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Article

Trustless–Participation in ROSCA Games

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Abstract

In this study, we propose a mechanism for rotational savings and credit associations (ROSCAs) by matching players into pools based on an anonymity rating while privacy and regulatory auditability are preserved; and fees and penalties guarantee collateral. We replace the conventional local trust, reputation, and social enforcement of these games with actuarially manufactured trust. We posit the generalization of cycle length from the usual lunar cadence to variable arbitrary periods. In fact, in Zimbabwe, ‘Rounds’ now vary the payout avenue itself, from regular cash contributions to formal bank transfers, mobile money and the dispensing of goods and groceries. We explore ex-ante solvency via concentration bounds, budget non-deficit under simple collateral schedules and individual rationality. Our study hints at the premise that actuarially mediated trust enables scalability, anonymity, and resilience to default.

Keywords: ROSCA; anonymity-score; variable-cycle; trustless participation; games

1. Introduction

1.1. Foundations of ROSCAs in Economics and Finance

Rotational Savings and Credit Associations (ROSCAs) represent one of the most pervasive informal financial institutions in the world. Known by various local names—*esusu* in Nigeria, *susu* in Ghana, *stokvel* in South Africa, *tanda* in Mexico, *hui* in China, and *arisan* in Indonesia—ROSCAs operate on a simple principle: members contribute regularly to a common fund, which is then allocated to players in turn. Despite their apparent simplicity, ROSCAs continue to attract scholarly attention because they persist across vastly different cultural, economic, and institutional contexts, often in parallel with or even in competition with formal banking systems.

The theoretical foundations of ROSCAs were laid by anthropologists and economists. Geertz [1] famously described ROSCAs as a “middle rung” in economic development, bridging subsistence and formal finance. Besley, Coate, and Loury [2] developed a seminal model showing that ROSCAs function as commitment devices, enabling players to overcome self-control problems and time-inconsistent preferences in savings. Subsequent empirical research deepened this view: Gugerty [3], studying women’s groups in Kenya, emphasized the role of social enforcement and reputational concerns, while Dagnelie and LeMay-Boucher [4] found that participation in Benin reflected both financial discipline and community solidarity. Anderson, Baland, and Moene [5] further examined enforcement issues, showing how informal sanctions underpin sustainability in the absence of formal contracts.

Parallel strands of research in development economics and finance have explored ROSCAs’ broader economic implications. Poverty reduction studies, such as Yusuf, Ijaiya & Ijaiya [6] in Nigeria and Mbizi & Gwangwava [7] in Zimbabwe, document how ROSCAs provide liquidity, fund microenterprises, and reduce vulnerability in the informal sector. In gender-focused research, Njoki & Muturi [8] and Choudhary & Tyagi [9] highlight how ROSCAs empower women entrepreneurs, enabling business continuity and household resilience. More recent work, such as Kamran & Uusitalo [10], situates ROSCAs within the discourse on financial inclusion, arguing that their embedded fairness and flexibility make them attractive to unbanked, low-income populations.

A different perspective emerges from algorithmic and mathematical economics. Abebe et al. [11] provide a computational framework for analyzing ROSCAs as coordination mechanisms, introducing concepts like the “price of anarchy” to measure efficiency losses under decentralized decision-making. Ikeokwu [12] extends this analysis to risk-averse agents, offering welfare bounds that formalize intuitive notions of fairness and stability. Similarly, Bauchet & Larsen [13] study Taiwanese bidding ROSCAs, showing how heterogeneity in group composition affects repayment behavior and allocative efficiency.

Another important development concerns the interaction between informal and formal financial markets. Recent empirical models by Wang [14] investigate how ROSCAs coexist with microfinance and banking institutions, finding evidence of both complementarity and competition. For example, ROSCAs may fill gaps where credit constraints remain binding, but may also crowd out participation in formal credit programs. Comparative work in Egypt (2024) reinforces this view, showing that households choose between ROSCAs, informal loans, and formal finance based on liquidity needs, trust, and transaction costs.

Finally, the digitalization of ROSCAs represents a rapidly growing field. Francois & Squires [15] report results from field experiments in the Democratic Republic of Congo, where mobile money-based e-ROSCAs achieved unexpectedly high contribution and success rates. This innovation demonstrates that the essential trust-based mechanism of ROSCAs can be preserved and scaled through technology, opening possibilities for hybrid models that blend informal trust networks with formal digital infrastructure.

Taken together, this body of research portrays ROSCAs as complex, adaptive systems that combine social, economic, and behavioral dynamics. Far from being relics of underdeveloped economies, ROSCAs continue to thrive because they provide robust solutions to fundamental problems of savings, credit, and risk-sharing. For policymakers and researchers alike, they offer lessons on the design of financial institutions that prioritize trust, accessibility, and community participation—principles that remain as relevant in the age of mobile money as in traditional village markets.

1.1. A Modern Framework

ROSCAs, popularly known as ‘Rounds’ in Zimbabwe, ‘Stokvels’ in South Africa and ‘Tandas’ in Mexico, are groups of friends or colleagues that contribute monthly to enable zero-interest lump-sum payouts. Despite their utility, these informal systems remain fragile due to social-tie dependence, geographic locality, and vulnerability to defaulting. We attempt to introduce a mathematical-economic structure that instead uses actuarial methods and mechanism design to mold trust, anonymity, and sustainability.

Our main contribution is the:

- i. Construction of a game-theoretic model of variable-cyclic, actuarially collateralized ROSCAs
- ii. Embedment of an explicit privacy choice (anonymity rating) with mechanism-compatible pricing.

2. Probability Model & Statistical Inference

2.1. Generative Considerations & Bayesian Reliability Scores

Cycles t are divided into periods $\Delta t > 0$, (e.g., twenty minutes, three hours, one day, seven months).. Let a group G have size $x \geq 2$ players. Each player makes a contribution $c > 0$ per cycle, at time $t = t_0$. This gives a pool size $p = cx$. Precisely a single player per cycle is allocated the pot by a platform mechanism. For player i in group G and cycle t , we let $X_{i,t} \in [0, 1]$ represent timely subscription in the cycle, wherein (1=subscribes), and (0=defaults). We permit strategic default. The latent subscription reliability for each player i per unit time is the probability of a player paying on time in any cycle conditional on remaining in the pool:

$$P_i = P(X_{i,t} = 1) \in [0, 1]. \quad (1)$$

The default rate is given by: $\theta_i = 1 - P_i$. Placing a conjugate Beta prior on the default rate: $\theta_i \sim \text{Beta}(\mathbf{a}_0, \mathbf{b}_0)$. After $\mathbf{n}_i$ observations with $\mathbf{s}_i = \sum_{t \leq \mathbf{n}_i} X_{i,t}$ timely subscriptions and $\mathbf{d}_i = \mathbf{n}_i - \mathbf{s}_i$ defaults,

$$\begin{aligned} \theta_i | \text{data} &\sim \text{Beta}(\mathbf{a}_0 + \mathbf{d}_i, \mathbf{b}_0 + \mathbf{s}_i), \\ p_i | \text{data} &\sim \text{Beta}(\mathbf{b}_0 + \mathbf{s}_i, \mathbf{a}_0 + \mathbf{d}_i) \end{aligned}$$

We therefore define a *Trust Score* as the posterior mean:

$$\mathbf{r}_i = \mathbf{E}[p_i | \text{data}] = \frac{\mathbf{a}_0 + \mathbf{d}_i}{\mathbf{a}_0 + \mathbf{b}_0 + \mathbf{n}_i} = \frac{\mathbf{b}_0 + \mathbf{s}_i}{\mathbf{a}_0 + \mathbf{b}_0 + \mathbf{n}_i}. \quad (2)$$

It follows that $A(1 - \alpha)$ credible interval for p_i is the Beta quantile interval given by:

$$[q\text{beta}(\frac{\alpha}{2}; \mathbf{b}_0 + \mathbf{s}_i, \mathbf{a}_0 + \mathbf{d}_i), q\text{beta}(1 - \frac{\alpha}{2}; \mathbf{b}_0 + \mathbf{s}_i, \mathbf{a}_0 + \mathbf{d}_i)].$$

Scores exclude protected attributes; features are behavioural and statistical only.

Posterior consideration. The probability that a player i makes a timely subscription in the next cycle is equivalent to the posterior mean $\mathbf{r}_i$. For k future cycles, the number of timely subscriptions follows a Beta-Binomial distribution:

$$X_{i,1 \dots k} \sim \text{Beta - Binomial}(k; \mathbf{b}_0 + \mathbf{s}_i, \mathbf{a}_0 + \mathbf{d}_i).$$

Empirical Bayes hyper-parameters. Selecting $(\mathbf{a}_0, \mathbf{b}_0)$ to match portfolio-level mean/ variance of payment rates: if historical portfolio mean is $\bar{p}$ with variance σ_p^2 ,

$$\begin{aligned} \mathbf{a}_0 &= \lambda \bar{p} \\ \mathbf{b}_0 &= \lambda(1 - \bar{p}) \\ \lambda &= \frac{(1 - \bar{p})\bar{p}}{\sigma_p^2} - 1 \quad \text{Clipped to } \lambda \geq 0. \end{aligned}$$

2.2. Group Default Risk Aggregation

Within a cycle, let $\mathbf{Y}_i = 1 - X_{i,t}$ be the default indicator. Conditional on trust scores $\mathbf{r}_i$, approximate $\mathbf{Y}_i$ as independent Bernoulli with mean $\mu_i := 1 - \mathbf{r}_{i,t}$. The group shortfall count is: $\mathbf{S}_G = \sum_{i \in G} \mathbf{Y}_i$. Its expected value and variance are:

$$\begin{aligned} \mathbf{E}[\mathbf{S}_G] &= \mu_G := \sum_{i \in G} (1 - \mathbf{r}_i) \\ \text{Var}(\mathbf{S}_G) &= \sum_{i \in G} \mu_i(1 - \mu_i). \end{aligned}$$

The normal approximation $\mathbf{S}_G \approx \mathbf{N}(\mu_G, \sigma_G^2)$ applies, whereby

$$\sigma_G^2 = \sum_{i \in G} (1 - \mathbf{r}_i),$$

when $|G|$ is big and no μ_i dominates.

Lemma 1. (Chernoff bound for Poisson-binomial). For any $\varepsilon > 0$:

$$P(\mathbf{S}_G \geq (1 + \varepsilon)\mu_G) \leq \exp\left\{\frac{-\varepsilon^2}{2 + \varepsilon} \mu_G\right\}. \quad (3)$$

Proof: The mgf of $\mathbf{S}_G$ is $\mathbf{M}_{\mathbf{S}_G}(t) = \prod_i \{1 - \mu_i + \mu_i e^t\}$. From Chernoff's method [16], $P(\mathbf{S}_G \geq x) \leq e^{-tx} \mathbf{M}_{\mathbf{S}_G}(t)$. Optimizing at $x = (1 + \varepsilon)\mu_G$ yields the bound (standard calculation), and convexity ensures tightness up to constants. $\square$

2.3. Anonymity Rating

A player chooses an anonymity score $A_s \in [0, 1]$. Higher A_s implies greater privacy but higher requirements and lower priority. We posit three deterministic schedules:

- Fee $f(A_s) = f_0 + \gamma A_s$,
- Collateral $\delta = \delta_0 + \tau A_s$,
- Priority weight $\omega(A_s) = \kappa_0 + \kappa_1(1 - A_s)$.

It follows that parameters are nonnegative and fees are charged as a fraction of; collateral is a holdback fraction of each inflow c ; priority weights affect pay-out lottery.

2.4. Collateral Sizing via Risk Metrics

Let per-cycle solvency collateral be $R_G = c \sum_{i \in G} \alpha_i$ where $\alpha_i \equiv \alpha(A_s)$ depends on the anonymity rating. Monetary shortfall $L_G = c S_G$. For a specified solvency level δ_{solv} , the collateral is set such that: $P(L_G > c S_G) \leq \delta_{solv}$. Under the normal approximation [17], this can be achieved by setting: $R_G = c(\mu_G + z_{1-\delta_{solv}} \sigma_G)$, where $z_{1-\delta_{solv}} \sigma_G$ is the standard normal quantile. This rule defines an explicit, risk-sensitive collateral sizing mechanism that scales with both group heterogeneity and posterior reliability scores.

Theorem 1. (Ex-Ante Solvency Bound). If the per-cycle collateral R_G satisfies the above expression, then group solvency holds ex-ante with probability at least $1 - \delta_{solv}$:

$$P(L_G \leq R_G) \geq 1 - \delta_{solv}. \quad (4)$$

Proof: Under the normal approximation, the standardized shortfall satisfies:

$$\frac{L_G - c\mu_G}{c\sigma_G} \sim N(0, 1). \quad (5)$$

It follows that,

$$P(L_G \leq R_G) = P(Z \leq z_{1-\delta_{solv}}) = 1 - \delta_{solv}. \quad (6)$$

□

Theorem 2. (Proportional collateral is Chernoff-optimal). Among policies of the form $\alpha_i \geq 0$ minimizing $\sum_i \alpha_i$ subject to the Chernoff tail bound with target δ_{solv} , the optimal policy sets

$$\alpha_i \propto \mu_i = 1 - r_i. \quad (7)$$

Proof: Using Lemma 1 with $x = (1 + \epsilon)\mu_G$, sufficiency is $\sum_i \alpha_i \geq (1 + \epsilon)\mu_G$. Minimizing $\sum_i \alpha_i$ under linear majorization of μ_G is solved by $\alpha_i \propto \kappa \mu_i$ with $\kappa = (1 + \epsilon)$. Any deviation that reduces some α_i while holding $\sum_i \alpha_i$ fixed raises the bound because Chernoff's exponent is convex in the vector of means. □

2.5. Cycle-Length Scaling and Default Intensities

Assuming defaults arise from a continuous-time Poisson process with user-specific intensities λ_i . Over cycle Δt .

$$P(\text{default}) = 1 - e^{-\lambda_i(\Delta t)} \approx (\Delta t)\lambda_i \quad \text{small } \Delta t, \quad (8)$$

And it follows that $\mu_i(\Delta t) \approx (\Delta t)\lambda_i$ and $\mu_G(\Delta t) \approx (\sum_i \lambda_i)(\Delta t)$.

Proposition 1. (The invariance of Cycle-Length). If collateral uses Theorem 2 with $\alpha_i \propto \mu_i(\Delta t)$, then the solvency probability target is invariant to the choice of (Δt) .

Proof: Scaling Δt scales μ_i and hence R_G linearly, leaving the Chernoff ratio unchanged. □

2.6. Payout Scheduling via Exponential Race

Implement weighted, one-per-user payout over m cycles via an exponential race: draw $E_i \sim \text{Exp}(w_i)$ with rates $w_i := w(A_s) r_i$. The payout order is the increasing order of E_i .

Lemma 2. (Lottery Weights),

$$\Pr(i \text{ is first}) = w_i / \sum_j w_j. \quad (9)$$

Proof: For exponentials, $\Pr(E_i = \min_j E_j) = w_i / \sum_j w_j$ by memoryless property. $\square$

Theorem 3. (Expected rank and dominance). The expected rank of player i is:

$$E[\text{rank}(i)] = 1 + \sum_{j \neq i} \frac{w_j}{w_j + w_i} \quad (10)$$

which is strictly decreasing in w_i . If $w_i \geq w'_i$ (others fixed), the rank distribution under w_i first-order stochastically dominates that under w'_i .

Proof: Follows from exponential order statistics and thinning arguments. $\square$

3. Cooperative Equilibrium and Solvency Guarantees

Here we study the incentives in the recurring game with public monitoring (we assume a platform that observes payments) as well as enforcement via collateral slashing and trust-score downgrades.

3.1. Game Form and Strategies

The stage game at cycle t : each active user chooses $a_{i,t} \in \{\text{pay}, \text{default}\}$. Monitoring is perfect: $X_{i,t} = 1$ iff $a_{i,t} = \text{pay}$. The platform may apply:

- collateral slashing $L_i = c\alpha_i$ upon default and
- score update $r_i w_i \geq w'_i r'_i$ via 2.1.

A **trigger strategy** profile σ : all pay each cycle; if any default occurs, the deviator is

- a) immediately slashed by L_i
- b) excluded for K cycles (or permanently), and
- c) faces reduced weight w'_i and increased future collateral proportional to $1 - r'_i$.

3.2. One-Shot Deviation and IC Bound

Let ΔU^{dev}_i be the gain from deviating once when others cooperate. The immediate gain is at most c (avoiding a payment). The immediate loss is L_i . Future continuation loss from exclusion/score drop is at least $\delta\Phi_i$, where:

$$\Phi_i = \frac{\Delta \text{wait cost from } w_i \rightarrow w'_i}{\text{payout delay}} + \frac{\Delta \text{collateral from } r_i \rightarrow r'_i}{\text{higher } \alpha_i} \quad (11)$$

Theorem 4. (Incentive compatibility). If for every player i ,

$$L_i + \delta\Phi_i \geq c, \quad (12)$$

then the cooperative profile is a subgame-perfect equilibrium (SPE).

Proof: By the *one-shot deviation principle* for repeated games with public monitoring, deviation is unprofitable if the present-value loss (slash plus discounted continuation loss) exceeds the one-shot gain c . Since enforcement is public and stationary, no profitable deviation exists; hence cooperation is an SPE. $\square$

Corollary 1. (Simple sufficient condition). Under proportional collateral $L_i = c\kappa(1 - r_i)$ and any nonzero continuation penalty $\Phi_i > 0$, choosing $\kappa \geq 1$ suffices for IC. Stronger κ or higher δ relaxes Φ_i requirements.

3.3. Solvency and Budget Balance

Let $R_G = c \sum_i \alpha_i$ be total collateral collected. Expected shortfall per cycle is $c\mu_G$.

Theorem 5. (Ex-ante solvency & budget balance). Under proportional collateral with $\kappa \geq 1$,

$$E[\text{slash revenue}] = c\mu_G \leq R_G/\kappa \leq R_G, \quad (13)$$
hence expected slashes cover expected defaults; with $\kappa > 1$ the platform holds a positive safety margin.

Proof: Linearity of expectation with $Pr(\text{default}_i) = \mu_i$ and $L_i = c\kappa\mu_i$ making $E[\text{slash}] = c\kappa \sum_i \mu_i^2 \leq c\kappa \sum_i \mu_i = c\kappa\mu_G$. Since $R_G = c\kappa\mu_G$, we have the stated inequalities. $\square$

3.4. Collusion Considerations

A coalition C pool reorder payouts internally. Under exponential race scheduling, the coalition's odds of winning any given rank are $\sum_{i \in C} w_i / \sum_j w_j$; internal reallocation will not affect the coalition's share of early ranks.

Proposition 2. (Rank Shares invariance of Coalition). For any C , the distribution of the minimum of $\{E_i: i \in C\}$ is $Exp[\sum_{i \in C} w_i]$. Hence the coalition cannot increase its aggregate priority beyond summing weights.

Proof: Sum-rate property of competing exponentials. $\square$

4. Discussion

We proposed a variable-cycle, privacy-aware framework that encourages trustless participation, and advocate for the expansion of the ROSCA game from interaction between socially-tied players to strangers in a community or even national setting; preserving fairness and solvency. Such a platform would make sure that total collateral is risk-sensitive and dynamically variable according to players' reliability and anonymity choices. Our thinking is that there should be a balance between risk contribution and anonymity, ex-ante solvency guarantees, and budget non-deficit in expected value. Future studies include empirical estimations using actual data and regulatory sandbox trials. A fully digitalized platform designed from this idea is feasible, although in the case of Zimbabwe, resistance from the central bank in fear of it being a Ponzi scheme could prove to be a challenge; which explains why as almost all of the programmers we have approached were reluctant to play these games!

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Abbreviations

ROSCA Rotational Savings and Credit Association

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