSCA participation, The theoretical model built allows for non zero interest rates to be accrued on savings done independently. Individuals who fear theft or claims by their spouses on their savings are considered to have a negative interest rate for independent savings. In contrast, mobile money is considered to have a positive interest rate. The results obtained from the model indicates that the equilibrium threshold is increasing in interest rate. This indicates more people are likely to find themselves better of saving independently, implying the possibility of a reduction in ROSCA participation as a result of the introduction of mobile money.

This paper is organized as follows; the next sections outline the details of ROSCAs and how they operate in the context of Ghana and based on information from the focus group used in this study. Section 3 details Mobile Money's operations and its accessibility in Ghana. Section 4 describes a model of choice between savings in a ROSCA and an outside option. Section 5 uses the model to discuss the possible impact of mobile money on the decision to participate in a ROSCA. Section 6 concludes.

2 ROSCAs in Ghana

This section covers the operations of ROSCAs in Ghana. A focus group of people who are presently members of ROSCAs or have been in ROSCAs in the past from various parts of Ghana were interviewed. The interview covers questions about why people participate in ROSCAs and what they perceive the benefits and costs of participating in a ROSCAs might be. The interviews provides insight on the rules by which the association operates and how that affects the benefits of being a member of the association.

ROSCAs in Ghana like in most places vary by how the pot is allocated [7]. The pot can be allocated randomly or by a bidding process. With random allocations, a draw can be made at each meeting to determine who gets the pot in that meeting, or the complete allocation for each meeting can be determined before the first set of contributions are made. Besley et al. (1993) considers both random and bidding ROSCAs in studying these associations, whiles Anderson and Baland (2002) only considers ROSCAs that predetermine their allocation randomly before any contributions are made. For this study, the focus is on ROSCAs with randomly predetermined pot allocations since this helps to pin down the ex-ante valuation of one's participation in the association.

Random allocation is the most common pot allocation mechanism used in Ghanaian ROSCAs (Owusu et al. (2013),Amankwah (2017) and Bortei-Doku Aryeetey and Aryeetey (1996)). Though ranks are assigned randomly, It is common place for members of the association to make accommodations in pot allocation in response to emergent needs of members or the credit history of its members. ROSCAs are known to make considerations for members who experience bad shocks such as sickeness, theft, funerals etc. In most instances if respondent's are yet to receive the pot, they might be allowed to receive the pot at the earliest possible meeting even if it is not their turn. Additionally, members who have acquired bad credit history from previous cycles by making delayed contributions or even missing some contributions are typically randomly assigned the latter few positions, while members with good credit history are randomly assigned to earlier positions. [8]

ROSCAs in Ghana meet weekly or monthly. They are on average made up of 10 individuals most of whom are women.[9] There is no large dataset to indicate the proportion of ROSCA

[7]Owusu et al. (2013),Amankwah (2017) and Bortei-Doku Aryeetey and Aryeetey (1996) through surveys give accounts of various types ROSCA allocations mechanisms in Ghana which is similar to the findings of Bouman (1995) for various other Sub-Saharan African countries.

[8]For details about allocation mechanisms of ROSCAs in Ghana, refer to Owusu et al. (2013) and Bortei-Doku Aryeetey and Aryeetey (1996).

[9]These details were obtained from several surveys conducted by Owusu et al. (2013)Bortei-Doku Aryeetey and Aryeetey (1996) and Amankwah (2017)

members that are women, but various surveys conducted by Owusu et al. (2013), Bortei-Doku Aryeetey and Aryeetey (1996) indicate that women constitute over 80 percent of ROSCA participants. Of the women in these ROSCAs, most are married with children. According to Bortei-Doku Aryeetey and Aryeetey (1996), most ROSCA participants are traders who use the association as a means of raising capital to invest in their trade.

The focus group interviewed for this study consists of 18 individuals, 4 of whom were once in ROSCA but currently are not. The remaining 14 individuals are current members of 4 different ROSCAs. 15 of the respondents were women indicating about 83 percent participation of women which comes as no surprise since is it common place for most ROSCA participants to be women. All participants are residents of 3 urban cities in Ghana, Accra, Kumasi and Sekondi. Respondents were asked about any ROSCAs they have participated in, currently or in the past. ROSCA sizes reported ranged from 5 to 14. The most common frequency of contribution reported was weekly though monthly contributions are also common. Weekly contributions ranged from GhC 10 ($ 2.2) to GhC 100 ($ 22), and of all active ROSCAs, only one was a bidding ROSCA. The remaining were random ROSCAs.

While members acknowledge that joining a ROSCA allows them to achieve their savings goals, there is also a significant concern for the possibility of defaults by members and how that might affect one's pay-off from joining the association. Members of ROSCAs are strongly aware that an earlier recipient of a pot could renege on their agreement to make any further contributions. It is also entirely possible that some member may not make his or her contribution because they are incapacitated by a bad shock. Respondents interviewed in this study highlighted that there is a need to make prior arrangement for the possibility that some members may not make their contributions.

There is a difference between a member refusing to make contributions and a member being incapable of making contributions. At any point in time, a member who refuses to make contributions is considered to be capable of making his contribution but choosing otherwise at all subsequent meetings in a cycle. In contrast, a member could be rendered incapable of making their contribution as a result of some bad shock to his income. Though bad shocks might incapacitate individuals from contributing at a meeting, they might continue to contribute at subsequent meetings. In this paper, the act of refusing to make one's contribution is defined as defaulting, while being incapable of making one's contribution at a meeting due to a bad shock is defined as skipping.

Defaults are dealt with social sanctions. Defaulting members are excluded from any future ROSCA activities. Besides excluding defaulters from ROSCA activities, they are also banned from any future informal loans since such people are considered as untrustworthy in their societies. As a result of such social punishments for defaults, defaults are not very common in ROSCAs. These social sanctions are enough to deter most members from defaulting.

Besides social sanctions, other preventive measures are taken by ROSCAs to ensure that defaults are kept at a minimum. Interviews in this study suggest measures similar to those indicated by Anderson et al. (2003). Only trustworthy members are accepted into the association to deal with adverse selection. Some groups also nominate a leader who oversees the activities of the group and enforces that all contributions are made. Lastly, the most unreliable members are randomly assigned latter ranks in the rotation to receive the pot.

Though defaults are well managed with social sanctions and other measures, skipping also pose significant risks to ROSCA participants. Interviews with respondents have shown that people are still concerned with the possibility of skipping in ROSCAs. The concern is that if some members skips, the organization itself can come undone with some members incurring losses. The consequences of skips is a risk that is enough to deter some people from joining ROSCAs. A respondent remarked on how his previous group was dissolved because some members had difficulty in making their contributions on time, which resulted in others contributing more than they received.

Skips associated with observable bad shocks are typically accommodated in ROSCAs. Members of the association know each other well, they live close to each other or work with each other and can, therefore, observe when one of its members experience a bad shock. Knowing each other minimizes the concern of moral hazard in ROSCAs. Contrary to defaults, members who skip are not punished in the cycle that they skip though they could be punished in subsequent cycles by being assigned a latter rank. Instead of punishment, measures are taken by the group to support the skipping member. Some respondents commented that this is the purpose of the group, to support their friends or family to pay school fees, fix their roofs, prepare for the planting season, etc.

Skips by net creditors are dealt with in different ways depending on the method of pot allocation. ROSCAs which chose a pot recipient at each meeting will usually assign the pot to the net creditor who can not make their contribution in that period. The pot is given to such a member in good faith that they can get out of their bad shock and resume contributions at subsequent meetings. This emergency allocation can be looked at as a loan in a time of need. A skipping net creditor could also decide to leave the association by collecting the total of all his contributions made so far and then exiting that cycle of contributions.

Skips by net debtors are dealt with carefully in order to minimize potential losses. Typically, In this situation, remaining members will equally share in paying the skipping members contribution in addition to making their contributions. They do this in the hopes that the skipping member can recover from their bad shock and resume contribution making. This measure reduces potential losses by reducing the incentive of a skipping member to default in the future.

The discussed measures taken to tackle skips indicate that ROSCAs rely on state contingent contributions to ensure its sustainability. This means of contribution is indicative of an Insurance component to savings done in a ROSCA. While one can expect to be assisted with their savings in bad times, they are also expected to assist other members who might experience a bad shock. Therefore, one can expect their payoff for saving in a ROSCA to be affected by the experience of their group members.

3 Mobile Money in Ghana

Mobile Money is a financial tool that any mobile phone users can assess via their mobile network operators. It was first introduced in Kenya as MPESA and has since been rapidly adopted across Africa. Since its introduction in 2009, mobile money has rapidly become a major means of transactions in Ghana. The number of active mobile money accounts have increased by over 3000 percent since 2012. The current number of active mobile money accounts stand at about 12.5 million according to the central bank of Ghana which is about half of the population of Ghana.

Details about mobile money for this study is obtained by interviewing various individuals in the mobile money market. Mobile money users, agents and officials of mobile network operators were interviewed to obtain a full understanding of how mobile money works. Information about how a mobile money account can be set up,how transactions can be made, transactional charges and the various mobile money services was collected via these interviews.

The rapid growth of mobile money subscription in Ghana can be partly accounted for by the vast penetration of mobile phones in the country. Ghana is considered to have ”leapfrogged” from the fixed-line telephone system with the advent of mobile phones. Since its introduction in 1992, mobile phone subscription has fast increased from 19,000 to about 40 million as of 2018 (Bank of Ghana, 2017). This rise in the subscription can be attributed to the decline in the cost of owning a mobile phone and the increase in network coverage as well as the sharp increase in the functionality of mobile phones. They have fast gone from being ”the rich man's accessory” to an essential tool for day to day activities. The penetration of the mobile phone in Ghana has spurred on many economic uses for the phone, and one such innovation is the Mobile Money service.

Besides the fact that almost everyone in Ghana has a mobile phone, access to mobile money has been propelled by the increase in the availability of the service to mobile users. Mobile money provides financial services using the existing distribution networks of mobile network operators which are widely spread across the country. There are six mobile network operators in Ghana, four of which provide Mobile Money services. These 4 are the largest in market share and coverage in the country, making it possible for most people across the country including those in rural areas have access to mobile money.

Mobile money can be described as electronic wallets which hold electronic cash issued by mobile network operators which are backed by equivalent real cash which is held in partner banks. The MNO providers of mobile money employ mobile money agents who are individuals who facilitate the conversion of cash into electronic form and the conversion of electronic money into cash. Deposits and withdrawals into this wallet must be done through a mobile money agent. Transfer of cash from one mobile money user to another does not require the assistance of a mobile money agent. Transfers can be done directly on one's mobile handset. According to the Bank of Ghana (2017) payment systems report there are over 190,000 active mobile money agents in the country. Yu and Ibtasam (2018) mention in their study of mobile money in Ghana that as of 2016, in the southern part of the country, one could find a mobile money agent within a 50ft radius.

The process of opening a mobile money account is quite simple. In order to create a mobile money account, one will need to present government-issued identification to a mobile money agent or the office of their mobile network provider. The ID is required to ensure that one's mobile number is officially registered to their name, which is a prerequisite for opening a mobile money account. Once the account is opened, a maximum deposit of GhC 2000 ($ 440) can be made via a mobile money agent or at the office of the network provider at no charges. For those who require frequent large transactions via mobile money perhaps due to their trade, the limit on the deposit can be extended upon a request made to the network provider.

Mobile money was first established to facilitate easier and cheaper transfer of money from individuals in urban cities to friends and family in rural areas within a country. Mobile money has since experienced a significant expansion in its uses. Not only can one make transfers within a country, but international transfers can now be made via mobile money. One can also use mobile money for a variety of purchases, to pay utility bills, pay school fees, receive payments from government and receive wages.

Besides deposits which are free, all other transactions via mobile money incur charges. Both withdrawal of cash from one's mobile money wallet, and transfers from one mobile money wallet to another incurs a typical charge of a 1% for transactions below GhC 500 and 0.5% for larger transactions. Charges on transfers from a mobile money wallet to a non mobile money user depends on whether they are done independently on one's mobile handset, or done with the assistance of a mobile money agent. When such transfers are made independently, a maximum charge of 3% is applied while the assistance of an agent with such transfers incurs a maximum charge of 5%.

In 2015, the central bank of Ghana made regulatory guidelines that allows mobile money users to earn interests on their deposits. The guidelines requires banks to make a 1.5 to 7% interest payments on cash flows from mobile money to their partner mobile network operators who in turn are to pay 80% of that to their mobile money customers. Eli Hini, head of finance department of MTN; the largest mobile money provider in Ghana, commented that this means mobile money customers can expect to earn an interest on their balance at the end of each month which will be paid out quarterly.

4 Model (ROSCA vs Autarky)

The objective of this section is to model the choice at the end of a contribution cycle to remain in a ROSCA or to save independently. The intuition behind the modelling is that individuals consider the pros and cons of the different savings tools in order to make their decision. The model entailed in this sections is a benchmark model which compares ROSCAs to an independent savings mechanism with has no associated problems besides that bad shocks can prohibit a person from reaching their savings goals. This modelling approach incorporates state contingent ROSCA contributions and savings which are adopted to deal with bad shocks. A 3 persons, 3 periods case is used to understand the dynamics of the decision as it is the smallest number that allows for insurance mechanisms in ROSCA contributions.

The model abstracts away from collusion. Individuals can not leave a ROSCA to form another ROSCA of their own. In the 3 persons case modelled here, an individual can only chose to leave or stay but once they leave, their only choice for saving will be to do so independently. Therefore in this model, an individual can chose to be in a 3 member ROSCA or not. If they chose not to, the remaining 2 will decide to save together as a 2 member ROSCA or save independently. There are therefore only 3 possibilities, either all 3 remain in the association, 2 remain in the association or all 3 leave the association to save independently.

Consider a group of 3 individuals who wish to own an indivisible durable good which cost too much to acquire with one period's income. These individuals are assumed to have no access to credit markets such that their only option to acquire the durable good is to save. Suppose each individual live 3 periods and each independently experience two states of the world; the good and the bad state. In the good state, an individual earns an exogenous high income $y_h > 0$, and in the bad state, earns an exogenous low income $y_l > 0$. Furthermore, suppose that there are only two exogenous possible events in this environment; Event 1, where everyone experiences the good state and Event 2, where exactly one of the three individuals experiences the bad state. Event 1 occurs with probability $\alpha \in (0, 1)$ and Event 2 occurs with the probability $1 - \alpha$.

Prior to any savings decisions, each individual i is considered to have a belief $p_i \in (0, 1)$ that in the occurrence of event 2, they will be the one of the three to experience the bad shock. I make the simplifying assumption that these prior beliefs are independent across individuals and not time specific. The low income y_l associated with the bad shock is considered to be too little for an individual to save, so that individuals can only afford to save when they earn the higher income y_h.

Each individual's utility depends on their consumption of non-durable consumption good $\{c_t\}_{t=1}^{3}$ and on whether the individual possesses the durable good or not. Possession of the durable good is denoted by $d \in \{0, 1\}$ which is 1 when one possess the durable good and 0 otherwise . An individual's utility of possessing the durable good is expressed as $V(d)$.

The durable good is assumed to costs $3a$ and all three individuals can chose to save together as a ROSCA or save independently. If all 3 individuals were to always experience the good state of the world, so that they earned the high income each period, it will be optimal for them to smooth their consumption and save a each period. Since each individual can incur a bad shock which incapacitates them from saving, both ROSCA contributions and independent savings will be state contingent. To be precise, ROSCA contributions will be dependent on the occurrence of events 1 and event 2, since the pot value received in a ROSCA depends on the contributions of other ROSCA members. On the other hand, savings done independently will be contingent on the history of the states that an individual experiences.

If all three individuals decide to save together in a ROSCA, then contingent on which event occurs, contributions will differ. The ROSCA agreement in this model is such that any member experiencing the bad shock is exempted from contributions whiles the others are expected to pay more in order to maintain the same level of pot value. This agreement is drawn from the responses obtained from the focus group used in this study, on how skips are dealt with within the savings association. Contingent on event 2 occurring, the 2 individuals experiencing the good state will be required to pay $\frac{3}{2}a$, while the one experiencing the bad state skips the contribution. Such state contingent contributions ensures that the pot value at each period is $3a$, so that each member can acquire the durable good. Therefore if all 3 individuals chose to save together as a ROSCA, each member is guaranteed to enjoy the services of the durable good within the 3 periods they live.

Given α the probability of the occurrence of event 1, an individual i with a prior belief p_i of experiencing the bad shock in event 2,the ex-ante expected utility of participating in a 3-member ROSCA to be

$$\mathbb{E}[U_i(c_1, c_2, c_3)] + V(1). \tag{1}$$

where

$$\mathbb{E}[U_i(c_1, c_2, c_3)] = 3\left[\alpha u(y_h - a) + (1-\alpha)[p_i u(y_l) + (1-p_i)u(y_h - 3a/2)]\right]. \tag{2}$$

Saving at home works a little differently. While saving a each period to smooth one's consumption will be optimal in an environment with no bad shocks, it is not optimal when there is a possibility that one might experience a bad shock. This is because in this environment one can not save in the event of a bad shock. If an individual experiences one bad shock, the only way he or she can reach their savings goal optimally will be to save $\frac{3}{2}a$ in the two other periods. If an individual experiences two bad shocks, his only way of reaching his savings goal will be to save up all $3a$ from one period's income which is impossible and hence the need to accumulate money in the first place. Lastly, if an individual experiences three bad shocks, then there is no way he can save at all.

Given all of the above, to maximize the chances of acquiring the durable good while saving independently, $\frac{3a}{2}$ will be saved when a high income is earned, until the savings target $3a$ is reached. The ex-ante utility for saving at home for individual i with prior belief p_i can be expressed as

$$\mathbb{E}[U_i(c_1, c_2, c_3)] + \mathbb{E}[V(d)], \tag{3}$$

where

$$\mathbb{E}[V(d)] = p_i^2(3-2p_i(1-\alpha))(1-\alpha)^2V(0) + [1-p_i^2(3-2p_i(1-\alpha))(1-\alpha)^2]V(1) \tag{4}$$

and

$$\begin{aligned}\mathbb{E}[U_i(c_1,c_2,c_3) =& 2p_i(1-\alpha)\left[\frac{3}{2}-(1-\alpha)^2p_i^2-(1-\alpha)p_i\right]u(y_l) + 2p_i^2(1-\alpha)^2(1-p_i(1-\alpha))u\left(y_l+\frac{3}{2}a\right)\\ &+2[1-p_i(1-\alpha)]\left[\frac{1}{2}+(1-\alpha)^2p_i^2-p_i(1-\alpha)\right]u(y_h)\\ &+2[1-p_i(1-\alpha)][1-(1-\alpha)^2p_i^2+p_i(1-\alpha)]u\left(y_h-\frac{3}{2}a\right)\end{aligned} \tag{5}$$

In choosing between a 3-member ROSCA and saving independently, one has to compare the ex-ante utilities of the different options. Therefore I create the measure $g(p)$ which is obtained by deducting the ex-ante utility of saving independently from the ex-ante utility of saving within a ROSCA, so that

$$\begin{aligned}g(p_i) =& 3\alpha\left[u(y_h-a)-u\left(y_h-\frac{3}{2}a\right)\right] - 2p_i^2(1-\alpha)^2[1-p_i(1-\alpha)]\left[u\left(y_l+\frac{3}{2}a\right)-u(y_l)\right]\\ &-\left[1+2(1-\alpha)^2p_i^2-2(1-\alpha)p_i\right][1-p_i(1-\alpha)]\left[u(y_h)-u\left(y_h-\frac{3}{2}a\right)\right]\\ &+p_i^2(1-\alpha)^2[3-2p_i(1-\alpha)]\left[V(1)-V(0)\right].\end{aligned} \tag{6}$$

Whenever $g(p_i)$ is positive, individual i is ex-ante better of saving in a 3-member ROSCA, otherwise he or she is better of saving in autarky.

4.1 Analysis

The state contingent contributions in a ROSCA discussed above can be considered as savings with an insurance component, and the cost or premium associated with this insurance is the extra contribution one has to make when another member experiences a bad shock. Anyone who perceives their probability of experiencing a bad shock to be small, will find less need for the insurance that is bundled into ROSCA savings. Mathematically, As p approaches 0, the difference between ex-ante ROSCA utility and autarky utility $g(p)$ approaches

$$\lim_{p_i \to 0}(g(p_i)) = 3\alpha\left[u\left(y_h - a\right) - u\left(y_h - \frac{3}{2}a\right)\right] - \left[u(y_h) - u\left(y_h - \frac{3}{2}a\right)\right] \tag{7}$$

The above expression can be positive or negative depending on the magnitude of α. This is because if an individual experiences only good shocks, then saving in a ROSCA presents a possibility $(1-\alpha)$ of covering other ROSCA members' contributions and a simultaneous possibility α of smoothing their consumption. Therefore, as α decreases, the possibility of smoothing one's consumption in a ROSCA decreases while the possibility of covering another member's contribution increases.

Given the magnitudes of the benefits and the costs associated with saving in a ROSCA, the sign of $\lim_{p_i \to 0} g(p_i)$ depends on the magnitude of α. When α approaches 0, Equation (7) becomes negative, implying that saving in autarky is more attractive in comparison to saving in a 3 member ROSCA. In contracts, if α approaches 1 then Equation (7) becomes positive indicating that saving in a ROSCA is more attractive than saving in autarky. Since Equation (7) is continuous and strictly increasing in $\alpha \in (0, 1)$, it implies that there exists a threshold $\alpha_0 \in (0, 1)$ such that for all $\alpha > \alpha_0$, $\lim_{p_i \to 0} g(p_i)$ is positive while for all values of $\alpha < \alpha_0$, $\lim_{p_i \to 0} g(p_i)$ is negative.

If an individual perceives that should event 2 occur, she is most likely to experience the bad shock, such that p_i approaches 1, then $g(p_i)$ approaches

$$
\begin{aligned}
\lim_{p_i \to 1} g(p_i) =& 3\alpha \left[u(y_h - a) - u\left(y_h - \frac{3}{2}a\right)\right] - 2(1-\alpha)^2\alpha \left[u\left(y_l + \frac{3}{2}a\right) - u(y_l)\right] \\
&+ 2(1-\alpha)\alpha^2 \left[u(y_h) - u\left(y_h - \frac{3}{2}a\right)\right] - \alpha \left[u(y_h) - u\left(y_h - \frac{3}{2}a\right)\right] \\
&+ (1-\alpha)^2(1+2\alpha)[V(1) - V(0)]
\end{aligned}
\tag{8}
$$

which can be expressed to be

$$
\geq (1-\alpha)^2 \left\{2\alpha \left[(y_h) - u\left(y_h - \frac{3}{2}a\right)\right] + [V(1) - V(0)]\right\}
$$

For any value of $\alpha \in (0, 1)$, Equation (16) is strictly positive. This indicates that if a person perceives themselves to be in a bad state with certainty should event 2 occur, then they are ex-ante better of participating in a ROSCA than saving independently.

The above analysis shows that, if the chances of a skip within a ROSCA is low enough, then saving in a ROSCA will be a better option than saving independently. In contrast, if the chances of a skip within a ROSCA is high, then there exists a threshold $\bar{p}$ of perceived likelihood of one experiencing a bad shock, such that one is indifferent between saving in autarky and saving in the 3-member ROSCA. The existence of the threshold is supported by that facts that $g(p_i)$ becomes negative as p_i gets small, positive as p_i gets large, and the derivative

$$
\begin{aligned}
\frac{dg(p_i)}{dp_i} \geq& (1-\alpha)\left[3 - 8p_i(1-\alpha) + 8p_i^2(1-\alpha)^2\right]\left[u(y_h) - u\left(y_h + \frac{3}{2}a\right)\right] \\
&+ 2p_i(1-\alpha)^2[1 - p_i(1-\alpha)][V(1) - V(0)]
\end{aligned}
$$

is strictly positive. This indicates that ROSCAs become more attractive as one perceives themselves to be more likely to experience the bad shock in the occurrence of event 2 if $\alpha < \alpha_0$.

Proposition 1 *There exists a value $\alpha_0 \in (0, 1)$ such that for all $\alpha > \alpha_0$ one is ex-ante better off saving in a ROSCA instead of saving in autarky for all $p \in (0, 1)$. Also, for all values of*

$\alpha < \alpha_0$ there exists a threshold $\bar{p}$ at which individuals are indifferent between saving in autarky and saving in a ROSCA. For values of $p \in (\bar{p}, 1)$ one is better of saving in a ROSCA otherwise they are better of saving independently.

The above proposition indicates that if there is a high enough chance that one of the 3 individuals could skip, then anyone with a prior belief p_i that is above the threshold $\bar{p}$, will be ex-ante better of saving in the ROSCA, otherwise they will be better of saving independently. The proof to this proposition is shown in the analysis preceding it, where it has been demonstrated that $g(p)$ is strictly increasing, and for $\alpha < \alpha_0$, $\lim_{p_i \to 0} g(p_i) < 0$ and $\lim_{p_i \to 1} g(p_i) > 0$.

Characterizing the Equilibrium

If an individual with a probability p_i of skipping below the threshold $\bar{p}$ chooses to save independently, the remaining two persons can chose to save independently as well, or save together as a two member ROSCA. As a 2 member ROSCA, they will have to contribute $\frac{3a}{2}$ for two periods to reach their target.

In a two member ROSCA, the members will not be able to insure each other since one will have to contribute all $3a$ in the event that the other skips. Since the premise of the set up is that individuals have to save or borrow to acquire $3a$, it is impossible for a member to contribute $3a$ in one ROSCA meeting. Therefore, contributions can only be made when both members experience a good shock. The ex-ante utility of saving in this 2-member ROSCA for a member with probability p_i is similar to saving at home except that the first recipient of the pot could contribute a total of only $\frac{3}{2}a$ and receive the pot. In contrast, the last recipient of the pot could contribute a total $\frac{3}{2}a$ and not receiving the pot. These circumstances can occur if there is a period where everyone experiences a good shock so that ROSCA contributions are made, and in the remaining periods, someone incurs a bad shock.

$$\alpha \left[2u\left(y_h - \frac{3a}{2}\right) + u(y_h) \right] + (1-\alpha)\left[p_i u(y_l) + (1-p_i)u(y_h)\right] + \alpha V(1) + (1-\alpha)V(0).$$

In the choice between a 2 member ROSCA and saving independently, the measure $g(p_i)$ can expressed as

$$g(p_i) \leq \left\{ (1 - 4p_i^3 + 3p_i^2) \left[V(1) - V(0) \right] + (2p_i^2 - 2p_i^3) \left(u(y_l) - u \left(y_l + \frac{3}{2}a \right) \right) \right\}$$

which is negative. It can be concluded from the above expression that these 2 individuals will be better off saving at independently. This means that in the environment I have set up, if one of the 3 individuals chooses to save independently, then everyone else will chose to save independently, otherwise they remain in a 3 member ROSCA.

Proposition 2 *Given values of $\alpha < \alpha_0$, if there is an individual i with belief $p_i < \bar{p}$, then others with believes $p_i > \bar{p}$ will be better of saving independently.*

The above analysis indicates that in the presence of bad shocks, the choice of saving at home and saving independently is determined by the belief that individuals have that they will incur a bad shock as well as the chances that ROSCA members might skip. In the simple model studied, if α the chances that someone in a ROSCA will skip is low then all individuals will be better of saving in a ROSCA. In contrast, If α the chance that someone in a ROSCA will skip is high, then an individuals could be made better of saving at home depending on their perceived chances of skipping. If that occurs then the remaining individuals will be better of saving independently too. There are therefore only two possible equilibria in this environment, one where all 3 individuals save together in ROSCA or the other where everyone saves independently.

Risk Aversion

In characterizing the equilibria for different populations, this study considers how the equilibrium is impacted by the risk aversion of individuals. To make the contrast, I compare the savings decision for a risk averse and a risk neutral individuals. To capture the decision for a risk neutral individual, a linear utility function $u(x) = x$ is used. The measure to determine the method of saving for a risk neutral individual can be expressed as

$$g_{\text{risk-neutral}}(p_i) = \left\{\alpha - 2p_i^2(1-\alpha)^2[1-p_i(1-\alpha)] - [1+2(1-\alpha)^2p_i^2 - 2(1-\alpha)p_i][1-p_i(1-\alpha)]\right\}\frac{3}{2}a$$
$$+ p_i^2(1-\alpha)^2[3-2p_i(1-\alpha)]\left[V(1)-V(0)\right]. \tag{9}$$

For risk averse individuals a concave increasing utility function will suffice.

$$g_{\text{risk-averse}}(p_i) \geq \alpha\left[u(y_h) - u\left(y_h - \frac{3}{2}a\right)\right] - 2p_i^2(1-\alpha)^2[1-p_i(1-\alpha)]\left[u\left(y_l + \frac{3}{2}a\right) - u(y_l)\right]$$
$$-[1+2(1-\alpha)^2p_i^2 - 2(1-\alpha)p_i][1-p_i(1-\alpha)]\left[u(y_h) - u\left(y_h - \frac{3}{2}a\right)\right]$$

To compare the ex-ante decisions of a risk neutral individual with a risk-averse individual, I study the difference in $g_{\text{risk-neutral}}(p_i)$ and $g_{\text{risk-averse}}(p_i)$. To determine the difference, let

$$u(y_h) - u\left(y_h - \frac{3}{2}a\right) = u\left(y_l + \frac{3}{2}a\right) - u(y_l) - \epsilon$$

where ϵ is positive. The difference $g_{\text{risk-averse}}(p_i) - g_{\text{risk-neutral}}(p_i)$ is

$$\geq \left\{\alpha - [1-p_i(1-\alpha)]\left[1-2(1-\alpha)p_i + 4p_i^2(1-\alpha)^2\right]\right\}\left\{\left[u\left(y_l + \frac{3}{2}a\right) - u(y_l)\right] - \frac{3}{2}a\right\}$$
$$+\left\{-\alpha + [1-2(1-\alpha)p_i\left[1-p_i(1-\alpha)\right]]\left[1-p_i(1-\alpha)\right]\right\}\epsilon \tag{10}$$

To show that $g_{\text{risk-averse}}(p_i) - g_{\text{risk-neutral}}(p_i)$ is positive, I show that equation (10) is strictly positive. To do this I show that equation (10) is positive at $p_i = 0$ and at $p_i = 1$, and is a monotonic function for all values of $p_i \in (0,1)$ and $\alpha \in (0,1)$[10].

Proposition 3 *A risk averse individual is more likely to participate in a ROSCA than a risk neutral individual.*

It can be concluded from the above result that a risk averse individual will require a lower probability p_i of experiencing a bad shock to prefer independent saving than a risk neutral individual will. This indicates that risk averse individuals have a lower threshold of $\bar{p}$ than risk

[10]The proof the $g_{\text{risk-averse}}(p_i) - g_{\text{risk-neutral}}(p_i)$ is strictly positive can be found in the appendix A.

neutral individuals. i.e

$$\bar{p}_{\text{risk-averse}} \leq \bar{p}_{\text{risk-neutral}}.$$

5 Saving with Non Zero Interest Rate

The benchmark model in the preceding session analyses the decision to accumulate savings in autarky or to accumulate savings in a ROSCA. While the the independent saving mechanism in the benchmark model has no special feature besides bad shocks, in this section, an independent savings with a specific storage technology which is expressed as a non zero interest rate will be studied. This sets us up to explore the impact that mobile money might have on ROSCA participation.

In 2015 the central bank of Ghana instructed through their Electronic Money Issuers guidelines, that banks pay interests of 1.5 to 7% on floats from mobile money platforms to the mobile network operators that operate mobile money. Out of the interest received by mobile money operators, 80% was mandated as interest payment to mobile money customers. This has resulted in customers earning some interest on their deposits. MTN Gh the largest mobile money providers in Ghana paid 98.9 million to their 8 million money subscribers in the second quarter of 2016 .

While savings at home accrues no interest, savings at home are subject to claims from others. Anderson and Baland (2002) suggest that instead of interest, saving at home for women might actually have a decaying storage technology due to claims from one's spouse. In this model I will consider a decaying technology as savings with a negative interest rate at home and savings in mobile money as saving with a positive interest rate. The difference that the interest rate makes in the return to saving outside a ROSCA (i.e independently) will be informative of the impact that mobile money will potentially have on ROSCA activities.

Given the same environment as the benchmark model in the previous section, consider the same 3 individuals who are heterogeneous in the likelihood of experiencing a bad shock $p_i \in (0, 1)$.

Suppose also, that these individuals are also aware of the interest rate r that is compounded on their savings each period, and that they consume the interest on their savings each period. Given the same assumptions as the benchmark model, the ex-ante utility of consumption when savings is done independently is

$$\begin{aligned}\mathbb{E}[U_i(c_1,c_2,c_3)] =& [1-p_i(1-\alpha)]^2\left\{[1-p_i(1-\alpha)]u(y_h+3ar)+p_i(1-\alpha)u\left(y_l+3ar\right)\right\}\\ &+2(1-\alpha)^2p_i^2[1-p_i(1-\alpha)]u\left(y_l+\frac{3}{2}ar\right)+(1+p_i(1-\alpha))u\left(y_l+\frac{3}{2}a(1+r)\right)\\ &+2(1-\alpha)p_i(1-p_i(1-\alpha))^2u\left(y_h-\frac{3}{2}a(1-r)\right)\\ &+[1+p_i(1-\alpha)]\left\{[1-p_i(1-\alpha)]u\left(y_h-\frac{3}{2}a\right)+p_i(1-\alpha)u(y_l)\right\} \qquad (11)\end{aligned}$$

In the same fashion as the benchmark model estimated, let $g_r(p_i)$ be defined as the utility of ROSCA participation minus the utility of saving with mobile money such that,

$$\begin{aligned}g_r(p_i) =& p_i(1-\alpha)(1-p_i(1-\alpha))\left\{[u_{0,0}-u_{0,1}]+(1-p_i(1-\alpha))[u_{0,0}-u_{0,2}]\right\}\\ &-p_i^2(1-\alpha)^2[1-p_i(1-\alpha)]u_{-1,0}+[p_i^2(1-\alpha)^2-3p_i(1-\alpha)-3\alpha+2]u_{-1,1}\\ &+[-1-2(1-\alpha)^3p_i^3+3p_i^2(1-\alpha)^2]u_{-1,3}-(1-p_i(1-\alpha))^3u_{-1,2}+3\alpha u_{-1,-1}\\ &+p_i^2(1-\alpha)^2[3-2p_i(1-\alpha)]\left[V(1)-V(0)\right]\end{aligned}$$

where $u(y_l)=u_{0,0}$, $u\left(y_l+\frac{3}{2}ar\right)=u_{0,1}$,$u\left(y_l+3ar\right)=u_{0,2}$,$u\left(y_l+\frac{3}{2}a(1+r)\right)=u_{0,3}$, $u\left(y_h-a\right)=u_{-1-,1}$,$u\left(y_h-\frac{3}{2}a\right)=u_{-1,1}$,$u\left(y_h-\frac{3}{2}a(1-r)\right)=u_{-1,3}$,$u\left(y_h\right)=u_{-1,0}$ and $u\left(y_h+3ar\right)=u_{-1,2}$.

Note that the distinction between $g_r(p_i)$ and $g(p_i)$ in the benchmark model is r. When $r=0$, these two functions are the same. The interest therefore is in the difference that r makes in this model.

Under the same assumptions of continuous, increasing and concave utility function $u(\cdot)$, there also exist a threshold $\tilde{p}$ such that $g_r(\tilde{p})=0$. To understand the impact of a non negative interest rate in this model the derivative of the threshold $\tilde{p}$ with respect to the interest rate r

and obtained as

$$d\tilde{p}/dr = \frac{A}{B} \tag{12}$$

where

$$\begin{aligned}
A =& a(1-\alpha)\tilde{p}[1-\tilde{p}(1-\alpha)]\left[-\frac{3}{2}u'\left(y_l+\frac{3}{2}ar\right)-3(1-\tilde{p}(1-\alpha))u'(y_l+3ar)\right] \\
&-3a\tilde{p}^2(1-\alpha)^2(1-\tilde{p}(1-\alpha))u'\left(y_l+\frac{3}{2}a(1+r)\right) \\
&+3a(1-\alpha)^2\tilde{p}^2(1-\tilde{p}(1-\alpha))u'\left(y_h-\frac{3}{2}a(1-r)\right) \\
&-\frac{3}{2}a(1-\tilde{p}^2(1-\alpha)^2)u'\left(y_h-\frac{3}{2}a(1-r)\right)-3a(1-\tilde{p}(1-\alpha))^3u'\left(y_h+3ar\right)
\end{aligned} \tag{13}$$

which is negative under the assumptions that the utility function is concave and strictly increasing.

$$\begin{aligned}
B \leq & -\left\{2\tilde{p}(1-\alpha)^2\left[u\left(y_l+\frac{3}{2}a(1+r)\right)-u\left(y_l+\frac{3}{2}a\right)\right]+\tilde{p}(1-\alpha)^2\left[u\left(y_l+\frac{3}{2}ar\right)-u(y_l)\right]\right. \\
&+3[1-\tilde{p}(1-\alpha)^2][1-\tilde{p}(1-\alpha)][u(y_h+3ar)-u(y_h)] \\
&\left.+3\tilde{p}(1-\alpha)^2[1-\tilde{p}(1-\alpha)]\left[u\left(y_l+\frac{3}{2}ar\right)-u(y_l)\right]\right\} \\
<&0
\end{aligned} \tag{14}$$

The Equation (12) is strictly positive, indicating that the threshold $\tilde{p}$ is strictly increasing in the interest rate r.

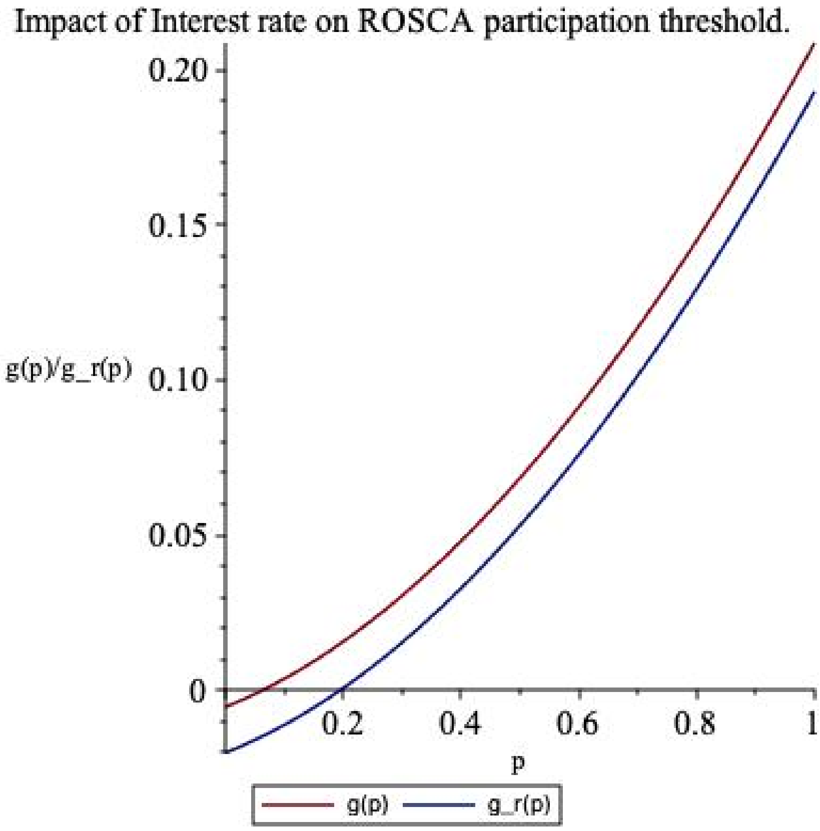

Figure 1: This graph is obtained for a 1% interest rate[11]

Proposition 4 *The introduction of mobile money to a population which is heterogeneous in probability p will result in a decrease in ROSCA participation.*

The proof to this proposition follows directly from the fact that the threshold $\tilde{p}$ is increasing in the interest rate r. So given the results of Anderson and Baland (2002), considering that households have a decaying storage technology due to claims from one's spouse, I can be expected that the introduction of Mobile money will result in some people leaving the ROSCA to accumulate their savings via Mobile money.

6 Conclusion

The introduction of a formal financial institution raises the question of how that might impact existing informal financial institutions. Understanding the possible impact of mobile money introduction on ROSCA activities is important in understanding how social welfare might be impacted. This paper studies how mobile money affects ROSCA activities on the participation dimension. Thus, this paper studies how incentive compatibility is affected by the introduction of mobile money.

To understand the possible impact of mobile money, it is important to understand why people chose to or not to save within a ROSCA. Review of existing literature indicates that savings at home are subject to claims by one's spouse, or claims' by one's self for those with limited self control. This study focus on the former motive for ROSCA participation. Claims on one's home savings are dealt with as a negative interest rate on savings at home. Another motive for saving in a ROSCA explored in existing literature is the insurance hypothesis. The insurance hypothesis in existing literature is linked to bidding ROSCAs, and while this study focuses on random ROSCAs, I introduce an insurance motive for saving in a random ROSCA.

The insurance motive in random ROSCAs explored in this study comes from uncovering how ROSCAs deal with defaults in contributions via interviewing a focus group. While most literature postulate that social sanctions are used in dealing with defaults, there is significant evidence that defaults persist in ROSCAs and threaten the sustainability of the association. By understanding and incorporating how contributions are affected by bad shocks within the association, an insurance motive is exposed and the full pay-off of ROSCA participation is captured in this study.

This study shows that there exists a threshold of probability of one experiencing a bad shock, below which one is better of saving independently and above which one is better off saving within a ROSCA. The results further indicates that risk averse individuals have a lower threshold than risk neutral individuals. In a 3 member ROSCA it is shown that under the assumption that pot values are equal to price of durable good, if one member is below the threshold, then all are better of saving independently, otherwise they all save together as a 3 member ROSCA.

When interest rates are introduced in the model it is found that the threshold increases with interest rate. This indicates that given a distribution of prior beliefs of experiencing a bad shock, one becomes more likely to be better of saving independently than saving in a ROSCA with the introduction of interest rate. It can be concluded from the model that the introduction of mobile money could result in the reduction of ROSCA participation.

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Appendix

The difference in the utility in a ROSCA from saving at home can be written as

$$
\begin{aligned}
g(p_i) =& 3\alpha \left[u(y_h - a) - u\left(y_h - \frac{3}{2}a \right) \right] - 2p^2(1-\alpha)^2[1 - p_i(1-\alpha)] \left[u\left(y_l + \frac{3}{2}a \right) - u(y_l) \right] \\
& - \left[1 + 2(1-\alpha)^2 p_i^2 - 2(1-\alpha)p_i \right] [1 - p_i(1-\alpha)] \left[u(y_h) - u\left(y_h - \frac{3}{2}a \right) \right] \\
& + p_i^2 (1-\alpha)^2 [3 - 2p_i(1-\alpha)] \left[V(1) - V(0) \right]. \qquad (15)
\end{aligned}
$$

The limit as p approaches 1 is

$$
\begin{aligned}
\lim_{p_i=1} g(p_i) =& 3\alpha \left[u(y_h - a) - u\left(y_h - \frac{3}{2}a \right) \right] - 2(1-\alpha)^2\alpha \left[u\left(y_l + \frac{3}{2}a \right) - u(y_l) \right] \\
& + 2(1-\alpha)\alpha^2 \left[u(y_h) - u\left(y_h - \frac{3}{2}a \right) \right] - \alpha \left[u(y_h) - u\left(y_h - \frac{3}{2}a \right) \right] \\
& + (1-\alpha)^2 [1 + 2\alpha][V(1) - V(0)] \qquad (16) \\
\geq & \alpha \left[u(y_h) - u\left(y_h - \frac{3}{2}a \right) \right] - 2(1-\alpha)^2\alpha \left[u\left(y_l + \frac{3}{2}a \right) - u(y_l) \right] \\
& + 2(1-\alpha)\alpha^2 \left[u(y_h) - u\left(y_h - \frac{3}{2}a \right) \right] - \alpha \left[u(y_h) - u\left(y_h - \frac{3}{2}a \right) \right] \\
& + (1-\alpha)^2 [1 + 2\alpha][V(1) - V(0)] \qquad (17) \\
=& - 2(1-\alpha)^2\alpha \left[u\left(y_l + \frac{3}{2}a \right) - u(y_l) \right] \\
& + 2(1-\alpha)\alpha^2 \left[u(y_h) - u\left(y_h - \frac{3}{2}a \right) \right] \\
& + 2\alpha(1-\alpha)^2 [V(1) - V(0)] + [V(1) - V(0)] \qquad (18) \\
\geq & 2(1-\alpha)\alpha^2 \left[u(y_h) - u\left(y_h - \frac{3}{2}a \right) \right] + [V(1) - V(0)]
\end{aligned}
$$

The Derivative of $g(p)$

The derivative with respect to p is

$$
\begin{aligned}
\frac{dg(p)}{dp} =& 6(1-\alpha)\left\{\left(\frac{1}{2}+2(1-\alpha)^2p^2-2(1-\alpha)p\right)\left(u(y_h)-u\left(y_h-\frac{3}{2}a\right)\right)\right.\\
&\left.+\frac{2}{3}p(1-\alpha)\left(u(y_h)-u\left(y_h-\frac{3}{2}a\right)\right)-\frac{2}{3}p(1-\alpha)\left(u\left(y_l+\frac{3}{2}a\right)-u\left(y_l\right)\right)\right\}\\
&+6p(1-p(1-\alpha))(1-\alpha)^2\left(V(1)-V(0)\right)\\
=&(1-\alpha)\left[3-8p(1-\alpha)+6p^2(1-\alpha)^2\right]\left[u(y_h)-u\left(y_h+\frac{3}{2}a\right)\right]\\
&+\left[-4p(1-\alpha)^2+6p^2(1-\alpha)^3\right]\left[u\left(y_l+\frac{3}{2}a\right)-u(y_l)\right]\\
&+6p(1-\alpha)^2[1-p(1-\alpha)][V(1)-V(0)]\\
\geq&(1-\alpha)\left[3-8p(1-\alpha)+8p^2(1-\alpha)^2\right]\left[u(y_h)-u\left(y_h+\frac{3}{2}a\right)\right]\\
&-4p(1-\alpha)^2[1-p(1-\alpha)]\left[u\left(y_l+\frac{3}{2}a\right)-u(y_l)\right]\\
&+6p(1-\alpha)^2[1-p(1-\alpha)][V(1)-V(0)]\\
\geq&(1-\alpha)\left[3-8p(1-\alpha)+8p^2(1-\alpha)^2\right]\left[u(y_h)-u\left(y_h+\frac{3}{2}a\right)\right]\\
&+2p(1-\alpha)^2[1-p(1-\alpha)][V(1)-V(0)]
\end{aligned}
$$

Note that the first term is positive since $3-8p(1-\alpha)+8p^2(1-\alpha)^2$

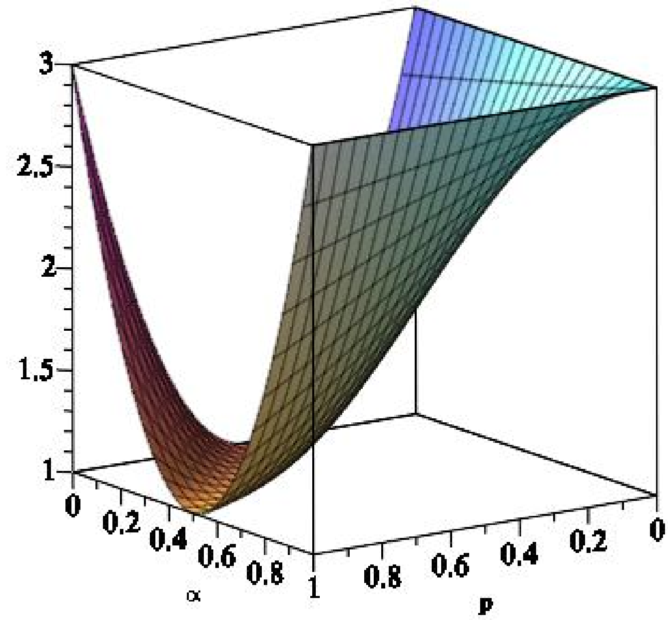

Figure 2: This is a graph of $3 - 8p(1-\alpha) + 8p^2(1-\alpha)^2$

Proof of Proposition 3 (Risk Neutral vs Risk Averse)

With a linear utility function $u(c) = c$ for a risk neutral individual,

$$g_{\text{risk neutral}}(p) = \left\{\alpha - 2p^2(1-\alpha)^2\left[1-p(1-\alpha)\right] - (1-2(1-\alpha)p\left[1-p(1-\alpha)\right])[1-p(1-\alpha)]\right\}\frac{3}{2}a$$

while with a arbitrary concave increasing utility function u has a measure represented by

$$g_{\text{risk averse}}(p) = 3\alpha\left[u(y_h - a) - u\left(y_h - \frac{3}{2}a\right)\right] - 2p^2(1-\alpha)^2\left[1-p(1-\alpha)\right]\left[u(y_l + \frac{3}{2}a) - u(y_l)\right]$$
$$-(1-2(1-\alpha)p\left[1-p(1-\alpha)\right])[1-p(1-\alpha)]\left[u(y_h) - u\left(y_h - \frac{3}{2}a\right)\right]$$

which is greater than

$$\alpha\left[u(y_h) - u\left(y_h - \frac{3}{2}a\right)\right] - 2p^2(1-\alpha)^2\left[1-p(1-\alpha)\right]\left[u(y_l + \frac{3}{2}a) - u(y_l)\right]$$
$$-(1-2(1-\alpha)p\left[1-p(1-\alpha)\right])[1-p(1-\alpha)]\left[u(y_h) - u\left(y_h - \frac{3}{2}a\right)\right]$$

Therefore $g_{\text{risk averse}}(p) - g_{\text{risk neutral}}(p) > g^{\star}(p)$, where

$$\begin{aligned} g^{\star}(p) = \alpha &\left[u(y_h) - u\left(y_h - \frac{3}{2}a\right) - \frac{3}{2}a\right] - 2p^2(1-\alpha)^2\left[1 - p(1-\alpha)\right]\left[u(y_l + \frac{3}{2}a) - u(y_l) - \frac{3}{2}a\right] \\ &-(1 - 2(1-\alpha)p\left[1 - p(1-\alpha)\right])[1 - p(1-\alpha)]\left[u(y_h) - u\left(y_h - \frac{3}{2}a\right) - \frac{3}{2}a\right] \end{aligned}$$

which with some rearrangement Let us consider

$$u(y_h) - u\left(y_h - \frac{3}{2}a\right) = u\left(y_l + \frac{3}{2}a\right) - u\left(y_l\right) - \epsilon$$

where ϵ is positive. (Due to the concavity of u)

$$\begin{aligned} g^{\star}(p) = &\left\{\alpha - 2p^2(1-\alpha)^2\left[1 - p(1-\alpha)\right]\right\}\left[u\left(y_l + \frac{3}{2}a\right) - u\left(y_l\right) - \frac{3}{2}a\right] \\ &-(1 - 2(1-\alpha)p\left[1 - p(1-\alpha)\right])[1 - p(1-\alpha)]\left[u\left(y_l + \frac{3}{2}a\right) - u\left(y_l\right) - \frac{3}{2}a\right] \\ &-\left\{\alpha - (1 - 2(1-\alpha)p\left[1 - p(1-\alpha)\right])[1 - p(1-\alpha)]\right\}\epsilon \end{aligned} \tag{19}$$

The objective it to prove that this is positive.

So at $p = 0$, Equation (19) is

$$\begin{aligned} (\alpha - 1)&\left[u\left(y_l + \frac{3}{2}a\right) - u\left(y_l\right) - \frac{3}{2}a\right] - (\alpha - 1)\epsilon \\ &= (1 - \alpha)\left[\frac{3}{2}a + u\left(y_l\right) - u\left(y_l + \frac{3}{2}a\right) + \epsilon\right] \end{aligned}$$

which is positive since $\frac{3}{2}a + u\left(y_l\right) - u\left(y_l + \frac{3}{2}a\right)$ is positive and ϵ is positive.

At $p = 1$, Equation (19) is

$$
\begin{aligned}
&\left\{\alpha - 2(1-\alpha)^2\alpha - (\alpha - 2(1-\alpha)\alpha + 2(1-\alpha)^2\alpha)\right\}\left[u\left(y_l + \frac{3}{2}a\right) - u\left(y_l\right) - \frac{3}{2}a\right] \\
&- \left\{\alpha - (\alpha - 2(1-\alpha)\alpha + 2(1-\alpha)^2\alpha)\right\}\epsilon \\
=& \left\{-4(1-\alpha)^2\alpha + 2(1-\alpha)\alpha\right\}\left[u\left(y_l + \frac{3}{2}a\right) - u\left(y_l\right) - \frac{3}{2}a\right] - \left\{2(1-\alpha)\alpha - 2(1-\alpha)^2\alpha\right\}\epsilon \\
=& \left\{4(1-\alpha)^2\alpha - 2(1-\alpha)\alpha\right\}\left[\frac{3}{2}a - u\left(y_l + \frac{3}{2}a\right) + u\left(y_l\right)\right] - 2(1-\alpha)\alpha^2\varepsilon \\
\geq& \left\{4(1-\alpha)^2\alpha - 2(1-\alpha)\alpha - 2(1-\alpha)\alpha^2\right\}\left[\frac{3}{2}a - u\left(y_l + \frac{3}{2}a\right) + u\left(y_l\right)\right] \\
=& \left\{4(1-\alpha)^2\alpha - 2(1-\alpha)^2\alpha\right\}\left[\frac{3}{2}a - u\left(y_l + \frac{3}{2}a\right) + u\left(y_l\right)\right] \\
=& \left\{2(1-\alpha)^2\alpha\right\}\left[\frac{3}{2}a - u\left(y_l + \frac{3}{2}a\right) + u\left(y_l\right)\right]
\end{aligned}
$$

which is positive

Now I show that Equation (19) is monotonic, i.e that the derivative is strictly positive or negative.

The derivative of Equation (19) is equal to

$$
\begin{aligned}
&\left\{[-4p(1-\alpha)^2 + 6p^2(1-\alpha)^3] - [-3(1-\alpha) + 8p(1-\alpha)^2 - 6p^2(1-\alpha)^3]\right\}\left[u\left(y_l + \frac{3}{2}a\right) - u\left(y_l\right) - \frac{3}{2}a\right] \\
&+ \left\{-3(1-\alpha) + 8p(1-\alpha)^2 - 6p^2(1-\alpha)^3\right\}\epsilon
\end{aligned}
$$

which simplifies into

$$
\begin{aligned}
&\left\{-3(1-\alpha) + 12p(1-\alpha)^2 - 12p^2(1-\alpha)^3\right\}\left[\frac{3}{2}a - u\left(y_l + \frac{3}{2}a\right) + u\left(y_l\right)\right] \\
&+ \left\{-3(1-\alpha) + 8p(1-\alpha)^2 - 6p^2(1-\alpha)^3\right\}\epsilon
\end{aligned}
$$

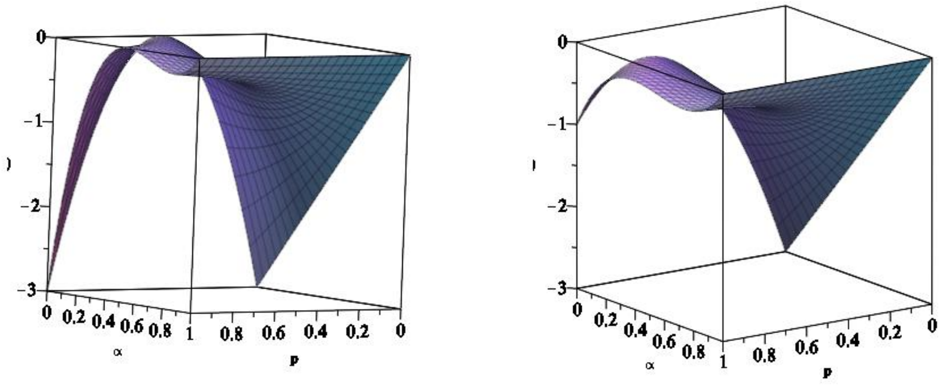

Figure 3: Figure (a) is a plot of the function side by side $f(p, \alpha) = -3(1-\alpha) + 12p(1-\alpha)^2 - 12p^2(1-\alpha)^3$ and (b) is a plot of the function $f(p, \alpha) = -3(1-\alpha) + 8p(1-\alpha)^2 - 6p^2(1-\alpha)^3$

both terms of the above equation are negative for values of $p \in (0, 1)$ and values of $\alpha \in (0, 1)$.

What I have shown is that the Equation (19) which lies below the function $g_{\text{risk averse}}(p) - g_{\text{risk neutral}}(p)$ for all values of $p \in (0, 1)$ is strictly positive indicating that $g_{\text{risk averse}}(p) - g_{\text{risk neutral}}(p)$ is also strictly positive.

Proof of Proposition 4

Consider independent savings with interest rate r is

$$\begin{aligned} g_r(p_i) = & p_i(1-\alpha)(1-p_i(1-\alpha))\left\{[u_{0,0} - u_{0,1}] + (1-p_i(1-\alpha))[u_{0,0} - u_{0,2}]\right\} \\ & - p_i^2(1-\alpha)^2[1-p_i(1-\alpha)]u_{-1,0} + [p_i^2(1-\alpha)^2 - 3p_i(1-\alpha) - 3\alpha + 2]u_{-1,1} \\ & + [-1 - 2(1-\alpha)^3 p_i^3 + 3p_i^2(1-\alpha)^2]u_{-1,3} - (1-p_i(1-\alpha))^3 u_{-1,2} + 3\alpha u_{-1,-1} \\ & + p_i^2(1-\alpha)^2[3 - 2p_i(1-\alpha)]\,[V(1) - V(0)] \end{aligned}$$

Where

$$u_{0,0} = u(y_l) \qquad u_{-1-,1} = u\left(y_h - a\right)$$
$$u_{0,1} = u\left(y_l + \frac{3}{2}ar\right) \qquad u_{-1,1} = u\left(y_h - \frac{3}{2}a\right)$$
$$u_{0,2} = u\left(y_l + 3ar\right) \qquad u_{-1,3} = u\left(y_h - \frac{3}{2}a(1-r)\right)$$
$$u_{0,3} = u\left(y_l + \frac{3}{2}a(1+r)\right) \qquad u_{-1,0} = u\left(y_h\right)$$
$$u_{-1,2} = u\left(y_h + 3ar\right)$$

Note that the implicit derivative of

$$\frac{d\tilde{p}}{dr} = \frac{A}{B}$$

where A is $\dfrac{dg_r(p_i)}{dr}$ and $B = -\dfrac{dg_r(p_i)}{dp}$.

$$\begin{aligned}
A =& a(1-\alpha)\tilde{p}[1-\tilde{p}(1-\alpha)]\left[-\frac{3}{2}u'\left(y_l + \frac{3}{2}ar\right) - 3(1-\tilde{p}(1-\alpha))u'(y_l+3ar)\right] \\
&- 3a\tilde{p}^2(1-\alpha)^2(1-\tilde{p}(1-\alpha))u'\left(y_l + \frac{3}{2}a(1+r)\right) \\
&+ 3a(1-\alpha)^2\tilde{p}^2(1-\tilde{p}(1-\alpha))u'\left(y_h - \frac{3}{2}a(1-r)\right) \\
&- \frac{3}{2}a(1-\tilde{p}^2(1-\alpha)^2)u'\left(y_h - \frac{3}{2}a(1-r)\right) - 3a(1-\tilde{p}(1-\alpha))^3u'\left(y_h + 3ar\right) \\
=& -3a(1-\alpha)\tilde{p}(1-\tilde{p}(1-\alpha))^2u'(y_l+3ar) - \frac{3}{2}a(1-\alpha)\tilde{p}[1-\tilde{p}(1-\alpha)]u'\left(y_l + \frac{3}{2}ar\right) \\
&- 3a\tilde{p}^2(1-\alpha)^2(1-\tilde{p}(1-\alpha))u'\left(y_l + \frac{3}{2}a(1+r)\right) \\
&+ \frac{3}{2}a(1-\alpha)^2\tilde{p}^2(1-\tilde{p}(1-\alpha))u'\left(y_h - \frac{3}{2}a(1-r)\right) \\
&+ \frac{3}{2}a(1-\alpha)^2\tilde{p}^2(1-\tilde{p}(1-\alpha))u'\left(y_h - \frac{3}{2}a(1-r)\right) \\
&- \frac{3}{2}a(1-\tilde{p}^2(1-\alpha)^2)u'\left(y_h - \frac{3}{2}a(1-r)\right) - 3a(1-\tilde{p}(1-\alpha))^3u'\left(y_h + 3ar\right)
\end{aligned} \tag{20}$$

$$
\begin{aligned}
A \leq & - 3a(1-\alpha)\tilde{p}(1-\tilde{p}(1-\alpha))^2 u'(y_l + 3ar) \\
& - 3a\tilde{p}^2(1-\alpha)^2(1-\tilde{p}(1-\alpha))u'\left(y_l + \frac{3}{2}a(1+r)\right) \\
& - 3a(1-\tilde{p}(1-\alpha))^3 u'\left(y_h + 3ar\right)
\end{aligned} \tag{21}
$$

which is strictly negative

The derivative with respect to p

$$
\begin{aligned}
\frac{dg_r(p)}{dp} =& 2p(1-\alpha)^2\left[u\left(y_l + \frac{3}{2}ar\right) - u(y_l)\right] + (1-\alpha)\left[u(y_l) - u\left(y_l + \frac{3}{2}a\right) + u(y_l) - u(y_l + 3ar)\right] \\
& + (4p(1-\alpha)^2 - 3p^2(1-\alpha)^2)[u(y_l + 3ar) - u(y_l)] \\
& + (-4p(1-\alpha)^2 + 6p^2(1-\alpha)^3)\left[u\left(y_l + \frac{3}{2}a(1+r)\right) - u(y_l)\right] \\
& + 2p(1-\alpha)^2\left[u\left(y_h - \frac{3}{2}a\right) - u(y_h)\right] + 3p^2(1-\alpha)^3\left[u(y_h) - u\left(y_h - \frac{3}{2}a(1-r)\right)\right] \\
& + (3p^2(1-\alpha)^3 - 6p(1-\alpha)^2)\left[u(y_h + 3ar) - u\left(y_h - \frac{3}{2}a(1-r)\right)\right] \\
& + 3(1-\alpha)\left[u(y_h + 3ar) - u\left(y_h - \frac{3}{2}a\right)\right] + 6p(1-\alpha)^2[1-p(1-\alpha)][V(1) - V(0)]
\end{aligned}
$$

Condition used to make proofs

$$
\begin{aligned}
& u\left(y_l + \frac{3}{2}ar\right) + (1-p(1-\alpha))\left[u\left(y_h - \frac{3}{2}a(1-r)\right) + V(1)\right] + p(1-\alpha)\left[u\left(y_l + \frac{3}{2}a(1+r)\right) + V(0)\right] \\
& \geq u\left(y_l + \frac{3}{2}a(1+r)\right) + (1-p(1-\alpha))\left[u\left(y_h\right)) + V(0)\right] + p(1-\alpha)\left[u\left(y_l\right) + V(0)\right]
\end{aligned}
$$

which can be rearranged into

$$
\begin{aligned}
\geq & 2p(1-\alpha)^2 \left[u\left(y_l + \frac{3}{2}ar\right) - u(y_l)\right] + (1-\alpha)\left[u(y_l) - u\left(y_l + \frac{3}{2}a\right) + u(y_l) - u(y_l + 3ar)\right] \\
& + 4p(1-\alpha)^2\left[u(y_l + 3ar) - u\left(y_l + \frac{3}{2}ar\right)\right] + 2p(1-\alpha)^2\left[u\left(y_l + \frac{3}{2}a(1+r)\right) - u\left(y_l + \frac{3}{2}ar\right)\right] \\
& + 3p^2(1-\alpha)^3[u(y_l) - u(y_l + 3ar)] + 2p(1-\alpha)^2\left[u\left(y_h - \frac{3}{2}a\right) - u(y_h)\right] \\
& - 3p^2(1-\alpha)^3\left[u(y_h) - u\left(y_h - \frac{3}{2}a(1-r)\right)\right] + 3p^2(1-\alpha)^3\left[u(y_h + 3ar) - u\left(y_h - \frac{3}{2}a(1-r)\right)\right] \\
& - 6p(1-\alpha)^2[u(y_h + 3ar) - u(y_h)] + 3(1-\alpha)\left[u(y_h + 3ar) - u\left(y_h - \frac{3}{2}a\right)\right] \\
\geq & 2p(1-\alpha)^2\left[u\left(y_l + \frac{3}{2}a(1+r)\right) - u\left(y_l + \frac{3}{2}a\right)\right] + 4p(1-\alpha)^2\left[u(y_l + 3ar) - u\left(y_l + \frac{3}{2}ar\right)\right] \\
& + 3p^2(1-\alpha)^3\left[u(y_l) - u(y_l + 3ar)\right] + (3p^2(1-\alpha)^3 - 3p(1-\alpha)^2)[u(y_h + 3ar) \\
& + 3(1 - p(1-\alpha)^2)[u(y_h + 3ar) - u(y_h)] \\
= & 2p(1-\alpha)^2\left[u\left(y_l + \frac{3}{2}a(1+r)\right) - u\left(y_l + \frac{3}{2}a\right)\right] + p(1-\alpha)^2\left[u\left(y_l + \frac{3}{2}ar\right) - u(y_l)\right] \\
& + 3p(1-\alpha)^2[1 - p(1-\alpha)]\left[u\left(y_l + \frac{3}{2}ar\right) - u(y_l)\right] \\
& + 3[1 - p^(1-\alpha)^2][1 - p(1-\alpha)][u(y_h + 3ar) - u(y_h)].
\end{aligned}
$$

which is strictly positive.

Using the above condition and a lot of rearrangement

$$
B = -\frac{d}{dp} \leq -2p(1-\alpha)^2\left[u\left(y_l + \frac{3}{2}a(1+r)\right) - u\left(y_l + \frac{3}{2}a\right)\right]
$$

therefore the derivative of the threshold is

$$
A/B > 0
$$