Signaling in Creditworthiness: Theory and Evidence from *Susu* Collection in Ghana

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Abstract

This paper extends signaling theory to creditworthiness. Focusing on *susu* collection in Ghana, we find that credit responses are generally increasing in the signaling effort exerted in saving. Inverse probability treatment weighted and double robust matching estimators show that clients who contributed savings on a daily basis received about $300 more on average, relative to clients who saved on more relaxed weekly or fortnightly schedules. Our schedule signaling result overrides alternative explanations and is robust to various specifications.

JEL codes: O17, D02, G21, C21.

Keywords: Financial development; Institutions; Signaling; Credit; Inverse probability treatment weighted estimators; Double-robust estimators.

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1 Introduction

A central result in labor economics is that prospective employees may indirectly signal their ability to potential employers by acquiring educational credentials (Spence (1973)). Similarly, signaling has been applied to topics such as electoral competition (Kartik and McAfee 2007), social norms (Sliwka 2007), and self-confidence (Santos-Pinto 2012). Signaling models have also been used in a few studies of investment and equity markets (Riley 2001), but have not been applied to creditworthiness.

The difficulties of evaluating creditworthiness reflect similar information asymmetries and market failures as those found in the employment literature. Lenders typically respond to information imbalances by rationing credit especially to poor developing country borrowers[1]. Clients are often harmed by such market inefficiencies while lenders often also lose out in the form of low repayment rates (Arnott and Stiglitz 1988). Screening by high collateral requirements and high interest rates can partially mitigate credit rationing and low repayment rates (e.g. Bester 1985), but these mechanisms are limited in their ability to assess creditworthiness and still have the potential to restrict many worthy borrowers from the market.

Recent prominent failures in credit markets have caused a rethinking of the standard theories of how best to deliver credit in developing countries. In 2010, the microfinance industry was shaken by several reports of significant client overindebtedness and related suicides in Andra Pradesh, India (See Banerjee, Duflo, Glennester and Kinnan (2013) for a discussion). Kaboski and Townsend (2011) found that a national credit program in Thailand cost 20% more than the sum of its benefits. In the Indonesian informal sector, community-based targeting performed worse than proxy-mean tests, since community members and the researchers assessed poverty differently (see Alatas, Banerjee, Hanna, Olken and Tobias (2012)). Existing research on credit markets (see Banerjee and Duflo (2010, 2012); Banerjee, Chandrasekhar, Duflo and Jackson (2012)) presents many different models that help us understand creditworthiness but has not yet asked whether employability is a suitable analogy for creditworthiness via saving schedules and potential signaling. This gap in the literature persists inspite of the general use of schedules programs in retail bank functions (see Flannery (1982)) and repayment operations (Field and Pande (2008)). Can signaling theory explain outcomes in credit markets and provide new avenues to extend credit to poor borrowers?

This paper presents a novel application of signaling to the problem of assessing creditworthiness among poor borrowers in a developing country.We test this theory using unique data from a savings and credit system in rural Ghana called *susu* csollection. *Susu* collection in Ghana is a financial arrangement where clients contribute regular savings to credit-providing deposit collectors (called *susu* collectors). In this work, we investigate whether credit provision through the *susu* collection system can be explained by signaling.

Like education and job market outcomes (see Willis and Rosen 1979), the application to cred-

[1] See Stiglitz and Weiss (1981) and Bester and Hellwig (1987).

itworthiness in our work involves self-selection of participants into different groups. Because of self-selection and the lack of an equivalent population untreated by *susu* collection[2], the environment of the problem is not amenable to an experimental set-up. We instead use matching estimators which can account for self-selection: the Inverse Probability Treatment-Weighted (IPTW) and Double-Robust (DR) estimators and allow us to study important phenomena in settings that are not amenable to experimental designs. These methods mitigate bias due to stratification as well as confounding caused by pre-treatment factors and selection bias (see Rosenbaum (1987), Lunceford and Davidian (2004) and Tsiatis (2006)). Both estimators improve efficiency and reduce bias compared to standard matching estimators (see Emsley, Lunt, Pickles and Dunn (2008); also note Imbens and Wooldridge (2009) for a survey). To our knowledge, this work is one of the first applications of IPTW and DR methods to empirical data in economic development[3].

We study individuals who signal their potential creditworthiness through savings schedules or timetables, and whether formal credit allocation is affected by such signals. Our signal is a savings schedule that involves a client exhibiting effort and consistency by contributing savings to a collector on a specific timetable. In particular, we generally show that when clients save on schedules that require more effort (frequent meetings with a collector), they receive increasingly larger amounts in loans. We then show that this result persists even when we account for missed payments.

This work develops a Spencian model of signaling creditworthiness that we generalize to multiple *susu* savings schedules that vary strictly in terms of required financial effort. The model predicts the following: (i) credit-constrained and relatively creditworthy individuals adopt schedules that require higher effort to differentiate themselves from contemporaries who are relatively non-creditworthy; (ii) rural banks' *susu* collectors respond to these observed savings signals with corresponding credit. The theory shows that loan outcomes increase in the effort exerted in mobilizing savings and are highest for those who save at the most difficult pace. The empirical results show credit outcomes for clients consistent with a signalling model where clients who signal higher ability through higher levels of savings effort receive more credit.

We also investigate alternative explanations that would be consistent with our signalling results. For example it is possible that the *susu* institution behaves like a credit reporting agency in providing information useful for credit provision decisions, as the equivalent of credit scores that may be used to assign loans and assess client creditworthiness (e.g. Luoto, McIntosh and Wydick (2007); Karlan and Zinman (2011)). In our setting of *susu* collection, missing payments within a savings schedule may provide information that leads to lower credit provision if signaling schedules were relatively unimportant as signals. Specifically, we are interested in whether the signal of being in

[2]Since *susu* participation in Ghana is nearly universal (above 75%) and includes all sectors of society from the unemployed, to entrepreneurs, to government workers, to university professors, a relevant control group that is unexposed to *susu* cannot be created for an experimental study. See Bortei-Doku and Aryeetey (1995) for a discussion of *susu*'s reach in Ghanaian society. Discussions with *susu* collectors and clients during field work repeatedly emphasized the importance of trust in the *susu* system and how that might be broken with an experiment that provided differential benefits either randomly or systematically.

[3]We also find our results to be consistent with propensity score matching estimators (See Supplementary Online Appendix).

a savings schedule overrides the saving consistency of a client, the latter of which is measured by missed scheduled savings payments to a collector. We find that missing payments of savings are not important for credit outcomes relative to the schedule signal of creditworthiness. We also investigate the possibility that the time collectors spend with their clients during or even outside *susu* collection might be used for assessing creditworthiness rather than schedule signals. While this might produce outcomes similar to our signaling outcome, collectors who socialized with their clients outside *susu* collection did not generally revise creditworthiness assessments and extra information from socializing did not over-ride the signalling outcomes. Finally, we are also able to disentangle reverse-impacts since we have data for individuals who neither demanded nor recieved credit. We test for whether credit outcomes could affect savings contributions, and do not find significant impacts. All of the results of alternative theories suggest that savings schedules are, in and of themselves, important signals for credit outcomes in a manner reminiscent of signaling in the economics of labor and education[4]

Working in a partnership with Kakum Rural Bank in the Central Region of Ghana, we collected data from individuals who contributed savings on a daily, twice-weekly (two days every week), weekly, or fortnightly basis. Owing to the varying frequency in submitting savings, (as well as barriers to successful saving), each savings schedule represents (1) a different degree of financial effort by an individual, and (2) a different signal to a *susu* collector in terms of strength. We also collected data on credit outcomes for individuals who contributed savings for at least three months and successfully applied for loans. We find that individuals who exert the most effort in submitting savings (on a daily basis) showed the strongest positive credit impacts of around 400 Ghana cedis[5]. In addition, we find a negative effect on credit offered for individuals using the least rigorous fortnightly savings schedule, relative to other savings schedules. The signaling effects of schedules in between these relatively extreme savings schedules confirm our main result, although these impacts are not always significant. We conclude that the signal of being in a savings schedule is particularly relevant to creditworthiness-related policy. By signaling creditworthiness indirectly, savings may not need to produce significant direct increases to productivity for either principals or agents to benefit.

Our work is related to research on loan schedules in the developed world, where clients receive increasingly larger credit on debt repayment, screened with higher interest rates (see Milde and Riley 1988). However, we focus on signaling creditworthiness via savings schedules which is ex-ante to credit provision. Savings institutions and schedules have received relatively little attention in the literature (Flannery (1982)) although they exist in large measures in both developed and developing countries. It is not unusual for credit-providing rural and community banks to rely on existing savings institutions, such as *susu*, in the informal financial sector on the African continent.

Although this work focuses on African financial markets, the analysis is germane to a recent debate in the literature that focuses on the recent rise of Asian economies. In China for example,

[4]The possibility of deviations from prescribed behavior are not important to our study in practical terms, although they partially motivate Hypothesis 3.

[5]During the study, 1 Ghana cedi was equivalent to about 0.70 USD (as of June 1, 2010).

Tsai (2004), Allen, Qian and Qian (2005) and Linton (2006) have argued that informal financial arrangements played a important role in financial development. These findings contrast with Ayyagari, Demirgüc¸-Kunt and Maksimovic (2010) who make a competing case that formal finance may be more strongly associated with Chinese firm-level growth. In our study, Spencian signaling from the informal finance system provides mutual benefits to formal and informal finance systems that are complementary (not substitutive).

This work also relates to recent theoretical studies such as Madestam (2010) which relies on moneylenders to similarly reduce information asymmetries in informal finance. Moneylenders are often traders who provide subsidized formal credit to entrepreneurs and may improve information flows to rural banks[6]. While moneylenders provide credit, they rarely provide other types of financial services to entrepreneurs, such as savings mobilization. This role of savings mobilization is often provided by formalized savings deposit collectors in the vein of Ashraf, Karlan and Yin (2006b), which studies the factors influencing the adoption of a deposit collection program in the Philippines. The present study differs in two important ways: first the *susu* collectors offer multiple different savings schedules with different degrees of economic effort and second we present mechanisms through which these different savings schedules affect the access to and the amount of credit.

This paper reads as follows. We first discuss the *susu* collection institution in Ghana and the need for formal loan facilities. We then present the theoretical frameworks before describing our data, the econometric framework, analyses and results. The final section considers some policy implications of assessing a signaling channel of creditworthiness. Model proofs and details are provided in Appendix A and the Online Appendix provides logit regressions and supplementary results.

1.1 *Susu* Collection and the Entrepreneur Need for Credit

In Ghana, the financial crises of the 1980s, with frequent bouts of inflation and closures of formal banks, produced a heightened need for cash on hand for individual obligations. This situation influenced a relatively sudden shift in *susu* savings participation from group-based rotating savings and credit associations (ROSCAs) to individual *susu* collection[7]. In Ghana, nearly everybody participates in *susu:* a survey by Aryeetey and Gockel (1991) estimated that 77% of Ghanaian market women saved their funds through *susu* collectors[8]. *Susu* clients nominate a reputable and trustworthy *susu* collector to save funds on their behalf. The *susu* collector visits market stalls, farms, or other areas of commerce and mobilizes funds on the behalf of clients typically on a daily basis. In the informal market arrangement, the total for each saving client is returned at the end of the month

[6]See Arnott and Stiglitz (1991), Floro and Ray (1997), Bose (1998) for theoretical motivations. Empirical work by Bell, Srinivasan and Udry (1997) as well as Jain (1999) and Varghese (2005) frame informal and formal financial arrangements as competitors: they are cooperative in Ghana (Aryeetey and Steel 1995)

[7]The institution of *susu* collection in Ghana predates the 1980s and 1990s, but rose in prominence during and after the 1990s. See Bortei-Doku and Aryeetey (1995) for details.

[8]This relatively new focus on *susu* collection has not been exclusive to Ghana. For instance, Steel, Aryeetey, Hettige and Nissanke (1997) show similar changes in savings deposit mechanisms following the similarly-timed financial crises in Tanzania, Nigeria, and Malawi. Although ROSCAs persist, their prominence is less significant in Ghana (Chamlee-Wright 1997).

minus a single day's deposit which the *susu* collector keeps as a commission (Aryeetey 1994).

While economic and other incentives motivate such commitment savings devices[9], the observed *willingness to pay to save* is counterintuitive. Using *independent susu* collectors is often a financial loss for participants because of the financial cost of saving (see Rutherford (2000); Ashraf, Gons, Karlan and Yin (2003)). In the past several years in Ghana formal sector banks, especially community banks, have adopted the informal sector methods and hired *susu* collectors on bank salaries to collect deposits and provide other banking services. One advantage of linking *susu* collectors with formal institutions is the absence of commissions that independent collectors must charge for their services. In field interviews, *susu* collectors also noted that beyond the assured safety of funds and better salaries, an added incentive for independent *susu* collectors to link with the rural formal sector is to be able to lend bank funds to clients.

Unlike other parts of Africa where rural formal finance is dominated by NGOs, formal financial services are supplied in rural Ghana mainly by community banks. These institutions are required by law to be majority-owned by the local community[10]. Rural banks have increasingly relied on *susu* collectors to mobilize funds traditionally lost to the informal sector, and often employ collectors to mobilize funds as permanent employees. While independent *susu* collectors are notorious for absconding with client savings, this reputation does not extend to rural bank *susu* employees. Whenever a savings contribution is made to a bank-affiliated collector, a client receives a *susu* slip recording the amount and other relevant information for personal record-keeping.

Susu collectors may access clients in different towns or rural areas on foot or using public transportation. *Susu* collectors are important to banks because of their information advantages: they mobilize savings funds on a consistent basis, as discussed above. However, bank *susu* collectors are also important to credit-constrained clients since they can allow individuals to credibly indicate their creditworthiness to rural and community banks.

After saving with a collector for a minimum of three months, a client may apply for a lump sum *susu* loan. A borrowing client must repay the amount (with a fixed interest rate of 23%) in full six months after the date of approval. Although a significant proportion of Ghanaians mobilize savings in the informal sector, investments and scaling businesses remain a challenge for varied reasons. We motivate the significant financial need for funds in Ghana beyond independent saving thresholds in the remainder of this section.

Consider an especially entrepreneurial migrant in peri-urban Ghana who has, over time, invested significant proportions of personal savings into renting an investment. This investment is a used portable photocopying machine (whose wholesale price was the equivalent of around 1000 Ghana

[9]Examples include the significant time and financial costs of leaving places of business to personally deposit savings at a bank, or the difficulty of honoring plans to save. See O'Donoghue and Rabin (1999) for a related discussion. The difficulties inherent in mobilizing savings in Africa and other regions of the developing world are summarized in Ashraf Karlan and Yin (2006a).

[10]Note Act 29 of the Companies Code 63 (Steel and Andah 2003). The provision of rural banking infrastructure in poorer areas was influenced by the shortcomings of commercial and agricultural banks, as well as a government delegation trip to the Philippines (see Nair and Fisha (2010)).

cedis or US $700 in 2010). As is often the case, our entrepreneur makes impromptu copies for students who cannot afford to buy whole books, or (much less commonly) social science researchers in the field. While the entrepreneur from our illustration may use his scarce savings to rent a machine from a relatively well-to-do businessperson, lack of capital access would prevent him from investing in a machine of his own. The scenario of a minimum investment scale that is beyond the savings ability of the entrepreneur is true of many investments for typical Ghanaian entrepreneurs. For example, the poorest women entrepreneurs (who carry wares for sale on their heads in markets) may otherwise be unable to invest in market "desks," a permanent open-air location costing the equivalent of 500 cedis. At the next rung, marketwomen who currently have "desks", may be unable to invest in all-weather kiosks, costing about 1000 cedis, with the levels of savings one could earn from a "desk".

A significant amount of credit or savings would be needed to secure investments in every case mentioned. The above (and other) projects would require a lump-sum that exceeds the amount the entrepreneur in question can currently save. A savings rate of around 8 Ghana cedis per month (the average in our sample) would mean a savings period of almost 5 years to reach the investment target of a desk in the above example of an itinerant entrepreneur. The lowest savings in the data are about 3 Ghana pesewas per month (about 2 US cents), which would imply a lifetime of savings to reach any of these lump-sum investments. Therefore, for some individuals, this scenario may be similar to a temporary savings poverty trap situation, where consistently low savings may delay improving economic outcomes.

Bouts of inflation are another concern for Ghanaian entrepreneurs[11]. Given that significant periods of time are needed to accrue savings, high inflation rates may artificially drive up the price of an investment over time. These fluctuations may continually postpone a date of attaining an investment. Within this context, credit would be necessary to support savings and act as a hedge against inflation. The credit outcomes in the data range from 17 Ghana cedis to 2,000 Ghana cedis, with an average of 583 Ghana cedis; much larger than the average personal savings (less than 10 Ghana cedis per month in the data). More than half (52% of *susu* clients) surveyed applied for a *susu* loan in the month of the survey.

1.2 Kakum Rural Bank and the Set-up of Multiple *Susu* Savings Schedules

The case that clients are motivated to mobilize savings (and hence credit) derived from discussions with *susu* collectors employed by Kakum Rural Bank (established in February 1980) in the Central Region of Ghana. The Kakum Enyidado *Susu* Scheme is used to provide credit to individuals who make daily, weekly, fortnightly or monthly savings deposits with *susu* collectors employed by the bank. A monthly schedule was instituted to allow savings mobilization every thirty days primarily for salaried employees. While monthly savings tend to be limited to individuals earning monthly

[11] According to the International Monetary Fund and the World Bank, inflation in Ghana was 11.5% on average between 2006-2010, down from a higher average of 20.4% between 2001-2005 (World Bank 2012).

paychecks, some relatively poorer clients use the schedule as well, citing its relative convenience[12].

Kakum Rural Bank also recently developed a twice-weekly schedule in conjunction with the Microsfere Fund for People and Nature NGO in the Central Region, and implemented it in tandem with the other schedules by early 2009. Interconnections between rural banks, *susu* collectors and microfinance NGOs are increasingly common in Ghana, although implementation (and the motives influencing it) tend to be led by rural bank officials. The twice-weekly schedule was established and promoted at the suggestion of the NGO throughout Central Ghana as a savings commitment device to encourage alternative and sustainable livelihoods, such as micro-enterprise (Microsfere Fund for People and Nature 2011).

Susu collectors from Kakum rural bank frequent the outdoor markets and other areas of commerce, with each collector typically serving up to 300 clients every day. The surveyed collectors in our study reported serving an average of around 200 on a daily basis. Each served client is on one of the schedules mentioned above and gives an individually chosen (but temporally consistent) deposit to the *susu* collector. If the client feels the current schedule is not satisfactory, the client could be moved to another schedule on a case-by-case basis. In discussions and interviews with clients and collectors, such a changing of schedule was relatively uncommon in practice.

A related concern is that the relative number of payments a client fails to make with his or her collector would vary considerably given different savings schedules. For example, a person who picks a daily schedule could miss more chances to save per month than a person who picks a weekly schedule. While the model developed below assumes a high level of self-awareness in schedule choice, we believe that this assumption is consistent with the actual absence of schedule-switching in the data. If the schedule choice influenced the number of missed payments a priori, we would see at least some schedule-switching, which we do not observe. We now present our signaling model.

2 Model

To structure our thinking about saving and creditworthiness, we present the fundamental dichotomous framework of signaling as introduced by Spence (1973) and expounded by Mas-Collel, Whinston and Green (1995) (see Appendix A for details). We then incorporate this model into a market setting with multiple degrees of signaling effort in subsection 2.2. All proofs are provided in Appendix A.

2.1 Basic Model

Our basic model is as follows. A client agent may reliably signal her creditworthiness indirectly, by submitting to a test that requires effort. The test in our setting refers to scheduled savings

[12]Only 17 out of 384 or 4% of clients use the monthly schedule, of which only about half received credit in the data. The monthly schedule is dropped from our analysis for relatively insignificant representation, which makes finding appropriate matches with other schedules in our data nearly impossible. The descriptive statistics for the monthly schedule are comparable to other schedules (see Table 1) and robustness checks including the monthly schedule show that its exclusion does not drive our findings.

contributions an individual may make to a *susu* deposit collector. We consider a single savings schedule that requires effort on the part of the saver and credibly signals the creditworthiness type of businessperson to a deposit collector.

Consider two types of entrepreneurs with creditworthiness Q_H and Q_L, such that $Q_H > Q_L > 0$ and $\lambda = \text{Prob}\,(Q = Q_H) \in (0,1)$. Before applying for a loan from a *susu* deposit collector an entrepreneur can make some *susu* savings contributions. These quantities s are observable to *susu* collectors.[13]

The opportunity and psychological cost of contributing these amounts to a *susu* collector for an entrepreneur of creditworthiness type Q is given by the twice continuously differentiable function $c(s,Q)$, so that its derivatives are as follows: $c(0,Q) = 0$, $c_s(s,Q) > 0$, $c_{ss}(s,Q) > 0$, $c_Q(s,Q) < 0$ for all $s > 0$, and $s_{sQ}(s,Q) < 0$. This means that the cost and the marginal cost of *susu* contributions are assumed to be lower for high-creditworthy entrepreneurs. We assume that the contribution of savings required for a rural bank loan would be relatively easier for a highly-creditworthy individual. These clients who are able to make scheduled savings (given the economic difficulties noted above) should be able to make regular credit payments as well.

Entrepreneurs worthy of high credit are willing to engage in scheduled *susu* contributions simply because it allows them to distinguish themselves from entrepreneurs worthy of low credit and receive higher loans. The basic reason why these contributions can serve as a signal here is that the marginal cost of *susu* contributions depends on the type of creditworthiness (high or low) an entrepreneur merits. Because the marginal cost of contribution is higher for an entrepreneur worthy of low credit, (since $c_{sQ}(s,Q) < 0$), a type Q_H entrepreneur may find it worthwhile to contribute some positive level $s' > 0$ to raise her loans by some amount $\triangle l > 0$, whereas a type Q_L entrepreneur would be unwilling to make these same levels of scheduled contributions in return for the same loan increase. As a result, institutions can reasonably come to regard contribution levels as signals of entrepreneur creditworthiness. Discussions from the literature on separating equilibria and other supplementary details are in Appendix A.

2.2 Model Environment with Multiple Levels of Signaling Efforts

While the basic signaling framework presumes that the signaling effort of savings is fixed, we extend the levels of signaling efforts by considering more than two frequencies of savings contributions in this section. The model assumes a strictly positive relationship between effort exertion and signaling precision of creditworthiness. We begin by providing the setup, constructing separating equilibria, before offering our hypotheses.

2.3 Setup of Multiple Degrees of Effort

As before, a privately informed client's choice of action (on the choice of savings) has two distinct effects on her credit payoff. The first is the noninferential impact while the second is through

[13] As noted in our earlier discussion, an individual's own savings are not as economically significant compared to a lump sum that can be gained via credit.

the inferences the deposit collectors draw about the private information. In equilibrium, an informed client optimally chooses a level of savings, understanding that uninformed collectors will be taking optimal actions conditional on their inferences from that action; and these inferences will be correct. If these inferences leave *no uncertainty* about the saving client's private information, then the equilibrium is *separating* for that agent. We generalize the above discussion to four levels of quality with respect to creditworthiness, Q_A where $A_i = \{a_1, a_2, a_3, a_4\}$, and $Q_{a1} > Q_{a2} > Q_{a3} > Q_{a4} > 0$. These levels of creditworthiness are associated with savings schedules which are similarly decreasing in terms of efforts required, and hence, signal strength. Consistent with the above explanation, the corresponding loans or credit amounts are notationally l_1, l_2, l_3, l_4.

We expound on our earlier discussion of saving effort, focusing on the multiple savings schedules discussed above. In this iteration of our model, we focus on the different savings schedules noted in the previous section. The daily schedule requires the most effort to commit to for two main reasons. The decision to adopt and utilize a daily schedule means that an entrepreneur must put aside funds aside every single *day* (the smallest time unit possible) to meet savings obligations. In the survey, this is the highest savings frequency that can be chosen. A related point is the potential psychological cost or personal embarrassment of not fulfilling a chosen savings schedule, to which a daily saver is the most exposed[14]. Therefore, the daily schedule requires more effort to commit to, relative to the weekly schedule for example. By committing to a daily savings timetable, an entrepreneur must put aside funds every day, whereas her counterpart on a weekly basis need do so every seven days[15]. As noted above, a client who chooses a daily schedule may be under more social pressure to contribute savings than a client on a more relaxed schedule.

We slightly extend our basic signaling game and suppress the subscripts for ease of explanation. We have two players which we call C (for client) and D (for deposit *susu* collector). C knows the value of a random variable q, whose support is a given finite set Q, so that $Q = \{0, ..N\}$. The prior beliefs of D are a probability distribution $\pi(.)$ over Q; these beliefs are common knowledge. Since Q is finite, $\pi(q)$ is the prior probability that the client's type is q.

1. Player C learns q, sends a savings signal s (drawn from a set S). This savings signal is a savings schedule.

2. Player D receives the signal s, and then takes an action l (drawn from a set L).

We allow L to depend on s and C to depend on q, (to merely repeat our discussion with slightly more appropriate notation). Stage 2 ends the game: The payoff to i is given by $u^i : Q \times S \times L \to \mathbb{R}$.

The separating equilibrium discussed in the prior section is the benchmark for the signaling games discussed in this section. We adopt the suitable and convenient single-crossing condition

[14] Bortei-Doku and Aryeetey (1995) note the importance of this issue in the *susu* collection context.

[15] To illustrate, individuals committed to the weekly schedules have smaller time constraints in contributing funds, relative to individuals committed to a daily schedule. At the extreme, a weekly customer may contribute savings gained the day before the scheduled meeting with her *susu* collector.

introduced by Karlin (1968), and expanded by Athey (2001). The single-crossing condition is provided in Appendix A. In our scenario with saving clients and crediting deposit collectors, $U^C(.)$ is strictly decreasing in the second argument (the signal), and increasing in the third argument (D's loan response) for all types. Therefore, indifference curves are well-defined in $S \times L$ for all q. The single-crossing condition implies that the indifference curves of different client types will cross only once. If a lower-type is indifferent between type signal-action pairs, then a higher type strictly prefers to send the higher signal. In this manner, the single crossing property links signals to types such that higher types send weakly higher signals in equilibrium. This provision guarantees that indifference curves from a given family of preferences cross at most once[16]. As noted before, we focus on classes of signaling games where a monotonic relationship exists between types and signals.

2.4 Construction of Separating Equilibria with Multiple Signals

We consider and construct separating equilibria for the multiple signals scenario, following our discussion in the previous section.

Proposition 1a.

The standard signaling game (l_i^*, s_i^*) has a separating equilibrium.

PROOF: See Appendix A.

Proposition 1b.

In any separating perfect Bayesian equilibrium, each entrepreneur type receives a loan equal to their quality of creditworthiness. In particular, if we restrict creditworthiness Q to three savings schedules, the separating perfect Bayesian equilibrium implies that $l*(s*(Q_{a1})) = Q_{a1}$, $l*(s*(Q_{a2})) = Q_{a2}$, $l*(s*(Q_{a3})) = Q_{a3}$.

PROOF: See Appendix A.

Following the discussion above, increasingly high-ability entrepreneurs are willing to adopt savings schedules which require more effort to distinguish themselves from their relatively low-ability counterparts. Once more, the marginal cost of contributions is a function of creditworthiness type.

2.5 Hypothesized Impacts of Savings Schedules Adoption and Signaling on Credit

The above analyses imply that savings schedules may have significant impacts on credit provision. Our interviews also show that saving schedules drive assessments of creditworthiness. If

[16]Mirlees (1976) offers scenarios where this may not be the case, while Mailath (1987) observes that it is almost impossible to verify that the single-crossing property will always hold. Although it should hold for a tractable subset of Q in our case, it is a suitable simplifying assumption since we have relatively few numbers and types of agents with ordered preferences (note Athey 2001).

savings schedules signal creditworthiness, the choice of a particular schedule will have distinct impacts.

Hypothesis 1: Signaling: Savings schedule choice influences credit outcomes.

Savings schedules' adoption signals creditworthiness to a deposit collector, yielding credit outcomes via a separating equilibria in the manner described above (as noted in Proposition 1a). The corresponding null hypothesis is that there are no credit impacts from adopting savings schedules. In this scenario, if the clients' signals from savings schedules do not establish credit outcomes, the assignment of credit will not vary by savings schedule.

Hypothesis 2: The effect of savings schedules on credit is strictly increasing in the effort required to make regular contributions.

Given multiple available schedules, a client who adopts a schedule that requires more frequent savings contributions signals to their deposit collector that they are creditworthy (relative to other clients who adopt schedules that require less effort). For this reason, clients who adopt more effort-intensive savings schedules are hypothesized to consistently receive higher credit.

2.6 Alternative Explanations

A question is whether the introduction of saving schedules has other effects that could have similar outcomes to the signalling result we are testing. We consider two alternative possibilities, where both explanations emphasize how savings schedules could provide other sources of information independent of the signal. First, credit provision in *susu* collection may function as a credit reporting agency, so that actual savings behavior to *susu* collectors may provide information akin to that which a credit rating agency collects. A second possibility is that time spent during or outside *susu* collection may be important for assessing creditworthiness.

2.6.1 Alternative Explanation: Credit Reporting Agency Mechanism

We have so far mostly considered one measure of creditworthiness: signaling via the context of a separating equilibrium. In a separating equilibrium, creditworthy clients signal their creditworthiness through a equivalent savings schedule. As an alternative explanation, we consider how *susu* collection may function like a credit reporting agency. In our context, how productive a client is in making savings within a particular schedule complements our signaling discussion. An individual who consistently misses payments may be considered less creditworthy and receive less credit independently of any signaling observed by the lender.

If we assume that creditworthiness is some function of both the signal s and the rate of missed payments d, then we can compare signaling and credit reporting approaches to investigate whether the level of missed payments has any effect on the signal from savings schedules. If the assessed creditworthiness by signaling is equal to assessed creditworthiness when both signaling and human capital are accounted for, then $f(s) = g(s,d) = C$. If this is the case, then we may conclude the schedule signal is relatively important in explaining creditworthiness compared to missed savings payments. If missed payments override the signal of the savings schedule, Hypothesis 3 is reached.

In the next sub-section, we reinterprete missed payments as deviations from prescribed behavior to motivate an complementary presentation of Hypothesis 3.:

Hypothesis 3: Missed savings payments within savings schedules negatively affect credit provision.

2.6.2 Alternative Explanation: Deviations in Savings Schedules

Missed payments payments may not only represent information on savings habits but also deviations from prescribed behavior. Since clients are aware of varying loans, we infer from Angeletos, Hellwig and Pavan (2006) and our discussion of *susu* collection that the presence of endogenous information means that the potential loans themselves yield relevant information about the coordination game. Deviations in savings behavior may be observed by a deposit collector, but may or may not be apparent to researchers. One aspect of deviations that would be apparent to both deposit collectors and the authors are the rate of missed savings payments within a savings schedule. We may infer how significant missing savings payments are in creditworthiness decisions in a way that complements the discussion in the previous sub-section.

We assume that significance of the rate of missed savings payments correlates with deviating behavior. To the extent that a client is unsatisfied with his or her schedule, the equivalent of Hypothesis 3 is predicted if we assume that significant missed payments would correlate with behavior that represent deviations to a collector. We therefore hypothesize that schedule choice is relatively unimportant in assessing creditworthiness. Missed savings contributions are important for a client (assigned to a particular savings schedule) receiving a credit outcome different from what they would observe in a separating equilibrium. The null hypothesis is that deviations are not significant and signaling (as discussed in the previous section) is sufficient to explain credit provision impacts of savings schedules.

2.6.3 Alternative Explanation: Information Channels

A second possibility is that time spent during or outside *susu* collection may provide important information channels for assessing creditworthiness. For example, a daily client may receive more credit than a weekly client (even in the absence of a signal) if the collector gains additional information from the daily visits which allows the collector more information than he would gain from weekly visits. If this information consistently affects collectors' creditworthiness assessments, as pointed out by a reviewer, one might expect a pattern similar to Hypothesis 2 where more frequent meetings provide more credit outcomes, if credit provision is increasing in the amount of information provided. In a related vein, more information may create a social bond between a client and their collector which may bias the collectors' assessments of client creditworthiness. While we cannot test these conjectures explicitly, we do test whether a stronger measure of additional information–the collector socializing with the client–affects credit provision and/or overrides the schedule signal.

3 Data Description and Estimation Strategies

3.1 Data Description

The data used in the analysis were collected between June 2010 and September 2010 in twenty-seven urban, peri-urban, semi-rural and rural areas in the Central Region of Ghana. At 9,826 square kilometres or 4.1 per cent of Ghana's land area, the Central Region is the third smallest in the nation. Although the capital, Cape Coast, was the initial seat of government during the British colonial era, the national capital was moved to Accra in 1877. The Central Region has had an incidence of poverty higher than the national average (International Labor Organization 2004).

The initial phase involved the interviewing 15 Kakum Bank *susu* collectors, and administering a comprehensive survey to each of them. We then used the *susu* collectors to interview 384 individuals all living and working within the Central Region. After extensive discussions with the *susu* deposit collectors, we decided the order of survey implementation should follow the quasi-random geographically-based routes collectors use while mobilizing funds across market areas. We now provide some description of our data, as well as our general estimation strategy in the next section, while we apply it in the subsequent one. Descriptive statistics are in Table 1.

3.2 Descriptive Statistics and OLS estimations

Table 1 shows summary statistics for the individuals who adopted the daily, twice-weekly, weekly, fortnightly, and monthly schedules. Our client variables draw closely from the literature on deposit collection (e.g. Ashraf Karlan and Yin (2006)). The client characteristics (age, gender, entrepreneur, household head, income, and the number of missed payments) are broadly similar across the various schedules. The credit outcomes fluctuate both intuitively (the daily savers receive the largest amount), and counterintuitively (the monthly savers receive more than individuals who save twice every week for example). The savings amounts similarly fluctuate, and given the proposed signaling theory, it is possible that the savings timetables or schedules may yield even more consistent information than actual savings amounts.

[insert Table 1 here]

We now present the basic estimation strategy. Our credit observations (dependent variable) refers to the amount offerred and accepted, which is some equilibrium between supply and demand. We only include clients in the sample who demanded credit, which is the vast majority of the sample. Given the discussion in Subsection 1.1 (showing the context in which we assume that demand for credit is high), we consider the credit offer observed from the *susu* collector to be indicative of the supply of credit offered by the bank. We briefly outline the basic strategy in this section before applying the strategy to particular methodologies in the next section.

We estimate the following equation:

$$L = \alpha + \gamma_k T_k + \mathbb{X}\beta + \varepsilon \tag{1}$$

where L is the credit amount, T_k is an adopted saving schedule. The Hypotheses (from the previous section) are:

$H_1 : \gamma_k > 0$, for all k

$H_2 : \gamma_1 > \gamma_2 > \gamma_3 > \gamma_4$.

$H_3 : \theta < 0$.

The error term, ε, is the residual capturing omitted variables as well as measurement error. The set $\mathbb{X}$ represents client characteristics (consisting of age, gender, entrepreneur, household head, and monthly income). We very briefly outline some hypotheses below, relating to how each independent variable should affect creditworthiness:

BACKGROUND FACTORS $\mathbb{X}$:

- AGE. Younger entrepreneurs should be more economically active, and thus creditworthy.
- GENDER. Female entrepreneurs may be more creditworthy, since women are relatively economically active in Ghanaian markets.
- ENTREPRENEUR. Sole-proprietors should be more economically active, and therefore creditworthy.
- HOUSEHOLD HEAD. Household heads (breadwinners) should be economically active and creditworthy.
- MONTHLY INCOME. Individuals who are more productive should earn more and be more creditworthy.

[insert Table 2 here]

Table 2 shows OLS estimates of equation (1). The covariates are dummy variables for age, gender, entrepreneur (sole proprietor), and monthly income. The savings schedules are our treatment variables. In our main regression, we find that the daily savers received the most credit, followed by the weekly schedule. Overall, these estimates show that the amount of credit is generally increasing in the effort exerted in signaling.

4 Inverse Probability Treatment-Weighting and Double-Robust Estimations

People who exert more effort in saving may not be a random sample of individuals due to self-selection: they may have had lower propensities to be poor, higher propensities to shoulder responsibilities, or showed initiative and risk-worthiness in areas such as entrepreneurship. Because our signaling model suggests that self-selection is important for creditworthiness, implementing a controlled experiment would be challenging if not impossible. In this section, we present Inverse Probability Treatment-Weighted (IPTW) and Double-Robust (DR) matching estimators as a way of accounting for the non-random and self-selected nature of the data. The literature shows that these approaches are preferrable to standard matching estimators in the presence of self-selection as in our study.[17]

We denote an individual i to have received a binary savings schedule treatment, T_i, where (i = *1* for treated individuals and $i = 0$ for non-treated individuals). Let $C_{i,1}$ and $C_{i,0}$ represent credit outcomes under treatment and controls respectively. The causal individual effect is given as:

$$C_{i,1} - C_{i,0}. \tag{2}$$

The observed outcome depends on the treatment savings schedule variable T_i such that $C_i = T_i C_{i,1} + (1 - T_i) C_{i,0}$. The variable C_i denotes the observed (continuous) credit outcomes variable (after savings have been contributed for three months). We allow the vector $\underline{X}_i$ to incorporate all baseline variables and pretest outcome measurements (age, gender, household status, entrepreneur, and monthly income). The true Average Treatment Effect π will then be:

$$\pi = E\left(C_{i,1} \mid \underline{X}_i\right) - E\left(C_{i,0} \mid \underline{X}_i\right) = E\left(C_{i,1} \mid \underline{X}_i, T_i = 1\right) - E\left(C_{i,0} \mid \underline{X}_i, T_i = 0\right) \tag{3}$$

.

4.1 Inverse Probability of Treatment-Weighted (IPTW) Estimators

Like many matching techniques, the inverse probability of treatement-weighted estimators rely on the propensity scores: the probability of joining a savings schedule given (pre-treatment) individual background characteristics. Our estimated scores, $\bar{p}_i$, are the predicted values from a logit model which is a function of these characteristics (see Rosenbaum and Rubin (1983); Smith and Todd (2005)). We use weights calculated from the estimated propensity scores to generate inverse probabilities of treatment weights.

[17] Authors such as Hirano and Imbens (2001) and Curtis, Hammill, Eisenstein, Kramer, and Anstrom (2007: s104) have encouraged the use of IPTW estimations in empirical work. While standard matching estimators mitigate confounding of pre-treatment variables, they may introduce selection bias due to stratification on a fixed number of strata. IPTW and DR estimation methods mitigate this selection bias due to stratification by using weights by the estimated propensity score (see Rosenbaum (1987), Lunceford and Davidian (2004), Bang and Robins (2005), Tsiatis (2006), also note Imbens and Wooldridge (2009) for discussions).

Following Lunceford and Davidian (2004), the simple inverse weight is $1/\bar{p}_i$ if $T_i = 1$. If $T_i = 0$, then the simple inverse weight is $1/(1-\bar{p}_i)$.

The inverse probability of treatment-weighted estimator averages over the sum of the weights for each group using the simple inverse weights and yields:

$$\bar{\pi}_{IPTW} = \left(\sum_{i=1}^{N} \frac{T_i}{\bar{p}_i}\right)^{-1} \sum_{i=1}^{N} \left(\frac{T_i C_i}{\bar{p}_i}\right) - \left(\sum_{i=1}^{N} \frac{1-T_i}{1-\bar{p}_i}\right)^{-1} \sum_{i=1}^{N} \left\{\frac{(1-T_i)C_i}{1-\bar{p}_i}\right\} \tag{4}$$

Our IPTW estimates are calculated using $\bar{\pi}_{IPTW}$, using robust standard errors based on the Huber/White/sandwich methods.

4.2 Double-Robust (DR) Estimators

The Double-Robust (DR) estimator $\bar{\pi}_{DR}$ is derived in Leon, Tsiatis and Davidian (2003) and Tsiatis (2006). It is as follows:

$$\bar{\pi}_{DR} = \frac{1}{N}\sum_{i=1}^{N} \frac{T_i C_i - (T_i - \bar{p}_i)\, q_1(\underline{X}_i)}{\bar{p}_i} - \frac{1}{N}\sum_{i=1}^{N} \frac{(1-T_i)C_i + (T_i - \bar{p}_i)\, q_0(\underline{X}_i)}{1-\bar{p}_i} \tag{5}$$

where $q_T(\underline{X}_i)$ refers to the predicted values from regressions of credit outcomes on the pre-treatment covariates, including baseline credit outcomes. Specifically, $q_T(\underline{X}_i) = E(C_i \mid T_i = T.\underline{X}_i)$ for $T = 0$ or $T = 1$. The coefficient estimates are implemented with the same model, but for each (treated and non-treated) group separately[18]. The robust form of the sampling variances are

$$N^{-2} \sum_{i=1}^{N} \bar{I}_{DR,i} \tag{6}$$

such that

$$\bar{I}_{DR,i} = \frac{T_i C_i - (T_i - \bar{p}_i)\, q_1(\underline{X}_i)}{\bar{p}_i} - \frac{(1-T_i)C_i + (T_i - \bar{p}_i)\, q_0(\underline{X}_i)}{1-\bar{p}_i} \tag{7}$$

When both models are correctly specified, the semiparametric efficient estimator equals the double-robust estimator. We provide our main IPTW and DR results in the next section[19].

5 IPTW and DR Results

5.1 Comparisons with Multiple Alternative Schedules as Controls

Tables 3 and 4 present the average treatment effects (differences) for the treatment schedules

[18] The estimator is consistent for true average treatment effects assuming (a) $\bar{p}_i$ is the true propensity score (b) the model relating credit outcomes to covariates is correctly specified.

[19] All estimations were also run with standard propensity score matching estimators. The results presented below are robust to estimation with standard propensity score matching and therefore only the DR and IPTW are reported. Results are available from the authors on request.

relative to comparison groups. For each savings schedule, we present all other savings schedules as control groups, with the comparison groups gained through the matching techniques discussed above. In both Tables 3 and 4, individuals who exert the most effort in signaling their creditworthiness to deposit collectors receive more credit. In Table 3, the daily schedule is shown to have a large significant credit impact (approaching 400 Ghana cedis), while the fortnightly schedule shows a large and significant negative credit effect (275 Ghana cedis). None of the other schedules yield significant credit impacts in our results.

[insert Table 3 here]

Our double-robust estimates (in Table 4) also show that individuals who choose the daily schedule receive much more credit on average (382 Ghana cedis). Saving on a fortnightly schedule had the most negative credit impact (235 Ghana cedis). However, individuals who use twice-weekly or weekly savings schedules do not show statistically significant negative credit impacts. While we do see some evidence of the type of strict hierarchy of effort to credit provision in credit declining from daily through fortnightly, that pattern is not significant and has non-significant reversals between weekly and two days per week.

[insert Table 4 here]

5.2 IPTW and DR Estimations Using Single Alternative Schedules as Comparison Groups

We present in Tables 5 and 6 average treatment effects of savings schedules on credit outcomes relative to single alternative schedules. The results are generally consistent with the prior discussion on using multiple alternative schedules as comparison groups. Each cell in Table 5 shows a different regression of the average treatment effects of various savings schedules on credit relative to a single other schedule. We find that Table 5 (using IPTW estimations) yields generally the same outcomes as Table 3. Committing to the most effort-intensive (daily) schedule has a large and significant credit effect relative to all other less effort-intensive schedules, with the effects ranging from 291 Ghana cedis for the weekly to 489 Ghana cedis for the least effort-intensive fortnightly schedule. While using the twice-weekly schedule (instead of the daily schedule) leads to a very significant credit decrease, the twice-weekly schedule has significantly better credit outcomes relative to the fortnightly schedule. Meanwhile, the least effort-intensive fortnightly schedule has large and significantly negative effects relative to the daily, twice-weekly and weekly schedules.

[insert Table 5 here]

Table 6 uses the double-robust estimator to show average treatment effects of the various savings schedules on credit (with each savings schedule serving as a comparison group), showing results very similar to the IPTW ones. Each entry represents a seperate double-robustness estimation. Using the daily schedule has a positive effect that is generally increasing as the effort-intensity of the comparison savings schedule decreases. The daily schedule has a positive credit effect relative to the twice-weekly and weekly schedules but is most pronounced relative to the fortnightly schedule (about 490 Ghana cedis). Similarly, the twice-weekly schedule has a significantly negative credit effect relative to the daily schedule, while the weekly schedule has a positive and significant credit effect relative to the fortnightly schedule. Finally, the fortnightly schedule has a negatively and significant average treatment effect relative to the daily schedule, although the effects relative to other comparison schedules are not significantly different from each other. The credit effects of the daily savings schedule thus far are the most economically and statistically significant, while the fortnightly savings schedule has the most negative significant credit impacts relative to the other schedules that require higher levels of effort. The twice-weekly and weekly savings schedules generally yield negative credit impacts that are generally similar[20].

[insert Table 6 here]

5.3 Credit Reporting Agency Results

A complementary explanation to our signaling finding may be that *susu* deposit collection and credit provision function in such a way that both signaling and credit reporting agency impacts would be important for credit decisions. In the case of the credit reporting agency explanation, we use missed payments within a schedule as our proxy variable for the level of consistency shown by a potential borrower. We therefore test the combined impact of the signal of being in a schedule with missing payments within that same schedule. Tables 7 and 8 provide IPTW and DR estimations where we consider the treatment to be having missed savings payments while in their savings schedule. If missed payments within schedules yield results similar to our initial signaling results, the signal of being in a schedule may be more important than missed savings is for assessing creditworthiness. The IPTW and DR results are columns 1-4 in Tables 7 and 8 respectively. The impacts on credit outcomes in Tables 7 and 8 are broadly similar in magnitude and significance to our previous results ignoring the missed payment differences: individuals who saved on a daily basis and had missed some savings payments received the highest credit amounts and fortnightly savers had the most negative credit impacts. While the credit bureau mechanism that would allow people to make consistent payments is important for the schedule, the evidence from this data suggest that

[20]While the twice-weekly schedule was created by an NGO with the explicit goal of helping entrepreneurs, it shows no evidence of being useful in signaling creditworthiness.

once entrepreneurs make a schedule choice, consistency in deposits within that schedule is not a relevant metric. It is worth noting that the levels of missed payments are relatively low. For example (in Table 1), the missed payments rate of daily savers is about 10%, with the average amount missed being 3 Ghana cedis. Thus we may not be observing large enough variations in missed payments to estimate a credit bureau effect.

[insert Table 7 here]

[insert Table 8 here]

5.4 Information Channels as Alternative Explanations

An alternative explanation may be that additional information exchange between *susu* collectors and clients during or even outside *susu* collection may be important for assessing creditworthiness.[21] We would expect the amount of information collected during *susu* collection to respect the relative ordering of the schedules, and would have anticipated a stronger hierarchy in schedule impacts than our findings. For example, we find that weekly savings is more significant than twice per week savings in affecting credit provision, which partially negates this possibility. In addition, qualitative interviews with collectors and clients found that the time spent collecting savings was generally not used to gather additional information.

A final concern is whether information channels other than *susu* collection signaling affect creditworthiness. For instance, all collectors spend some time visiting and socializing with their clients during non-business hours. Information exchange between *susu* collectors and clients during such non-business hours may be important alternative channels for assessing creditworthiness. We analyze non-business socializing that may correlate with potentially additional information. Out of 15 collectors, we designate the 7 who reported that they spent between above the average time (of around half an hour) socializing with their clients during their last visit, as "social collectors" who have additional information through socializing.

Using that variation in collector behavior, we evaluate the impact of socializing on credit provision. We find similar results in credit provision for daily savers who had highly social collectors, implying that socializing does not generally lead to additional credit provision. Tables 9 and 10 show our findings. We consistently find negative impacts for fortnightly savers with highly social collectors, implying that the schedule signal overrides additional information from socializing. Fortnightly savers receive less credit although collectors have more information. While we find the same impact on daily scheduled savings as our main finding, we find that twice-weekly savers have similar effects to daily savers on credit provision (and slightly higher estimates).[22] Socializing only

[21] This discussion follows comments from a reviewer and assumes that more information about a client would make a collector more likely to provide credit to that client.

[22] The DR estimation was not feasible for weekly savers, due to a matching failure.

seems to be important for twice-weekly savers, but does not change credit provision for daily savers or other savers. In the case of weekly savers we can see that when the signal of economic effort is sufficiently negative, it is not amenable to additional information from socializing. Although socializing gained additional information and higher credit provision for twice-weekly savers, it is the exception that proves the rule that savings schedules matter to credit provision.

[insert Table 9 here]

[insert Table 10 here]

6 Robustness Checks

Thus far, we have considered credit availability from deposit collectors to be significantly affected by savings mobilization on schedules. An alternative explanation may be that credit instead affects savings. The argument is as follows. If individuals mobilize more or less savings upon receiving credit from a collector, we would observe a significant credit impact on savings. However, the results we already have should lower concerns of such a reverse causality. The treatment variables we use, savings schedules are associated with financial effort and self-selection, which should be negatively correlated with the propensity to substitute savings contributions with received credit. Nevertheless, to check for robustness, we examine the possibility that the parameters of interest (savings schedules) are correlated with the error term once we control for observables in our matching algorithms. Since we have a control population which did not demand and therefore did not receive any credit, we are able to test whether reverse causality is at play: that is, whether receiving credit affects savings outcomes. Our IPTW and DR results are shown in the first and second columns (respectively) of Table 11, where the amount of savings is the dependent variable and the control group are people who did neither demanded nor received credit. We do not find any evidence that credit receipt significantly affects savings contributions, which we take to imply there should be little concern with reverse causality driving our results.

[insert Table 11 here]

We have tested a number of alternative models. The results are in the Supplementary Online Appendix. We find similar results after adding more variables to our unique IPTW and DR matching algorithms although matchings are not always feasible in the data. For example, even after including various variables to further disaggregate occupations within the same markets[23], we generally find

[23] Specifically, we added variables for the following occupations: farmer, fisherman, tailor/seamstress, drinking bar operator, doctor, nurse, baker, carpenter, accountant, apprentice, banker, building contractor, caterer, hairdresser, lawyer, lottery agent/receiver, pastor/minister, pharmacist, shoe cobbler, nursing mother, oil processer, student, teacher, video editor, zoomlion agent (garbage collector), technical repairer, cleaner, consultant, driver.

the daily savers to attain the highest credit provision. Additional results in the Appendix also use standard propensity score matching and provide similar results to the main text. This partially mitigates concerns that the findings in the main text are driven by omitted variable bias. Our alternative specifications all suggest that clients and collectors prioritise the daily savings schedule, and the latter consider saving on a daily schedule to be a relatively strong signal of creditworthiness.

7 Conclusions

This work argues that signaling theories from the economics of education and labor can explain creditworthiness within formal-informal finance in developing countries. We first presented a theoretical framework for analyzing various degrees of signaling effort using savings schedules to show creditworthiness. The model predicts that savings schedules requiring more effort signal greater creditworthiness, and that this signal should lead to higher offers of credit to people who make stronger signals. Using quasi-experimental methods that improve on standard matching, we find overall support for our argument in our data from the Central Region of Ghana. The strongest positive and negative signals (daily and fortnightly savings respectively) yield the highest and lowest credit outcomes for entrepreneurs. We also consider a comparison of signaling to a credit reporting agency mechanism that emphasizes consistency of savings payments as a complementary channel to creditworthiness, finding no evidence for the credit reporting agency mechanism. The fact that missed payments do not affect credit outcomes implies that signaling is relatively more important for credit compared to a credit rating agency mechanism. We also find that collectors' time spent socializing with clients strengthens our main schedule signaling result. Formal sector banks benefit from the kinds of signals that are available in informal contexts, and we find such signals to be more important than social connections.

While we realize our study is localized, we believe our application of the signaling discussion to creditworthiness in formal-informal financial markets has important policy implications for the operation of developing country credit markets. Although microfinance institutions are noticing the productivity and other economic benefits of savings[24], our main signaling finding implies that savings schedules may provide signaling advantages beyond savings consistency benefits. The microcredit community would do well to study the potential applicability of the *susu* setup in Ghana to other countries and microsavings projects would do well to consider using information signals from savings mobilization to expand access to credit. Both changes would have the potential to improve credit access and improve the ability of microcredit organizations to gain information on their clients.

Many future directions remain for this line of work. We are unable to examine whether creditworthiness is observed perfectly at the time of credit receipt or revealed gradually over time (see

[24] See *The Economist* (2010).

Arcidiacono, Bayer, and Hizmo (2010) for the education signaling case). For instance, the strength of the signal chosen may correlate with financial investments on receipt, as for example in recent work by de Mel, McKenzie and Woodruff (2008) who find capital returns to vary significantly with entrepreneurial ability. Dynamic learning models, where lenders' knowledge of individual ability improves over time may be relevant as formal-informal economic institutions evolve further. In addition, the reliability of creditworthiness signals could be modeled and tested in future research to assess the signals' long-term quality.

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TABLE 1—SUMMARY STATISTICS OF SAVINGS SCHEDULES AND INDIVIDUAL CHARACTERISTICS

Variables	Daily	Two days per week	Weekly	Fortnightly	Monthly
Age	31.02	34.21	32.38	34.30	39.65
	(8.92)	(9.19)	(8.41)	(8.54)	(8.94)
Female	0.46	0.49	0.69	0.66	0.53
	(0.50)	(0.50)	(0.47)	(0.48)	(0.51)
Entrepreneur	0.79	0.71	0.85	0.94	0.82
	(0.41)	(0.46)	(0.36)	(0.24)	(0.39)
Household Head	0.36	0.21	0.38	0.61	0.59
	(0.48)	(0.41)	(0.47)	(0.49)	(0.51)
Monthly Income (in Ghana cedis)	288.13	212.09	236.41	140.10	271.76
	(561.02)	(540.49)	(557.81)	(291.59)	(964.33)
Missed Savings Payments/Times Defaulted per month	3.01	1.61	1.71	1.07	0.65
	(4.97)	(2.19)	(2.83)	(0.90)	(0.49)
Default rate (rate of missed savings payments in %)	10.04	18.73	39.80	49.94	65.01
	(16.56)	(25.60)	(66.21)	(42.17)	(49.23)
Savings contributions (in Ghana cedis)	16.53	5.98	5.92	6.36	3.34
	(36.30)	(16.21)	(35.24)	(13.87)	(5.57)
Credit (in Ghana cedis)	877.57	566.18	623.11	389.36	433.70
	(512.29)	(497.94)	(399.13)	(368.89)	(593.93)
Number of Observations per schedule	99	92	109	67	17

Notes: The savings schedules (daily; two days per week; weekly; fortnightly) refer to the arranged frequency at which a client deposits savings with a *susu* collector. Entrepreneur is an indicator variable for whether the individual is self-employed in the informal sector. Missed Savings Payments/Times Defaulted per month is the individual-level count of the number of times scheduled savings were not honored during the last month.

TABLE 2—SAVINGS SCHEDULES AND CHARACTERISTICS: OLS BASELINE ESTIMATES

Dependent Variable: *Susu* Credit (in Ghana cedis)	(1)	(2)	(3)	(4)	(5)
Daily	464.28***	314.24***			
	(118.51)	(102.07)			
Two Days per week	179.85**		-39.77		
	(85.73)		(80.61)		
Weekly	202.38**			-19.07	
	(96.21)			(79.28)	
Fortnightly					-249.49***
					(76.06)
Age	-1.92	-2.03	-1.12	-1.92	-1.97
	(4.47)	(4.53)	(4.73)	(4.56)	(4.44)
Female	-61.81	-90.76	-111.93	-105.63	-63.17
	(91.98)	(90.56)	(91.06)	(90.70)	(92.12)
Entrepreneur	-45.25	-75.15	-101.79	-100.05	-55.84
	(101.97)	(104.40)	(102.53)	(103.26)	(100.67)
Household Head	-39.57	-37.40	-79.17	-69.82	40.20
	(89.38)	(80.98)	(84.05)	(82.23)	(87.26)
Monthly Income (in Ghana cedis)	0.06	0.08	0.13	0.14**	0.10
	(0.07)	(0.06)	(0.06)	(0.06)	(0.06)
Constant	506.11***	699.18***	770.65***	779.89***	761.26***
	(152.01)	(144.44)	(144.39)	(151.59)	(139.31)
N	184	184	184	184	184

Notes: The savings schedules (daily; two days per week; weekly; fortnightly) refer to the arranged frequency at which a client deposits savings with a *susu* collector. Columns 1-5 report OLS coefficients with robust standard errors. *** denotes significance at the 1% level; ** refers to significance at the 5% level;* implies significance at the 10% level.

TABLE 3—INVERSE PROBABILITY TREATMENT-WEIGHTED ESTIMATES OF SAVINGS SCHEDULES ON CREDIT:
ALL OTHER SAVINGS SCHEDULES AS COMPARISON GROUPS

Treatment and Comparison Group Variables:	Comparison Group: All other Savings Schedules (1)	Comparison Group: All other Savings Schedules (2)	Comparison Group: All other Savings Schedules (3)	Comparison Group: All other Savings Schedules (4)
Treatment: Daily	395.80***			
	(98.73)			
Treatment: Two Days per Week		-57.71		
		(81.27)		
Treatment: Weekly			30.05	
			(72.52)	
Treatment: Fortnightly				-274.59***
				(63.76)
N	184	184	184	184

Notes: For each treatment schedule (daily; two days per week; weekly; fortnightly), the comparison group is yielded from all other savings schedules. Columns 1-4 report Inverse Probability Treatment-Weighted Effects with robust standard errors based on Huber/White/sandwich contexts. *** denotes significance at the 1 percent level; ** refers to significance at the 5 percent level;* implies significance at the 10 percent level.

TABLE 4—DOUBLE-ROBUST ESTIMATES OF SAVINGS SCHEDULES ON CREDIT: ALL OTHER SAVINGS SCHEDULES AS COMPARISON GROUPS

Treatment and Comparison Group Variables:	Comparison Group: All other Savings Schedules (1)	Comparison Group: All other Savings Schedules (2)	Comparison Group: All other Savings Schedules (3)	Comparison Group: All other Savings Schedules (4)
Treatment: Daily	381.96***			
	(87.08)			
Treatment: Two Days per Week		-31.47		
		(76.78)		
Treatment: Weekly			-21.03	
			(68.69)	
Treatment: Fortnightly				-235.24***
				(53.43)
N	184	184	184	184

Notes: For each treatment schedule (daily; two days per week; weekly; fortnightly), the control schedules include all other schedules. Columns 1-4 report Double-robust estimates with robust standard errors. For each treatment savings schedule, the comparison group is yielded from all other savings schedules. *** denotes significance at the 1 percent level; ** refers to significance at the 5 percent level;* implies significance at the 10 percent level.

TABLE 5—INVERSE PROBABILITY TREATMENT-WEIGHTED ESTIMATES OF SAVINGS SCHEDULES ON CREDIT:
INDIVIDUAL SAVINGS SCHEDULES AS COMPARISON GROUPS

Treatment and Comparison Group Variables:	Comparison Group: Daily (1)	Comparison Group: Two Days per week (2)	Comparison Group: Weekly (3)	Comparison Group: Fortnightly (4)
Treatment: Daily		343.55***	290.76**	488.86***
		(111.97)	(109.47)	(110.05)
N		94	77	81
Treatment: Two Days per week	-343.55***		-47.49	187.80**
	(111.97)		(86.20)	(84.20)
N	94		103	107
Treatment: Weekly	-290.76**	47.49		233.19***
	(109.47)	(86.20)		(81.50)
N	77	103		90
Treatment: Fortnightly	-488.86***	-187.80**	-233.19***	
	(110.05)	(84.20)	(81.50)	
N	81	107	90	

Notes: The savings schedules (daily; two days per week; weekly; fortnightly) refer to the arranged frequency at which a client deposits savings with a *susu* collector. Columns 1-4 report Inverse Probability Treatment-Weighted Estimates with robust standard errors based on Huber/White/sandwich contexts. For each treatment savings schedule, the comparison group is yielded from alternative individual savings schedules. *** denotes significance at the 1 percent level; ** refers to significance at the 5 percent level;* implies significance at the 10 percent level.

TABLE 6—DOUBLE-ROBUST ESTIMATES OF SAVINGS SCHEDULES ON CREDIT: INDIVIDUAL SAVINGS SCHEDULES AS COMPARISON GROUPS

Treatment and Comparison Variables:	Comparison Group: Daily	Comparison Group: Two Days per Week	Comparison Group: Weekly	Comparison Group: Fortnightly
	(1)	(2)	(3)	(4)
Treatment: Daily		384.78***	223.27**	490.11***
		(113.46)	(99.49)	(91.09)
N		94	77	81
Treatment: Two Days per Week	-384.78***		20.53	176.10**
	(113.46)		(83.82)	(68.60)
N	94		103	107
Treatment: Weekly	-223.27**	-20.53		157.70**
	(99.49)	(83.82)		(65.70)
N	77	103		90
Treatment: Fortnightly	-490.11***	-176.10**	-157.70**	
	(91.09)	(68.60)	(65.70)	
N	81	107	90	

Notes: The savings schedules (daily; two days per week; weekly; fortnightly) refer to the arranged frequency at which a client deposits savings with a *susu* collector. Columns 1-4 report Double-robust estimates with robust standard errors. For each treatment savings schedule, the comparison group is yielded from alternative individual savings schedules. *** denotes significance at the 1 percent level; ** refers to significance at the 5 percent level;* implies significance at the 10 percent level.

TABLE 7—INVERSE PROBABILITY TREATMENT-WEIGHTED ESTIMATES OF MISSED SCHEDULE PAYMENTS ON CREDIT:
ALL OTHER SAVINGS SCHEDULES AS COMPARISON GROUPS

Treatment and Comparison Group Variables:	Comparison Group: All Savings Schedules (1)	Comparison Group: All Savings Schedules (2)	Comparison Group: All Savings Schedules (3)	Comparison Group: All Savings Schedules (4)
Treatment: Missed Daily Payments	401.65*** (113.22)			
Treatment: Missed Two Days per Week Payments		160.52 (276.42)		
Treatment: Missed Weekly Payments			3.70 (62.21)	
Treatment: Missed Fortnightly Payments				-372.86*** (56.45)
N	184	184	184	184

Notes: The treatment group in every schedule missed at least one appointment to save money with their *susu* collectors. The comparison groups refer to all clients who did not miss any savings payments to their *susu* collectors. Columns 1-4 report Inverse Probability Treatment-Weighted Estimates with robust standard errors based on Huber/White/sandwich contexts. *** denotes significance at the 1 percent level; ** refers to significance at the 5 percent level;* implies significance at the 10 percent level.

TABLE 8—DOUBLE-ROBUST ESTIMATES OF MISSED SAVINGS PAYMENTS ON CREDIT: ALL OTHER SAVINGS SCHEDULES AS COMPARISON GROUPS

Treatment and Comparison Group Variables:	Comparison Group: All Savings Schedules (1)	Comparison Group: All Savings Schedules (2)	Comparison Group: All Savings Schedules (3)	Comparison Group: All Savings Schedules (4)
Treatment: Missed Daily Payments	329.87*** (117.38)			
Treatment: Missed Two Days per Week Payments		215.90** (93.78)		
Treatment: Missed Weekly Payments			11.29 (65.89)	
Treatment: Fortnightly Payments				-320.04*** (76.66)
N	184	184	184	184

Notes: The treatment group in every schedule missed at least one appointment to save money with their *susu* collectors. The comparison groups refer to all clients who did not miss any savings payments to their *susu* collectors. Columns 1-4 report Double-robust estimates with robust standard errors. *** denotes significance at the 1 percent level; ** refers to significance at the 5 percent level;* implies significance at the 10 percent level.

TABLE 9—INVERSE PROBABILITY TREATMENT-WEIGHTED ESTIMATES OF SOCIALIZING DURING NON-BUSINESS HOURS ON CREDIT: ALL OTHER SAVINGS SCHEDULES AS COMPARISON GROUPS

Treatment and Comparison Group Variables:	Comparison Group: All other Savings Schedules (1)	Comparison Group: All other Savings Schedules (2)	Comparison Group: All other Savings Schedules (3)	Comparison Group: All other Savings Schedules (4)
Treatment: Daily	496.78***			
	(105.48)			
Treatment: Two Days per Week		520.19***		
		(183.61)		
Treatment: Weekly			-317.22**	
			(144.83)	
Treatment: Fortnightly				-177.48*
				(102.55)
N	184	184	184	147

Notes: The treatment group in every schedule has a *susu* collector who spent an hour during non-business hours socializing with their clients. The comparison groups refer to all clients whose collectors did not similarly socialize with their clients. Columns 1-4 report Inverse Probability Treatment-Weighted Estimates with robust standard errors based on Huber/White/sandwich contexts. *** denotes significance at the 1 percent level; ** refers to significance at the 5 percent level;* implies significance at the 10 percent level.

TABLE 10—DOUBLE-ROBUST ESTIMATES OF SAVINGS SCHEDULES OF SOCIALIZING DURING NON-BUSINESS HOURS ON CREDIT: ALL OTHER SAVINGS SCHEDULES AS COMPARISON GROUPS

Treatment and Comparison Group Variables:	Comparison Group: All other Savings Schedules (1)	Comparison Group: All other Savings Schedules (2)	Comparison Group: All other Savings Schedules (3)	Comparison Group: All other Savings Schedules (4)
Treatment: Daily	424.18*** (98.33)			
Treatment: Two Days per Week		476.32*** (167.16)		
Treatment: Weekly			-	
Treatment: Fortnightly				-197.36*** (61.58)
N	184	184	-	147

Notes: The treatment group refers to clients who save on daily, two days per week, weekly and fortnightly savings schedules with *susu* collectors. The comparison groups refer to all other savings schedules. Columns 1-4 report Double-Robust Estimates with robust standard errors. *** denotes significance at the 1 percent level; ** refers to significance at the 5 percent level;* implies significance at the 10 percent level.

TABLE 11—INVERSE PROBABILITY TREATMENT-WEIGHTED AND DOUBLE-ROBUST ESTIMATES OF CREDIT ON SAVINGS CONTRIBUTIONS

Treatment and Comparison Group Variables:	Comparison Group: No credit (Inverse Probability Treatment-Weighted Estimates) (1)	Comparison Group: No credit (Double-Robust Estimates) (2)
Treatment: Received credit (Inverse Probability Treatment-Weighted Estimates)	-8.50 (5.67)	
Treatment: Received credit (Double-Robust Estimates)		-8.30 (6.00)
N	341	341

Notes: The treatment group received credit from their *susu* collectors. The comparison client group did not demand or receive credit. Columns 1 and 2 report Inverse Probability Treatment-Weighted Estimates and Double-Robust Estimates respectively. The matching estimation procedures are identical to the prior tables (Tables 3-8). *** denotes significance at the 1% level; ** refers to significance at the 5% level;* implies significance at the 10% level.

Appendix A: Models and Proofs

7.1 Savings as a Creditworthiness Signal: A Spencian Set-up

In this model, an agent may reliably signal her creditworthiness indirectly, by submitting to a test that requires effort. The understanding is that in any sub-game perfect Nash equilibrium, all entrepreneurs whose creditworthiness exceed an arbitrary threshold in creditworthiness will yield to this test. The test in our setting refers to regular savings contributions an individual makes to a *susu* deposit collector. Providing these amounts require effort on the part of the saver and credibly signal the type of businessperson to a deposit collector, as explained in the present framework. We consider a single savings schedule in this section.

Consider two types of entrepreneurs with creditworthiness Q_H and Q_L, such that $Q_H > Q_L > 0$ and $\lambda = \text{Prob}\,(Q = Q_H) \in (0,1)$. Before applying for a loan from a *susu* deposit collector an entrepreneur can make some *susu* savings contributions. These quantities s are observable to *susu* collectors.[25]

The opportunity and psychological cost of contributing these amounts to a *susu* collector for an entrepreneur of creditworthiness type Q is given by the twice continuously differentiable function $c(s,Q)$, so that its derivatives are as follows: $c(0,Q) = 0$, $c_s(s,Q) > 0$, $c_{ss}(s,Q) > 0$, $c_Q(s,Q) < 0$ for all $s > 0$, and $s_{sQ}(s,Q) < 0$. This means that the cost and the marginal cost of *susu* contributions are assumed to be lower for high-creditworthy entrepreneurs. We assume that the contribution of savings required for a rural bank loan would be relatively easier for a highly-creditworthy individual. These clients who are able to make consistent savings (given the economic difficulties noted above) should be able to make regular credit payments as well.

We can allow $u(l,s \mid Q)$ to denote the utility of an entrepreneur of creditworthiness Q who chooses *susu* contribution level s and receives loan l. The utility is presented as follows: $u(l,s \mid Q) = l - c(s,Q)$; that is, the difference between the loan given and the cost of contributions made before it was received[26].

The basic *susu* contribution-credit outcome signaling game is summarized below.

1. A random move of nature determines the entrepreneurs' creditworthiness level.

2. Conditional on her type (high or low creditworthiness), the entrepreneur chooses how much *susu* contributions to make (we simplify this decision in terms of effort the individual exerts).

3. Once the contribution level is chosen, the entrepreneur enters the market for loans.

4. Conditional on the observed *susu* contributions, deposit collectors simultaneously make loan offers.

[25] As noted in our earlier discussion, an individual's own savings are not as economically significant compared to a lump sum that can be gained via credit.

[26] An entrepreneur of type Q may earn $r(Q)$ by working with informal *susu* collectors, who mobilize savings funds but do not provide loans. One can think of this construct as independent savings. For simplicity, we assume throughout this section that $r(Q_H) = r(Q_L) = 0$.

7.2 Perfect Bayesian Equilibrium (PBE)

The PBE denotes a set of strategies and a belief function $\nu(s) \in [0,1]$ giving the institutions' common probability assessment that the entrepreneur is of high creditworthiness after observing *susu* contribution level s. The requirements for a perfect Bayesian equilibrium are as follows:

• The entrepreneur's strategy is optimal given the deposit collector's strategy.

• The belief function $\nu(s)$ is derived from the entrepreneur's strategy using Bayes' rule where possible.

• The institutions' loan offers following each choice constitute a Nash equilibrium of the simultaneous-move loan offer game in which the probability that the entrepreneur is of high creditworthiness is $\nu(s)$.

We initiate our discussion from the end of the game. Suppose that after observing some contribution level s , the institutions attach a probability of $\nu(s)$ that the entrepreneur is of type Q_H. If so, the expected creditworthiness of the entrepreneur is $\nu(s)Q_H + (1-\nu(s))Q_L$. In a simultaneous-move loan offer game, the collectors' (pure strategy) Nash equilibrium loan offers equal the entrepreneur's expected creditworthiness.

7.3 Separating Equilibria and *Susu* Contributions

Suppose that $s^*(Q)$ is the entrepreneur's equilibrium *susu* contribution choice as a function of her creditworthiness, and let $l^*(s)$ be the economic institution's equilibrium loan offer as a function of the entrepreneur's *susu* contribution level.

Proposition 1

In any separating perfect Bayesian equilibrium, each entrepreneur type receives a loan equal to their creditworthiness level: $l^*(s^*(Q_H)) = Q_H$ *and* $l^*(s^*(Q_L)) = Q_L$.

PROOF: See Appendix A.

Lemma 1

In any separating Bayesian equilibrium, $s^*(Q_L) = 0$; *that is, a entrepreneur having low levels of creditworthiness chooses to make no susu contributions.*

PROOF: See Appendix A.

From the above discussion, type Q_L's indifference curve through her equilibrium level of *susu* contributions and loans is shown in Figure 1 in a separating equilibrium. Using the diagram, we can construct a separating equilibrium as follows: Let $s^*(Q_H) = \tilde{s}$, let $s^*(Q_L) = 0$, and we present the schedule for $l^*(s)$. The *susu* deposit collectors' equilbrium beliefs following *susu* contribution choice s are $\mu^*(e) = (l^*(s) - Q_L)/(Q_H - Q_L)$. Since $l^*(s) \in [Q_L, Q_H]$, they satisfy $\mu*(s) \in [0,1] \forall s \geq 0$.

To verify that this is a perfect Bayesian equilibrium, *susu* collectors may have beliefs where s is neither 0 nor $\tilde{s}$. However, it must be the case that $\mu(0) = 0$ and $\mu(1) = 1$. The loan offers drawn,

which have $l^*(0) = Q_L$, and $l^*(s^*) = Q_H$ reflect exactly these beliefs. The equilibrium path allows for different loan schedules that may support *susu* contribution choices.

7.4 Entrepreneur's Strategy

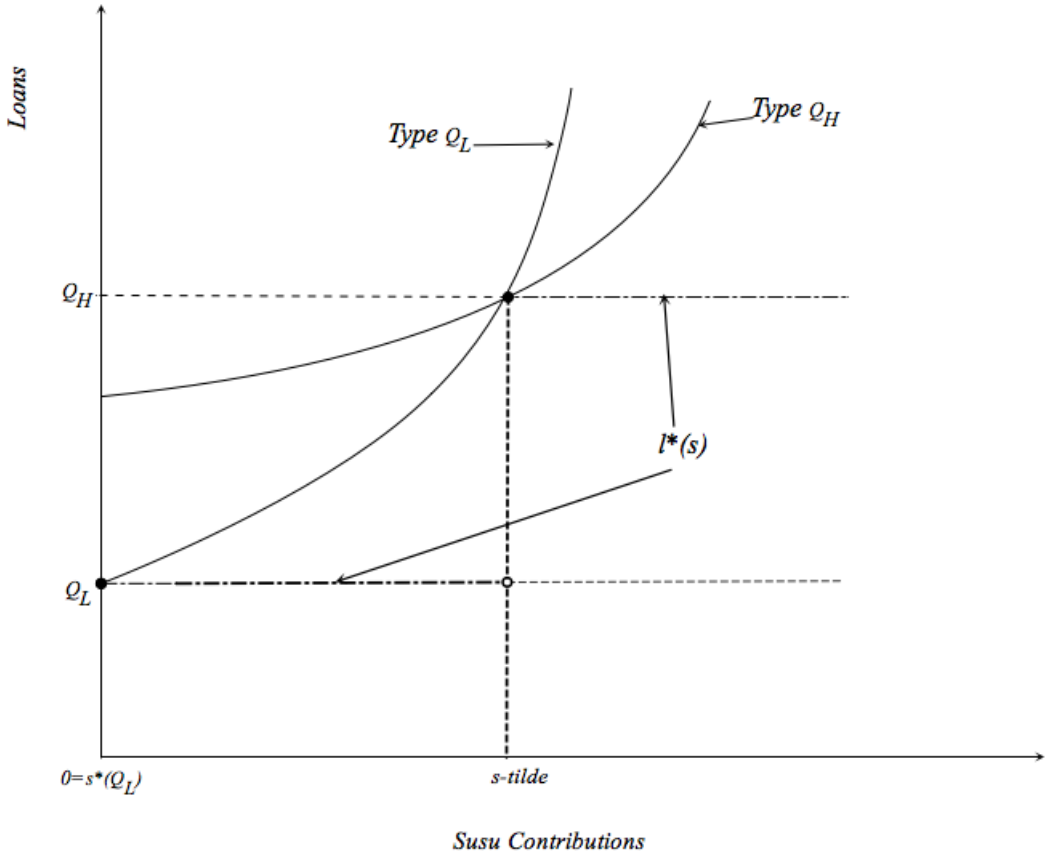
The equilibrium path allows for many loan schedules that can arise to support *susu* contribution choices. In the below perfect Bayesian equilibrium, institutions believe that the entrepreneur is certain to be of high type if $s \geq \tilde{s}$ and certain to be of a low type if $s < \tilde{s}$. The resulting loan schedule has $l^*(s^*) = Q_H$ if $s \geq \tilde{s}$ and $l^*(s^*) = Q_L$ if $s < \tilde{s}$. We now focus on Figure 1 to explain the entrepreneur's strategy and deposit collector's incentives, given variation in information.

The *susu* collectors employed by rural banks observe varying deposit mobilization levels. Rural banks' *susu* collectors believe that an entrepreneur is certain to be of high type if $s \geq \tilde{s}$ and certain to be of a low type if $s < \tilde{s}$.

Entrepreneurs worthy of high credit are willing to engage in *susu* contributions simply because it allows them to distinguish themselves from entrepreneurs worthy of low credit and receive higher loans. The basic reason why these contributions can serve as a signal here is that the marginal cost of *susu* contributions depends on the type of creditworthiness (high or low) an entrepreneur merits. Because the marginal cost of contribution is higher for an entrepreneur worthy of low credit, (since $c_{sQ}(s,Q) < 0$), a type Q_H entrepreneur may find it worthwhile to contribute some positive level $s^{'} > 0$ to raise her loans by some amount $\triangle l > 0$, whereas a type Q_L entrepreneur would be unwilling to make these same levels of contributions in return for the same loan increase. As a result, institutions can reasonably come to regard contribution levels as signals of entrepreneur creditworthiness.

We note that the contribution level of the high-ability entrepreneur cannot be below $\tilde{s}$ in a separating equilibrium because if it were, the low-ability entrepreneur would deviate and pretend to be highly creditworthy by choosing the high-credit contribution level. On the other hand, the contribution level of the high-credit entrepreneur cannot be above an arbitrary s_1 because if it were, the high-credit entrepreneur would prefer to contribute no funds, even if this resulted in her being perceived as of low creditworthiness. Figure 1 shows creditworthiness signaling by *susu* savings.

Figure 1: *Susu* Savings and Creditworthiness Signaling



We now provides proofs of the model propositions and definitions in the main text.

Proof of Proposition 1

In any perfect Bayesian equilibrium, beliefs are correctly derived from the equilibrium strategies using Bayes' rule to be on the equilibrium path. Thus, on seeing *susu* contribution level $s^*(Q_L)$, institutions must assign probability one to the entrepreneur having creditworthiness of Q_L. Likewise, *susu* collectors assign probability one that an entrepreneur has creditworthiness Q_H upon seeing *susu* contribution level $s^*(Q_H)$. Note that the corresponding loans reflect Q_L and Q_H , respectively.

Proof of Lemma 1

This is proved by contradiction. Suppose the opposite scenario is true: that when a worker's creditworthiness type is Q_L , she chooses some strictly positive savings level $\hat{s} > 0$. According to proposition 1, by doing so, the entrepreneur receives a loan equal to Q_L. However, she would receive a credit outcome of at least Q_L if she instead chose s = 0. Choosing $s = 0$ would save her the cost of *susu* contributions, and therefore she would be strictly better off by doing so. This contradictions the assumption that $\hat{s} > 0$ is her equilibrium level.

Definition 1

Single Crossing Property: Let Q,S,L be real intervals.
$U^C(.)$ supports the single-crossing condition if $U^C(q,s,l) \leq U^C\left(q,s^{'},l^{'}\right)$
$\Longrightarrow U^C\left(q^{'},s,l\right) \leq U^C\left(q^{'},s^{'},l^{'}\right) \forall q^{'} > q.$

In our scenario with saving clients and crediting deposit collectors, $U^C(.)$ is strictly decreasing in the second argument (the signal), and increasing in the third argument (D's loan response) for all types. Therefore, indifference curves are well-defined in $S \times L$ for all q. The single-crossing condition implies that the indifference curves of different client types will cross only once. If a lower-type is indifference between type signal-action pairs, then a higher type strictly prefers to send the higher signal. In this manner, the single crossing property links signals to types such that higher types send weakly higher signals in equilibrium.

Proof of Proposition 2a

Assume that the best response function of D be $DR(q)$ be uniquely defined, and strictly increasing in q. We will prove the proposition by constructing a possible equilibrium path and confirming that this path is part of a separating equilibrium. We walk through the following steps:

1. q_0 selects the signal s_0^* that maximizes $U^C(q_0,s,DR(q_0))$.
2. Suppose that s_i^* have been specified for $i = 0,...,n-1$ and let $U^*(t_i) = U^C(q_i,s^*,DR(q_i))$.
3. Define s_n^* to solve the optimization problem:

Maximize $U(q_n,s,DR(q_n))$ subject to $U^C(q_{n-1},s,DR(q_n)) \leq U^C(q_{n-1})$.

Assume solutions for the maximization problems of Step 1 and Step 2. The process inductively produces a signaling strategy for the client and a response rule for the deposit collector defined on $\left\{s_0^*,...,s_N^*\right\}$. When the DR function is strictly increasing, the single-crossing condition implies that the signaling strategy is strictly increasing. We complete the strategy by observing that in each game, the deposit collector takes the action $DR(q_n)$ in response to signals in the interval $s_n \leq s < s_{n+1}$; the action $DR(q_0)$ for $s < s_0^*$; and the action $DR(q_N)$ for $s > s_N^*$. By the definition of the best response function, the deposit collector is best responding to the client's strategy. This confirms the existence of a separating equilibrium.

Proof of Proposition 2b

In any perfect Bayesian equilibrium, the beliefs are correctly derived from the equilibrium strategies using Bayes' rule to be on the equilibrium path. Thus, on observing the *susu* schedule corresponding to Q_{a1}, the deposit collector assigns a probability of one to the client being type Q_{a1}, and

offers the corresponding loan. On observing the schedule corresponding to Q_{a2}, the deposit collector assigns a probability of one to the client being type Q_{a2}, since that schedule requires more effort to adopt as a signal. As a result, the client receives the relevant loan. Finally, the deposit collector assigns a probability of 1 to the client being type Q_{a3} on observing the adoption of the relevant savings schedule.