The Economics of Currency Redemption[*]

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Abstract

Many currencies are backed by promises of redemption—including stablecoins, pegged currencies, bank deposits, and asset-backed securities—but it is unclear why redemption is important when redemption volumes are often low. We show in a search-theoretic model of money that redeemability can coordinate agents on a monetary equilibrium despite zero steady-state redemption volume. However, either mispricing of the redemption good or a lack of confidence can trigger a run. Moreover, with heterogeneity in agent preferences, redeemability may become both costly and necessary for money circulation. We test the predictions of our model using unique transaction-level data from a real-world used-goods trading platform, as well as novel cross-sectional and time-series variation in redeemability. The evidence leads to new insights regarding the benefits, costs, risks, and optimal design of currency redemption.

JEL Classification: *E41, E42, G23*

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1 Introduction

Stablecoins—privately issued cryptocurrencies that are redeemable into government fiat—reached an annual transfer volume of 27.6 trillion US dollars in 2024. This staggering number is equivalent to the Gross Domestic Product (GDP) of the United States in 2023.[1] In response to the rapid rise of cryptocurrencies, central banks are experimenting with blockchain-based digital currencies (CBDC) and token-based financial systems.[2] These developments have triggered intense debate among industry observers, regulators, central bankers, and scholars alike. Questions that they confront include: How can issuers successfully circulate a currency? What are the benefits, costs, and systemic risks of currency redemption? How does the economic environment shape the costs and benefits of redemption? What is the optimal redemption policy for currency issuers?

The controversy surrounding the economics of currency redemption is hardly new. Bank deposits are redeemable into cash. Pegged currencies are redeemable into other currencies. Historical currencies were often redeemable into gold or silver. According to historians and anthropologists, redemption by credit institutions and states was essential for the initial emergence of money (Mitchell-Innes 1913, 1914; Knapp 1924; Lerner 1947; Humphrey 1985; Wray 2004; Graeber 2011).[3] Regulators and central banks enact many policies to ensure currency redeemability, including reserve requirements, deposit insurance, and financial surveillance.[4] Yet, there is little formal economics research—theoretical or empirical—on the role of redemption in sustaining monetary equilibria.

In this paper, we provide new theory and real-world evidence on the economics of currency redemption. Theoretically, we introduce endogenous money redemption into a New

[1] Source: https://blog.cex.io/ecosystem/stablecoin-landscape-34864

[2] For example, `https://www.atlanticcouncil.org/cbdctracker/` reports the global landscape of CBDC exploration. By February 2025, 3 CBDCs had been launched and 44 pilots are ongoing

[3] See also Goodhart (1998) for useful context regarding the "credit" and "state" theories of money.

[4] For further examples of the important role of redeemability, see histories of the booms and busts of European and American banknotes during the 18th and 19th centuries (Volta, 1893; Hamilton, 1946; Gorton, 1996; Velde, 2007; Friedman and Schwartz, 2008; Sanches, 2016) as well as the recent run on the stablecoin UST (Liu, Makarov, and Schoar, 2023).

Table 1. Redemption policy and volumes, major stablecoins, 2022

	USDT (Tether)	USDC (Circle)
Trading Volume	$864 billion	$1,680 billion
Circulating Supply	$136.6 billion	$55.5 billion
Redemption Volume	$16 billion	$42 billion
Redemption Fees and Policies	Anyone can redeem 0.1% redemption fee Must redeem at least $100,000	Only wholesale providers can redeem Standard: instant, no fee if < $2 million Basic: up to two days processing, no fee
Reserves	Treasury bills: $39.2 billion Cash: $5.3 billion Other cash equivalent: $11.4 billion Corporate bonds, funds & precious metals: $3.4 billion Other investment: $2.7 billion Secured loans: $5.9 billion	Treasury bills: $34.1 billion Cash: $10.6 billion

Notes: Table shows the motivating examples of USDT and USDC. As Tether does not report their annual redemption volume, Ma, Zeng, and Zhang (2023) identify the official crypto addresses in major blockchain networks of the top stablecoins, including USDT and USDC, and calculate the average monthly redemption volume in each blockchain network of these stablecoins from 2021 to 2022. Based on their data, we estimate the total redemption volume of USDT and USDC in 2022 by the redemption volume of stablecoins on Ethereum network divided by the share of stablecoins issued on Ethereum.[5] [6] The trading volume, circulating tokens, and assets are collected from the reserve reports in December 2022 of Tether and Circle. We also report the latest redemption policies and fees.

Monetarist model of money as a medium of exchange. The theory is then supported by new empirical evidence from a real-world redeemable currency. In particular, we study an unusually comprehensive data set that captures both real and monetary transaction outcomes for an entire subeconomy through the rise and fall of a platform digital currency. We combine novel cross-sectional variation with time-series variation in currency redeemability. Our findings highlight how currency redemption may be crucial for early currency adoption, and how monetary equilibrium with a redeemable currency can be fragile, especially when the issuer may have difficulty sustaining redemption promises.

As motivation, Table 1 shows some basic features of the two major stablecoins in circulation. In 2022, redemption volumes for USDT and USDC were approximately $16 billion

[5]The circulating volume of USDC and USDT are obtained from DeFiLlama

[6]Circle will publish their latest annual redemption volume on their official website. As of February 27, 2025, the total redemption volume of USDC in the last 365 days is $134.9 billion, while the total USDC transaction volume is $3,176 billion.

and \$42 billion, respectively. This is relatively small compared to their trading volume of \$864 billion and \$1,680 billion, respectively. It is a puzzle why redeemability enabled the rapid adoption of stablecoins, when redemption volume is typically very low. It is also intriguing that stablecoin issuers impose restrictions on redemption, including delays, limits on volume, and restrictions on the types of redeemers.

In what follows, we sketch a theoretical model that incorporates endogenous redemption choices into the Kiyotaki-Wright (1993) framework. In this model, trade is subject to the problem of double coincidence. Money that trades one-to-one for goods can emerge to facilitate exchange as a medium by becoming widely accepted. We incorporate redeemability by allowing agents to choose whether to immediately redeem money for a redemption good that yields a utility v_R upon receiving money. We then characterize the impact of redeemability on currency circulation.

The model shows that currency redemption is a very low cost method for encouraging currency adoption. In a homogeneous-agent version of the model, redeemability can coordinate agents on a monetary equilibrium despite *zero* steady-state redemption. The reason is as follows. An increase in the value of v_R can encourage agents to accept money. This increase in money acceptance, in turn, raises the rate at which agents who accept money find profitable trades. Increased transactions can make holding money more attractive than redeeming it immediately. Therefore, if the probability of single coincidence is sufficiently high and v_R is sufficiently large but not too large, there exists a unique monetary equilibrium without any realized token redemption.

However, currency redemption also introduces systemic risks. Specifically, a run equilibrium emerges if v_R is high relative to a cutoff that increases with the expected share of agents that accept currency. In the run equilibrium, agents redeem until the money stock is depleted. Therefore, both mispricing of the redemption good and a lack of confidence are disastrous, both for the agents in the economy and for the currency issuer itself.

Moreover, with sufficient agent heterogeneity, it is possible that redeemability becomes both costly and necessary for sustaining a monetary equilibrium even in the steady state. Specifically, we consider environments where the probability of single coincidence is not high, and redemption utility v_R varies across agents. In such an economy, agents with high v_R will redeem money rather than hold it and wait for trades. Moreover, money acceptance by the latter agents may be necessary for a monetary equilibrium to exist. We also find in this model that money acceptance, in-flows, and redemption all grow with v_R, so money flows from agents with low v_R to agents with high v_R.

An immediate corollary for this result is that the optimal redemption policy should minimize the level of redemption volume, while keeping it high enough to maintain currency circulation. This result may explain why stablecoin issuers typically restrict redemption or charge a redemption fee.

The predictions of the model are then tested using unique data from an online platform through which a large number of Toronto-based users traded second-hand items such as clothing, accessories, plants, and furniture. As first documented by Wong (2024), the Bunz platform operated a redeemable digital currency, but later discontinued redemption due to cash flow problems. The simplicity of the setting makes it easier to analyze than most, while still offering the advantage of being rooted in a real-world context. The novelty of the empirical work here is to combine new cross-sectional variation in redemption convenience with time-series variation in redeemability to quantify the empirical relationship between token redeemability, acceptance, and flows.

The evidence confirms two predictions that emerge from the heterogeneous agent model of redeemable currency. First, we find that geographic proximity to redemption opportunities is associated with higher token adoption, inflows, and redemption, but not higher token outflows, issuance, or holdings in the Bunz economy. Tokens therefore on average flowed from users who are far away from redemption opportunities to those who are closer. This finding reveals that the choice by users to accept tokens was not purely driven by strategic complementary in token acceptance—as is the case in many canonical monetary models—

it was influenced in part by their proximity to redemption opportunities. We confirm the robustness of this finding using alternative definitions of redemption convenience and a rich set of individual-level control variables.

Second, we find that the halt in redeemability caused massive drops in token acceptance and flows, even in areas where redemption was comparatively inconvenient. These reductions are orders of magnitude larger than the effects of a one standard deviation increase in the cross-sectional exposure to redemption prior to the halt. Moreover, initial cross-sectional differences in money acceptance and inflows disappeared. This finding suggests that while strategic complementarities in current acceptance were significant in this real-world setting, they were not sufficient to sustain a monetary equilibrium in the absence of current redemption. Together, our two sets of empirical findings highlight a need to account for heterogeneity in agent preferences when analyzing real-world currency systems.

In summary, the evidence and theory presented here clarify the benefits, costs, and risks of using redeemability to encourage currency circulation. We find that redeemability can be an effective and low-cost method for encouraging the adoption of a currency system. However, a lack of confidence and mispricing of the redemption good can lead to a currency run. Moreover, when agent preferences are heterogeneous, continual and costly redemption expenditure may be needed to prevent such a system from collapse. The optimal policy minimizes steady-state redemption volume while ensuring currency circulation. Our findings help to explain the prominent role of redeemability in the rise and fall of currencies throughout history. They can also inform the design and operation of emergent digital payment systems.

The rest of the paper is organized as follows. The next subsection discusses related literature. Section 2 presents the theoretical framework. Section 3 provides background on the Bunz economy. Section 4 documents the cross-sectional relationship between redemption convenience and token use. Section 5 reports the heterogeneous impact of reduced redemption. Section 6 concludes.

1.1 Related Literature

To our knowledge, this paper is the first to study the economics of currency redemption using a heterogeneous agent New Monetarist model of redeemable money or cross-sectional variation in redeemability. Previously, Wong (2024) presented high-frequency time-series evidence on the impact of monetary expansion and reduced redeemability in the Bunz economy. Here, we extend their work by exploring novel cross-sectional heterogeneity in redemption convenience. We establish new empirical findings, interpret using a novel heterogeneous-agent model with endogenous redemption choices, highlight the previously underappreciated role of agent heterogeneity in explaining equilibrium behavior, and explore the economics of optimal redemption policy.

Our work relates to a small but growing empirical literature that studies transaction-level evidence on currency crises and bank runs. For example, Iyer and Puri (2012) and Iyer, Puri, and Ryan (2016) study shocks to an Indian bank and find that depositors' withdrawal behavior depends on the underlying solvency risk induced by the shock, and on the cross-sectional characteristics of depositors, including their deposit insurance status and sophistication. Liu, Makarov, and Schoar (2023) find that the run on cryptocurrency LUNA was driven by investors' concerns regarding the sustainability of the blockchain system, and wealthy and sophisticated investors were the first to run in the cross-section.

Recent papers on platform currencies view tokens as a financial instrument to represent certain benefits promised by the issuer and study platform funding raising problems, for example, Cong, Li, and Wang (2022), Sockin and Xiong (2023), and Garratt and van Oordt (2024). Our paper differentiates with these papers by viewing tokens as a medium of exchange with stable value in circulation, rather than a financial product with future uncertainty. A recent more related literature focuses on the redemption-based token issuance and its design, for example, Rogoff and You (2023) and Rogoff, He, and You (2024), but they mainly focus on the nature of issuance policy design and do not touch redemption effects on token acceptance and money circulation. Our paper contributes to this literature by purely studying redemption convenience and its distributional effects on money adoption in the context of stablecoins, which are pegged to fiat currencies or redemption of goods with stable economic values.

The growing literature on digital payments also considers the role of interventions and subsidies in encouraging adoption using technology adoption models. Crouzet, Gupta, and Mezzanotti (2023) study the 2016 Indian demonetization intervention that increased the relative benefit of firms using electronic payment methods instead of cash, and find that the temporary intervention led to a persistent increase in adoption. Alvarez et al. (2023) show using a technology diffusion model calibrated to transaction-level data on Costa Rica's national electronic payment system "SINPE" to characterize the optimal subsidy. Alvarez, Argente, and Van Patten (2023) documents the failure of Bitcoin's rollout in El Salvador, despite Bitcoin being declared legal tender. Unlike these contributions, our approach explicitly models the microstructure of transactions and therefore leads to a different set of policy prescriptions: We show that redeemability can encourage currency adoption in a cost-effective manner, but poorly designed redemption policies can lead to "runs" on the currency and that under some circumstances a reduction in redeemability may lead to a monetary collapse.

Our theoretical work builds on an early strand of the New Monetarist literature that considers how platform or government policy may affect the existence and uniqueness of monetary equilibria. Two early papers—Aiyagari and Wallace (1997) and Li and Wright (1998)—show that enforcement of a legal mandate to accept tokens among a subset of the population can engender a unique monetary equilibrium (see also Soller Curtis and Waller 2000; Lotz and Rocheteau 2002; Lotz 2004). Selgin (2003) shows that adaptive learning alone precludes agents from coordinating on a monetary equilibrium. In this paper we highlight how a credible promise of redemption can achieve a unique monetary equilibrium at zero steady-state cost and with no need for legal enforcement.

There are related models where banking is added to the Lagos-Wright framework (e.g.

Berentsen, Camera, and Waller 2007; Chiu et al. 2023; Gu et al. 2023; Williamson 2024). Wong (2024) develops a version of Kiyotaki and Wright (1993) where the agents' rate of redemption is *exogenous*. However, to our knowledge, there are no prior New Monetarist models of redeemable money with *endogenous* redemption choices. Our results shed light on the nature of redeemable money systems and help to explain their prevalence.

Our work also connects to New Monetarist literature that considers the effects of agent heterogeneity. Most directly, we build on Shevchenko and Wright (2004), who study a version of Kiyotaki and Wright (1993) with agent heterogeneity and partial acceptance. More recent literature incorporates agent heterogeneity into the Lagos-Wright model (e.g., Rocheteau, Weill, and Wong 2021). The later contribution, however, does not focus on the impact of agent heterogeneity on the uniqueness and existence of monetary equilibria.

2 Theoretical Framework

In this section, we devise a search-theoretic model in which agents endogenously choose whether to accept and redeem money. We begin with a model with identical agents similar to Kiyotaki and Wright (1993). In the model, agents must solve a coordination problem for money to successfully mediate transactions—since it is profitable for agents to accept money only if they expect others to do the same—leading to an equilibrium where money circulates and one where it does not. We show that redemption opportunities guarantees that money circulates. This can be accomplished at very low cost, since there may be zero steady-state redemption volume in equilibrium. However, a run equilibrium may also emerge, depending on redemption good pricing and strategic beliefs.

We then incorporate both heterogeneity in utility for transaction goods and heterogeneity in access to redemption opportunities. Our model builds on Shevchenko and Wright (2004), which analyzes economies with agent heterogeneity and partial money acceptance. We show that agents with greater redemption opportunities are more likely to accept money and engage in sales, leading to a flow of money from agents with low redemption opportunities to those with high redemption opportunities. Moreover, a positive steady-state redemption volume may be necessary for a monetary equilibrium to exist. Moreover, optimal redemption policy minimizes redemption volume subject to the constraint that money circulates.

2.1 Model with Identical Agents

A set of agents in the economy is denoted by N, with measure $\mu(N) = 1$. Each agent i can produce a unit of a certain type of goods, G^i, and can consume only one type of goods g^i. Agents cannot consume their own products, so they have to meet and exchange goods with other agents in order to consume. Goods are perishable, and production is instantaneous. Each agent derives utility $u_C > 0$ from consuming a good, incurs cost $c > 0$ from producing a good, and we assume that $u_C - c > 0$. Each agent discounts future utility with time preference $\beta > 0$.

Time is discrete. In each period, agents meet with probability $\alpha > 0$. The probability that agent i meets another agent whose product i can consume is $P(g^i \in G^j) = x$. Conditional on this, a "double coincidence of needs" has probability $P(g^j \in G^i \mid g^i \in G^j) = y$. To simplify notation, we let $B = \alpha xy(u_C - c)$ denote the expected gain from barter in a period, and $l = \alpha x(1 - y)$ denote the probability of a "single coincidence" meeting.

Money is indivisible, durable, and has zero storage cost. The money supply is denoted by $M > 0$. We assume that one unit of money is always traded for one unit of commodity. This finding matches the fact that there was no observed inflation in the Bunz economy. It can also be rationalized by models with price coordination frictions (**?**).

Agents' decisions. In this model, each agent has two decision variables: acceptance π and redemption ρ. Since agents are fully symmetric in their production and homogeneous on all other aspects, we suppress the index i on the decision variables.

When agents meet in pairs, they barter and consume upon a double coincidence of needs. Upon a single coincidence of needs, the agent with the ability to produce the desired good faces a decision problem of whether to accept money from their transaction partner. We describe this decision with π, the probability of accepting money upon a single coincidence meeting. We allow agents to use mixed strategy in money acceptance, hence $\pi \in [0, 1]$. We use Π to denote each agent's expectation of other agents' probability of accepting money.

Upon receiving a unit of money, the agent can choose to redeem immediately and enjoy utility flow v_R, or hold the unit of money in anticipation of using it for a future transaction. We describe this decision with ρ, the probability of redeeming money upon receiving it. Similarly, we allow for mixed strategies and $\rho \in [0, 1]$.

Thus, agents can transition between two states: state 0 of not having money, or state 1 of receiving one unit of money. We denote the measure of agents in state 1 as μ_1. Then, given agents' decision problem, their value functions are characterized by the following equations.

$$V_t^1 = \max_{\rho} \underbrace{B}_{\text{Barter utility}} + \underbrace{\rho\left[v_R + \beta V_{t+1}^0\right]}_{\text{redemption utility}} \tag{1}$$

$$+ \underbrace{(1-\rho)\Big[l\Pi(1-\mu_1)u_C + \beta\Big(l\Pi(1-\mu_1)V_{t+1}^0 + \Big(1 - l\Pi(1-\mu_1)\Big)V_{t+1}^1\Big)\Big]}_{\text{Transaction utility as buyer}}$$

$$V_t^0 = \max_{\pi} \underbrace{B}_{\text{Barter utility}} \underbrace{-lM\pi c + \beta\Big[lM\pi V_{t+1}^1 + (1 - lM\pi)V_{t+1}^0\Big]}_{\text{Transaction utility as seller}} \tag{2}$$

Solution concept. We solve for the steady state symmetric Nash Equilibrium in π, ρ. In equilibrium, we let $\pi = \Pi$. In addition, the equilibrium measure of agents choosing not to redeem upon receiving one unit of money must be equal to the money supply, hence μ_1 and M satisfy the relation $\mu_1(1-\rho) = M$. Steady state requires that the flows of agents between state 0 and state 1 are equalized, such that

$$\overbrace{\mu_1}^{\text{Prob. of being in S1}} \cdot \underbrace{[\rho + (1-\rho)l\Pi(1-M)]}_{\text{Prob. of transition, S1 to S0}} = \overbrace{(1-\mu_1)}^{\text{Prob. of being in S0}} \cdot \underbrace{lM\pi.}_{\text{Prob. of transition, S0 to S1}} \tag{3}$$

From the agents' point of view, there are two uses of money: redemption and transaction. The value of these two uses depend on v_R and u_C, respectively. Depending on the parameters, a multiplicity of equilibria may arise. Since the value functions are linear in the decision variables, optimal strategies are corner solutions with $\pi, \rho \in \{0, 1\}$ for most parameter values, except for a measure zero set of knife edge cases. Therefore, we focus on the symmetric pure strategy equilibria.

We define the equilibrium as "Non-monetary" if $\pi^* = 0, \rho^* = 0$, i.e., agents neither accept nor redeem money. We define the equilibrium as "Monetary" if $\pi^* = 1, \rho^* = 0$, i.e., agents accept money and do not redeem. We define an equilibrium as "Run" if $\rho^* = 1$, i.e. agents always redeem. In this case, the steady-state money stock is zero, and there is multiplicity of equilibria with regarding to π, since agents are indifferent between any $\pi \in [0, 1]$. We assume that the agents' expectation that other agents accept money is the same across agents, and denote this expectation as $\tilde{\Pi} \in [0, 1]$, in situations where this belief is not pinned down by the solution concept.

Proposition 1. *Suppose consumption utility $u_C > \underline{u}$ for some $\underline{u} > 0$. Then:*

1. *The Non-Monetary equilibrium exists if and only if $v_R \leq 0$.*
2. *The Monetary equilibrium exists if and only if $v_R \leq u_m$, where u_m is a cutoff value that is strictly positive.*
3. *The Run equilibrium exists if and only if $v_R \geq v_R\left(\tilde{\Pi}\right)$, where $v_R(\cdot)$ is an increasing function such that $v_R(0) = 0 < u_m < v_R(1)$.*

Proof. See Appendix. □

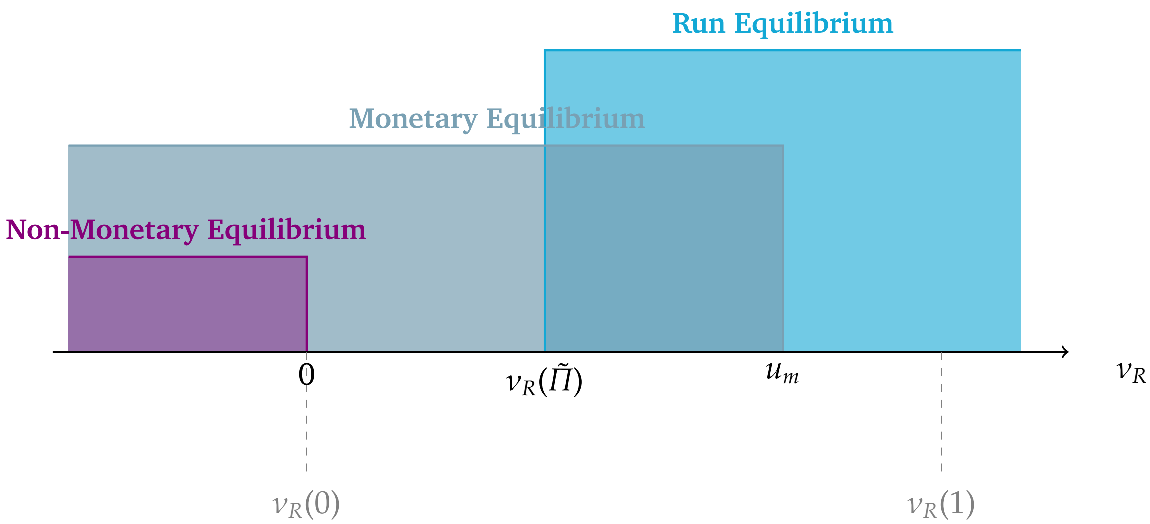


Figure 1. Equilibrium Existence as a Function of v_R

Notes. This figure illustrates how the existence of different equilibria depends on the value of redemption utility v_R. The ranges of v_R that sustain the Non-Monetary equilibrium, Monetary equilibrium, and Run equilibrium are colored in purple, gray and blue respectively.

Proposition 1 shows that positive redemption utility eliminates the non-monetary equilibrium. When redemption utility $v_R \leq 0$, the model features multiple equilibria, with all agents either accepting or not accepting money. With any positive redemption utility $v_R > 0$, the non-monetary equilibrium disappears. However, as redemption utility further increases, a run equilibrium emerges. If v_R becomes sufficiently high, the run equilibrium becomes the unique equilibrium. Figure 1 illustrates this result.

As previously mentioned, a multiplicity arises within the Run Equilibrium because agents are indifferent between whether or not to accept money themselves in a transaction when the money stock is zero. However, agents are *not* indifferent between whether *others* accept money, since their acceptance choices affect the opportunity cost of redemption. If agents believe that others are unlikely to accept money, then the run equilibrium exists even when redemption utility v_R is low. If instead agents expect that others are likely to accept money, then the run equilibrium exists only when redemption utility v_R is high.

2.2 Model with Heterogeneous Agents

In this section, we extend the model to incorporate heterogeneity among agents to account for the richness of our empirical setting. Two specific forms of heterogeneity are added. First, agents are heterogeneous in terms of the utility they derive from consuming transacted goods. We denote agent i's consumption utility as u_C^i. For simplicity, we assume that u_C^i is distributed uniformly on a support $[\underline{u}_C, \overline{u}_C]$ across the distribution, where $\underline{u}_C > 0$. Second, the issuer offers heterogeneous redemption utilitys to agents, denoted as $v_R^i \geq 0$.

To keep the steady-state money supply constant in the economy, we assume that money is exogenously issued to agents in each period. Specifically, agents who hold no money receive a unit of money with probability σ. This assumption matches the way the Bunz platform issues money to users via helicopter drops in our empirical setting, and can be altered without significantly changing the intuitions we highlight.

Under these assumptions, the enriched Bellman equations of the agent i are given by

$$V_{1,t}^i = \max_{\rho_t^i} \underbrace{B}_{\text{Barter utility}} + \underbrace{\rho_t^i \left[v_R^i + \beta V_{0,t+1}^i\right]}_{\text{Redemption utility}} + \underbrace{(1-\rho_t^i)\Big[lW_t u_C^i + \beta\Big(lW_t V_{0,t+1}^i + \Big(1-W_t\Big)V_{1,t+1}^i\Big)\Big]}_{\text{Transaction utility as buyer}} \quad (4)$$

$$V_{0,t}^i = \max_{\pi_t^i} \underbrace{B}_{\text{Barter utility}} \underbrace{-lM_t\pi_t^i c + \beta\Big[lM_t\pi_t^i V_{1,t+1}^i + (1-lM_t\pi_t^i)V_{0,t+1}^i\Big]}_{\text{Transaction utility as seller}} + \underbrace{\beta\sigma(V_{1,t+1}^i - V_{0,t+1}^i)}_{\text{Issuance value}}. \quad (5)$$

Following the previous section, π_t^i denotes agent i's probability of accepting money in a single-coincidence meeting and ρ_t^i denotes her probability of redeeming money upon receiving it. In addition, μ_t^i denotes the probability that agent i is in state 1 in period t. $M_t = \sum_j \mu_{t-1}^j(1-\rho_{t-1}^j)$ denotes the money stock, while $W_t = \sum_j \pi_{t-1}^j(1-\mu_{t-1}^j)$ is the aggregate probability that agent i meets an agent that accepts money.

Individual state transition follows the law of motion,

$$\mu_{t+1}^i = \mu_t^i(1-\rho_t^i)(1-lW_t) + (1-\mu_t^i)(\pi_t^i lM_t + \sigma). \quad (6)$$

As before, we define a steady state equilibrium where aggregate quantities and individual optimal decisions, $\left(M, W, \{\mu^i\}_i, \{\pi^i\}_i, \{\rho^i\}_i\right)$, are constant in time.

We first study agents' optimal individual decisions as a function of their consumption utility u_C^i and redemption utility v_R^i. We relegate the details of analyses to the Appendix and directly present the structure of optimal decisions in the following Lemma.

Lemma 1. *Given $W, M \in (0,1)$, each agent i's optimal choice (π^i, ρ^i) as a function of (u_C^i, v_R^i) is given by Figure 2.*

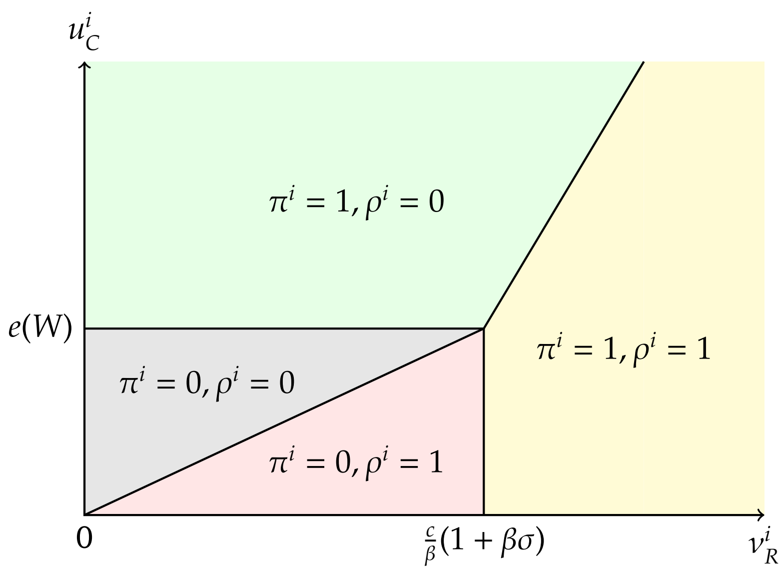


Figure 2. Optimal individual acceptance and redemption

Notes. This figure presents how each agent i's optimal acceptance decision π^i and redemption decision ρ^i depend on u_C^i, v_R^i. Cutoffs between regions are functions of the aggregate states and primitives.

Proof. See Appendix. □

Figure 2 shows that agents accept money if and only if either (a) redemption utility v_R^i exceeds a certain cutoff $\frac{c}{\beta}(1+\beta\sigma)$, or (b) consumption utility u_C^i is large relative to a cutoff $e(W) = \frac{c}{\beta}\frac{1+\beta\sigma-\beta(1-lW)}{lW}$, which increases in lW, the aggregate probability that agent i meets an agent that accepts money. Among these agents, those whose u_C^i is large relative to v_R^i do not redeem. Agents with both low u_C^i and low v_R^i do not accept money. However, some may redeem whatever money that they are issued, if v_R^i high when compared to u_C^i .

The optimal acceptance and redemption choice characterized above imply that money will on average flow from agents who do not redeem towards agents who redeem in steady-state equilibrium. Moreover, as money on average flow towards the redeeming agents, goods accordingly on average flow away from redeeming agents.

To see this formally, let money inflows from peers to agent i be $S^i = lM(1-\mu^i)\pi^i$, i.e., the expected number of transactions in which agent i accepts money in exchange for a produced good. Let money outflows from peers be $P^i = lW\mu^i(1-\rho^i)$, i.e., the expected number of transactions in which agent i uses money to obtain a good.

Proposition 2. *In any steady-state equilibrium, consider any two agents i, j with consumption utility $u_C^i = u_C^j$ and redemption utility $v_R^i < v_R^j$. Their behaviors satisfy:*

1. *The probability of accepting money increases with redemption utility, i.e., $\pi^i \leq \pi^j$.*

2. *The volume of money inflows from peers increases with redemption utility, i.e., $S^i \leq S^j$.*

3. *The volume of money outflows from peers decreases with redemption utility, i.e., $P^i \geq P^j$.*

Proof. See Appendix. □

We next examine what types of equilibria exist in the heterogeneous agent model. Here we take the issuer's redemption policy as exogenous. We extend the proof strategy developed in Shevchenko and Wright (2004) to characterize two dimensions of equilibrium choices among a large and heterogeneous population. For tractability, we assume that u_C^i and v_R^i are distributed independently. We also assume the following:

Assumption 1. $\underline{u}_C < e(1)$ *and* $\overline{u}_C > e(\frac{1}{1+\sigma})$.

This assumption imposes that the dispersion of u^i_C among agents is large. The first cutoff is chosen to ensure that there exist some agents with low enough u^i_C such that they don't accept money for transaction purposes even when all other agents are accepting money, and the second cutoff is chosen to ensure that there exist some agents with high enough u^i_C such that they accept money for transactions even if only a small share, $\frac{1}{1+\sigma}$, of other agents are accepting money. In the appendix, we provide more details on how to interpret this assumption and show why it is sufficient for the following proposition on equilibrium classification. Intuitively, the existence of low u^i_C agents ensures that there *cannot* exist a monetary equilibrium without sufficient redemption, whereas the existence of high u^i_C agents ensures that there *cannot* exist a non-monetary equilibrium when redemption is sufficiently high.

The following Proposition shows that in this case, the economy converges to a unique non-monetary equilibrium if redemption utilities for any positive set of agents are below a cutoff value. If instead redemption utilities for all agents are above the same cutoff value, it converges to a unique monetary equilibrium.

Proposition 3. *Suppose that u^i_C and v^i_R are independently distributed. Then, there exists $\overline{v} > \frac{c}{\beta} + \sigma$ such that:*

1. *There exists a unique* non-monetary *equilibrium in which all agents optimally play $\left(\pi^i = 0, \rho^i = 1\right)$, the aggregate money acceptance probability is $W^* = 0$, and the aggregate money stock is $M^* = 0$ if the issuer assigns redemption utility $v^i_R < \frac{c}{\beta} + \sigma$ to any positive set of agents.*

2. *There exists a unique* monetary *equilibrium in which agents optimally play either $\left(\pi^i = 1, \rho^i = 0\right)$ or $\left(\pi^i = 1, \rho^i = 1\right)$, both strategies are played by positive shares of agents, and the aggregate states $W^*, M^* > 0$ if the issuer assigns redemption utility $v^i_R \in [\frac{c}{\beta} + \sigma, \overline{v}]$ to all agents. The fraction of agents playing each strategy and the values of W^*, M^* depend on the exact distribution of v^i_R.*

Proof. See Appendix. □

Note that Assumption 1 plays a very important role in Proposition 3. Previously, Proposition 1 showed that there exists both a monetary equilibrium and a non-monetary equilibrium when redemption utility is zero. In the economy considered here, however, there is instead only a non-monetary equilibrium when redemption utilities are zero. The reason is that the presence of agents who actively redeem from the issuer is now *necessary* for the existence of the monetary equilibrium. In other words, steady-state redemption volume is now a needed cost of sustaining money circulation.

2.3 Optimal Redemption Policy

Here we briefly consider the optimal redemption policy by the currency issuer. We define the cost of a redemption regime as $C(\{v_R^i\}_i) = E_i[v_R^i \rho^i]$, the equilibrium flow of redemption utility. For simplicity, we assume that the platform cannot observe the consumption utility of agents. We ask: What level of redemption utility is needed to coordinate agents on a monetary equilibrium with minimal redemption cost?

In the homogeneous agent model above, any positive redemption utility is sufficient to induce a unique monetary equilibrium. Therefore, the optimal policy is to choose a minimally positive level of redemption utility.

In heterogeneous agent model above, the issuer can guarantee that agents accept money as long as redemption utilities are larger than some positive cutoff. This cutoff is greater than zero since agents who accept and redeem are needed to sustain a monetary equilibrium. However, offering more redemption does not further increase money acceptance and is costly for the issuer. Therefore, the least costly distribution of redemption is to assign the same redemption utility $v_R^i \equiv \frac{c}{\beta} + \sigma$ to all agents.

2.4 Testable Predictions

The heterogeneous-agent model has two empirical predictions:

Prediction 1. *In any monetary equilibrium, money acceptance and in-flows increases with redemption utility v_R in the cross-section.*

Prediction 2. *If there is sufficient dispersion in consumption utility u_C, then redeemability may be necessary for money circulation. In this case, there is a transition from a monetary equilibrium to a non-monetary equilibrium if redemption is halted.*

3 Empirical Setting: Bunz Platform

To test the predictions of our theory, we turn to unique transaction-level data from Bunz. The Bunz community was founded in 2013 and consisted primarily of young millennial adults in Toronto who arranged to trade second-hand items such as clothing, accessories, plants, and groceries through a mobile app platform. The community's founder forbade cash transactions, so the platform's roughly ten thousand daily active users, who were largely strangers meeting bilaterally in a decentralized manner, initially had to barter.[7]

Itn April 2018, the Bunz platform introduced a redeemable digital token, BTZ. Each user was endowed with 1000 BTZ upon digital wallet activation. Users could then send BTZ to other users and earn BTZ from the app by answering a survey, inviting friends to join the app, or posting new items. To promote the token, Bunz operated a token redemption program, which allowed users to purchase goods using BTZ at partner local stores at a fixed exchange rate of 100 BTZ to 1 Canadian dollar (CAD).[8] After accepting BTZ payments, the owners of local stores would then receive cash from Bunz HQ at the same fixed exchange rate. The platform did not buy or sell tokens apart from direct issuance to users and redemption at partner stores.

Bunz users can receive BTZ in two ways. First, users receive BTZ from the Bunz Platform

[7] The platform enforced this ban on cash by removing any items asking for cash from the mobile app. Further details are provided in Wong (2024).

[8] In 2018, the average exchange rate was 1 CAD to 0.77 USD.

by registration, completing specific tasks.[9] Second, users can sell items to other users for BTZ tokens. As for the token outflow, users can either send BTZ to other users to buy their products or redeem the BTZ tokens at merchants cooperating with the Bunz platform to get goods such as coffee, beer, daily necessities, etc. The Bunz Platform will then send these merchants CAD to buy back the BTZ that the merchants hold. Figure 5 illustrates how the token moves between users, merchants, and the Bunz platform.

Bunz provided timestamped data for the universe of items posted, messages sent, BTZ transactions, and user ratings after transactions. A unique feature of the data provided by the Bunz platform is that user activity with and without BTZ are both observed at high frequency. The geolocation of a large subset of users is also known. For these reasons, we can study how the adoption of digital money depends on a given user's proximity to redemption opportunities.

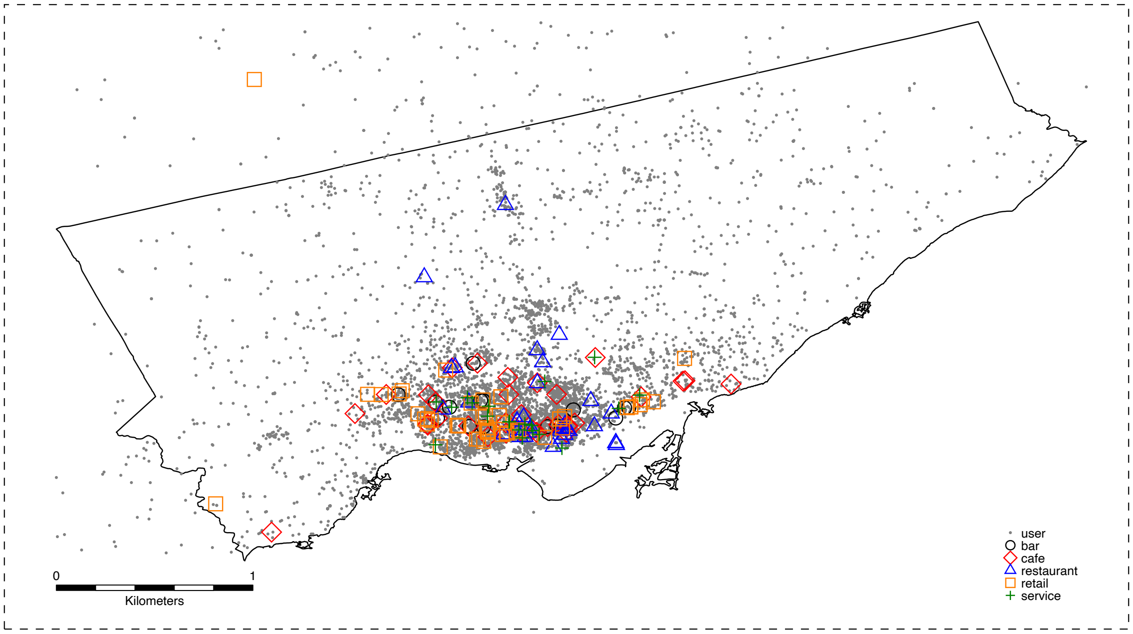
Figure 3 shows the location of the merchants and active users located in Toronto. As shown in the gray dots on the map, most active users live in the city center of Toronto. Other users live sporadically in Toronto. As for the merchants, in total, 216 merchants at some point accepted BTZ as the payment method, and 155 of the merchants were located in Toronto. These merchants included 50 retail shops, 34 restaurants, 33 cafes, 20 service merchants, 15 bars, 2 beauty merchants, and 1 gallery in Toronto. Most of the merchants in Toronto also locate in the city center of Toronto. Generally, users located in the city center have higher redemption network exposure than user located in other areas.[10] Section 4 studies the cross-sectional relationship between token use and redemption convenience during the period when the BTZ redemption program was in operation.

Figure 4 shows the number of active merchants over time. We define the active mer-

[9]Bunz may offer BTZ token for watching a video or advertisement, answering questions provided by Bunz, visiting the webpage of a third party such as a Bunz sponsor, and remaining there for a specified time, or other actions or circumstances Bunz may designate from time to time. See https://bunz.com/terms

[10]Between September and November 2018, Bunz dramatically increased the supply of BTZ through helicopter drops to users in an attempt to drive user traffic. As documented by Wong (2024), the monetary expansion caused large and persistent increases in transaction volume and items posted on the platform among existing users, but did not detectably alter token acceptance patterns.

Figure 3. Map of users and redemption store locations

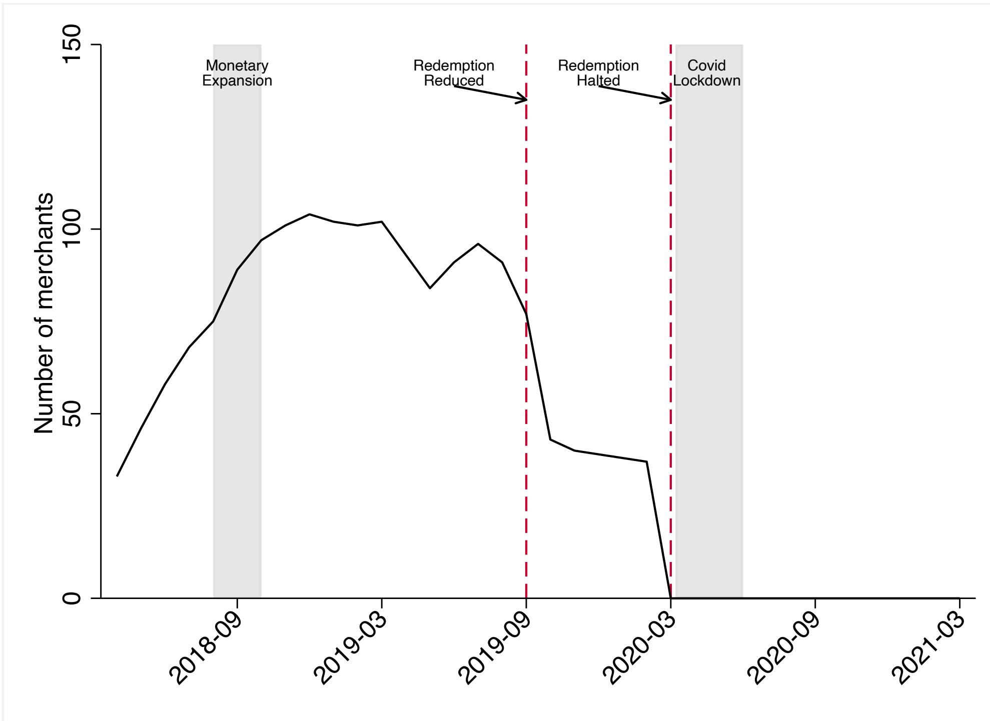


Notes: The map presents the location of the frequent users and redemption stores. Frequent users are defined as users with 20 item posts from April 2018 to August 2019. The users and redemption stores are in an area with a longitude between 79.11524° W and 79.63926° W and a latitude between 43.58100° N and 43.85546° N. This area includes Toronto and parts of its neighborhood.

chants after they start to accept BTZ payments. Suppose the merchants do not accept BTZ redemption after a specific month. In that case, these merchants will be excluded from the active merchants group after that month. From April 2018 to December 2018, the number of active merchants increased continuously. Additionally, Bunz expanded the monetary supply from August 2018 to October 2018. The number of active merchants grew faster during this period. On September 10, 2019, Bunz halted on redemption at retail and service-providing stores without giving any prior notice, causing some users to stop accepting BTZ and rush to the remaining merchants to redeem their BTZ. On February 26, 2020, Bunz completely halted the Shop Local program but called it a temporary pause.

In prior work, Wong (2024) showed that the BTZ price of posted items remained highly stable throughout the observable period. The lack of price adjustment likely reflects the

Figure 4. Total number of merchants over time



Notes: Figure plots the number of active merchants that accept BTZ payments over time. Merchants are defined as active at the month of opening. If merchants no longer have redemption transactions after a specific month, these merchants will be excluded from active merchants.

difficulty of coordinating prices without a centralized currency exchange.

4 Effects of Redemption Convenience on Token Usage

In this section, we provide an empirical test of Prediction 1. According to Prediction 1, token redemption, acceptance, and inflows increase with redemption utility. We test this prediction by estimating the relationship between redemption exposure and token usage behavior. We focus on the period between April 2018 and August 2019, when the redemption program was at its full extent. As predicted, we find that proximity to redemption opportunities increases token redemption, token inflows from peers, and token acceptance, but did not affect token issuance, token outflows to peers, or token holdings. These differences are not attributable to differences in user characteristics or activeness.

4.1 Methodology

We study how exposure to redemption opportunities affect user behavior using the following regression specification:

$$y_i = \beta \times Exposure_i + \epsilon_i, \tag{7}$$

where y_i represents outcomes including token redemption, activeness, token acceptance, flows, and holdings of user i. β is the estimated relationship between the number of merchants within 1 km of users and users' behavior related to tokens. We measure user-level exposure to redemption opportunities using the average number of redemption merchants within 1 km of users from April 2018 to September 2019. This variable captures the number of redemption stores that the users easily access on foot. Section 5 shows event study plots confirming that these correlations are stable over time.

We focus on a subsample of frequent users with identifiable locations in Toronto. This sample accounts for roughly half of the activity on the platform. We drop users who post fewer than 20 items between April 2018 and August 2019 and those who posts more than 70% of items in only one month. We also exclude users for whom we cannot identify an exact location.[11] This leaves 7,162 users. This sample accounts for 53% of redemption, 60% of ratings, 47% of token inflows, and 57% of token outflows (see Appendix Table A1 and Appendix Table A2).

4.2 Results

Token redemption. Table 2 Column (1) documents that redemption exposure is positively correlated with actual redemption volume. Column (1) an additional merchant within 1 km of users corresponds to statistically significant 7.3% more tokens redeemed. Table A3 Columns (1) and (2) show the statistically significant positive effect of redemption exposure on the number of transactions with token inflow and probability to receive token

[11] 32.94% of users only provide their city of residence. These users are dropped.

Table 2. Effect of redemption exposure on token circulation

	(1) Asinh token redeemed	(2) Asinh token issued	(3) Asinh token inflow	(4) Asinh token outflow
Exposure	0.073*** (0.007)	0.0001 (0.003)	0.042*** (0.006)	-0.003 (0.006)
Baseline mean	2.220	6.341	5.232	5.688
# Obs	7,162	7,162	7,162	7162

Notes: Table shows the effect of redemption exposure on token circulation. The redemption exposure is defined as the number of merchants within 1 km of users. Columns (1)-(4) report the asinh ($asinh(x) = ln(x + \sqrt{x^2 + 1})$) amount of token circulated in the Bunz community. The analysis period is from April 2018 to August 2019. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

from other users.

Token issuance. Table 2 Column (2) documents that merchant exposure has no impact on the token sent by Bunz. Bunz will send users some tokens when they register or complete specific tasks. [12] Specifically, users only receive statistically insignificant 0.01% more tokens from Bunz platform. Table A3 Columns (3) and (4) also report that there is no statistically significant difference of the number of issuance transactions and the transaction probability among users with different merchant exposure.

Token inflow from peers. Table 2 Columns (3) shows that users will receive more tokens from other users by selling items when they have higher redemption exposure. To measure the transactions, we use the amount of tokens received by users, the number of transactions of token inflow, and the dummy variable indicating that users receive tokens. When users, on average, have one more merchant nearby, they will receive statistically significant 4.2% more tokens from other users. Similarly, Table A3 Columns (5) and (6) document that

[12] Bunz may offer tokens for watching a video or advertisement, answering questions provided by Bunz, visiting the webpage of a third party such as a Bunz sponsor, and remaining there for a specified time, or other actions or circumstances Bunz may designate from time to time. See https://bunz.com/terms

Table 3. Effect of redemption exposure on token acceptance

	(1) Token acceptance	(2) Token acceptance	(3) Asinh BTZ Holdings
Exposure	0.003***	0.003***	0.003
	(0.001)	(0.001)	(0.004)
Baseline mean	0.291	0.250	7.389
# Obs	7,162	2,824	7,162

Notes: Table shows the effect of redemption exposure on token acceptance. The redemption exposure is defined as the number of merchants within 1 km of users. The analysis period is from April 2018 to August 2019.

users with higher redemption exposure will sell more items for tokens and are more likely to receive tokens from other users.

Token outflow to peers. Table 2 Column (4) shows that redemption exposure does not have significant impact on the token outflow to other users. An additional merchant within 1 km of users corresponds to statistically insignificant 0.3% decrease in the amount of token outflow. Table A3 Columns (7) and (8) confirm that redemption exposure does not have significant effect on the number of transactions with token outflow and the probability to spend tokens on buying items from other users.

Token acceptance. Table 3 Column (1) shows that redemption exposure is positively associated with token acceptance. We define token acceptance as the share of items that a user posts with a token price, which signals the user's willingness to accept tokens. An additional merchant within 1km corresponds to a statistically significant 0.3 p.p. increase in token acceptance. Column (2) shows that this positive correlation is robust to including only users who posted at least 20 items before the introduction of the BTZ token.

Token holdings. Table 3 Column (3) shows that redemption exposure is uncorrelated with user token holdings. An additional merchant within 1km of the users corresponds to

Table 4. Effect of redemption exposure on activeness

	(1) Asinh ratings	(2) Asinh item posts	(3) Any item posts
Exposure	0.003	-0.0004	0.0001
	(0.002)	(0.002)	(0.001)
Baseline mean	1.142	2.365	0.580
# Obs	7,162	7,162	7,162

Notes: Table shows the effect of redemption exposure on the activeness of users. The redemption exposure is defined as the number of merchants within 1 km of users. The analysis period is from April 2018 to August 2019.

a statistically insignificant 0.3% increase in token holdings.

User activeness. Table 4 shows that users with different merchant exposure are not more active before the redemption collapse. We use the inverse hyperbolic sine (asinh) of ratings, the asinh of item posts, and the dummy variable indicating that users post an item in a month to measure the activeness of users. As shown in Column (1), users will only send statistically insignificant 0.3% more ratingss to other users during the token rollout period. The results for the other two measurements of the user activeness. Columns (2)-(3) also report that users with higher redemption exposure do not receive more ratings [13] or are more likely to post items. This results suggests that the previous estimates are unlikely to be driven by differences in the underlying trade network or user characteristics.

Robustness. Appendix Table A4 shows that our results are highly robust to using other measures of redemption exposure, including log number of merchants within 1km, log number of tokens redeemed from merchants within 1km, log number of redemption transactions within 1km, the negative log average distance to merchants, and the negative log average distance to merchants weighted by redemption volume. Among these measures, our preferred redemption exposure measure explains the largest fraction of variation in

[13] Users will rate each other after completing a transaction, with or without the token.

token acceptance across users, as measured by regression R^2.

Appendix Table A5 shows that the results are robust after we add the demographic controls, activeness control, and the proximity to city center. The demographic data include the age, income, and education level. As the demographic data is the survey data of the Bunz, we only have 2,204 users who have completed these surveys. Table A5 Panel A reports that the results are still robust when we control the users' demographic characteristics. Panel B also confirms that the results are still robust when we control for the activeness level of users. Finally, Panel C documents that our results are not affected by the distance between users' location and city center.[14]

Appendix Table A6 also shows that the results are also robust to the active users before the token introduction. Another concern for our baseline results is that the new active users after token introduction are attracted by the redemption merchants to register. Therefore, we focus on the 2,824 users who post more than 20 items before token introduction. Appendix A6 the results are not affected by the sample selection.

5 The Heterogeneous Effects of Redemption Collapse

In this section, we provide an empirical test of Prediction 2. According to Prediction 2, redeemability is necessary for money circulation in the presence of sufficient dispersion in the utility for transacted goods across agents. To test this prediction, we estimate the effect of an unanticipated halt in redemption on user-level outcomes using an interrupted time-series design. As predicted, we find that the halt in redemption caused token use to decline throughout the platform. The decline was much larger than the initial cross-sectional difference in token acceptance and flows due to differences in redemption convenience. This finding suggests that the halt triggered a transition from a monetary equilibrium to a non-monetary one.

[14]When users only provide their city of residence, Bunz will record their address as city centre. Therefore, we define the location where most users are in as the city center.

5.1 Methodology

To visualize the effect of redemption collapse, Figures 5 and 7 plot the trend of the token acceptance and token circulation behavior of frequent users with high, low, and zero redemption exposure from April 2018 to March 2021. Users with zero redemption exposure are those without merchants within 1 km. Users with high (low) redemption exposure are those with above (below) median average merchants within 1 km, excluding those with zero redemption exposure. We use this criteria to divide the users because of the distribution of the merchant exposure. [15]

Tables A7 - A10 estimate the effect of the redemption collapse on user-level outcomes using the following regression, focusing on data after September 2019, when redemption was first reduced:

$$y_{i,t} = \beta_1 Post + \beta_2 Exposure_i \times Post + \gamma_i + \epsilon_{i,t} \tag{8}$$

where y_i is the measurements for users' behavior related to tokens, and γ_i is the individual fixed effects. β_1 measures how the users' token related behavior will change after the redemption collapse while β_2 is the estimated difference among users with different merchants exposure after the redemption collapse.

5.2 Results

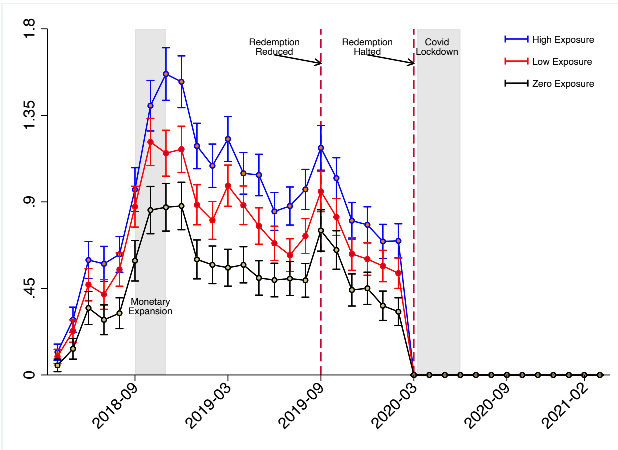
Token redemption. Figure 5 Panel A shows that the amount of token redeemed for all three groups with different redemption exposure drops to zero after the redemption system collapse.

Token issuance. Figure 5 Panel B shows that Bunz gradually reduced the issuance significantly after the redemption system halted but the Bunz Platform, on average, gave approximately the same amount of tokens to users in high, low, and zero exposure groups. Appendix Table A7 Column (1) reports that all users will receive statistically significant less

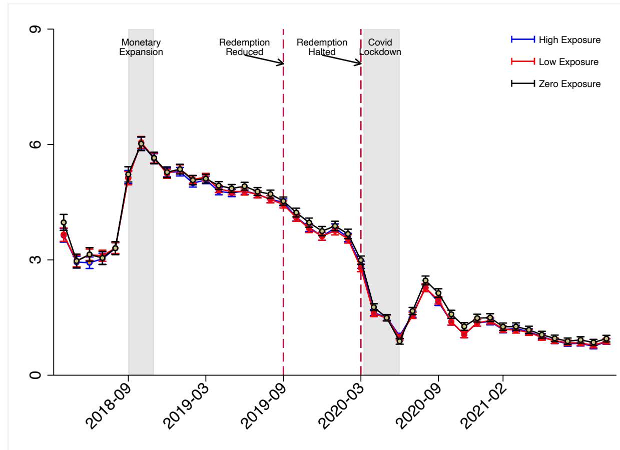
[15] As shown in the Appendix Figure A2, most of the users do not have any redemption exposure and the number of users with more redemption exposure gradually decreases.

Figure 5. Token redemption and issuance over time, by redemption exposure

Panel A: Asinh BTZ redeemed



Panel B: Asinh BTZ issued



Notes: The figure shows the average token redeemed and issued for frequent users with high, low, and zero redemption exposure, respectively, over time. Frequent users are defined as users with 20 item posts from April 2018 to August 2019.

tokens from Bunz, while they only receive statistically insignificant 0.6% less tokens after the redemption collapse. [16]

Token inflow from peers. Figure 6 Panel C reports that users receive significantly less tokens and gap among three exposure groups narrows to around zero after the redemption collapse. Appendix Table A7 Column (2) confirms the effect of the redemption collapse. There is drops in token inflow regardless of initial exposure and users further receive 2.1% less token when the number of merchants around them increases by one. [17]

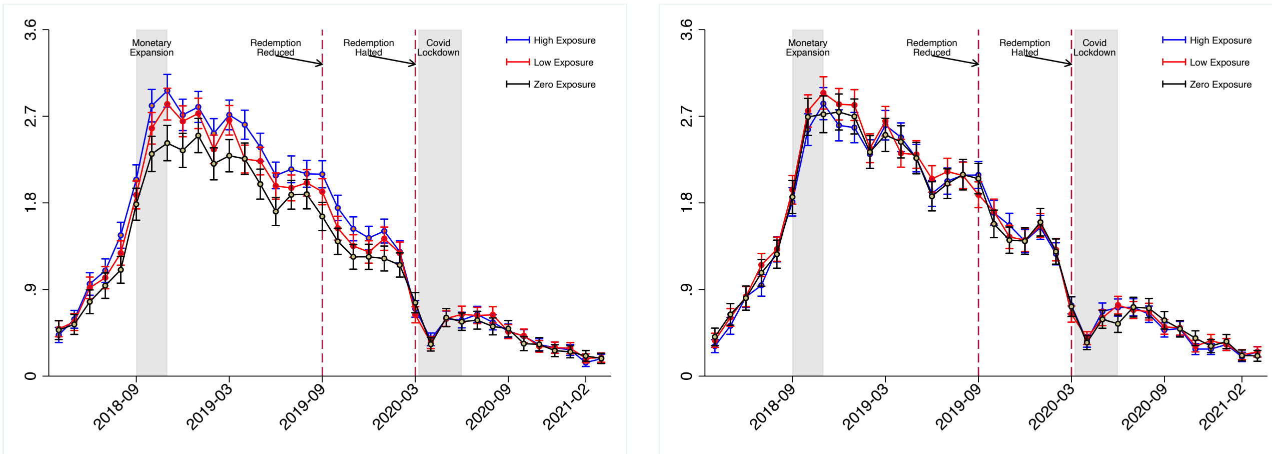
Token outflow to peers. Figure 6 Panel D documents that the amount of tokens sent to other users dropped significantly after the redemption collapse, while there is still no difference among users in the three exposure groups. As shown in Appendix Table A7 Column (3), users will spend significantly less tokens to buy items from other users regardless of ini-

[16] Appendix Table A8 Columns (1) and (2) document that this effect is robust for the number of issuance transactions and the probability to receive tokens from Bunz.

[17] Appendix Table A8 Columns (3) and (4) show the similar effect on the number of transactions with token inflow and the probability to receive tokens.

Figure 6. Token inflow and outflow over time, by redemption exposure

Panel A: Asinh BTZ inflow from other users | Panel B: Asinh BTZ outflow to other users



Notes: The figure shows the average token inflow and outflow for frequent users with high, low, and zero redemption exposure, respectively, over time. Frequent users are defined as users with 20 item posts from April 2018 to August 2019.

tial exposure, but the an additional merchant within 1 km of users only further corresponds to statistically insignificant 0.7% less tokens sent to other users. [18]

Token acceptance. Figure 7 Panel A shows that users will be less willing to accept BTZ and the difference among users in different groups disappear. Appendix Table A9 Column (1) reports that the redemption collapse will correspond to statistically significant decrease in token acceptance for all sample users, and one more merchants within 1 km of users will further make the token acceptance drop by statistically significant 0.3 p.p.. Column (2) confirms that this effect is robust to the subsample of users who are active before the introduction of the token.

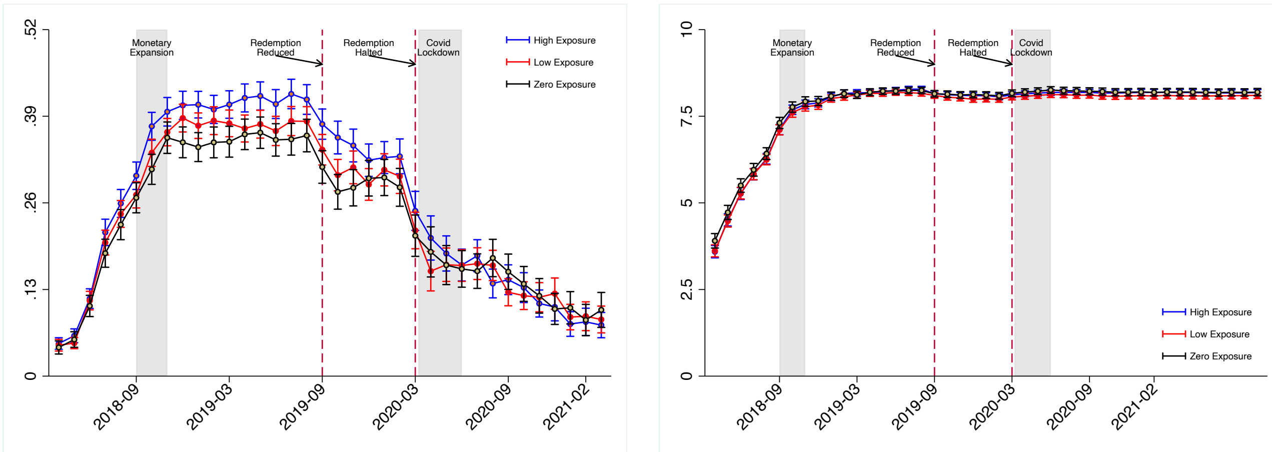
Token holdings. Figure 7 Panel B shows that users in all three groups hold more tokens after the redemption collapse, but their token holdings are the same. Table A9 Column (3) also support this trend. Users will hold statistically significant 8.1% more tokens. However,

[18]Appendix Table A8 Columns (5) and (6) also confirm that effect is robust for the number of transactions with token outflow and the probability to send tokens.

Figure 7. Token acceptance and holdings over time, by redemption exposure

Panel A: Token acceptance

Panel B: Asinh BTZ holding



Notes: The figure shows the token acceptance behavior and holdings for frequent users with high, low and zero redemption exposure, respectively, over time. Frequent users are defined as users with 20 item posts from April 2018 to August 2019.

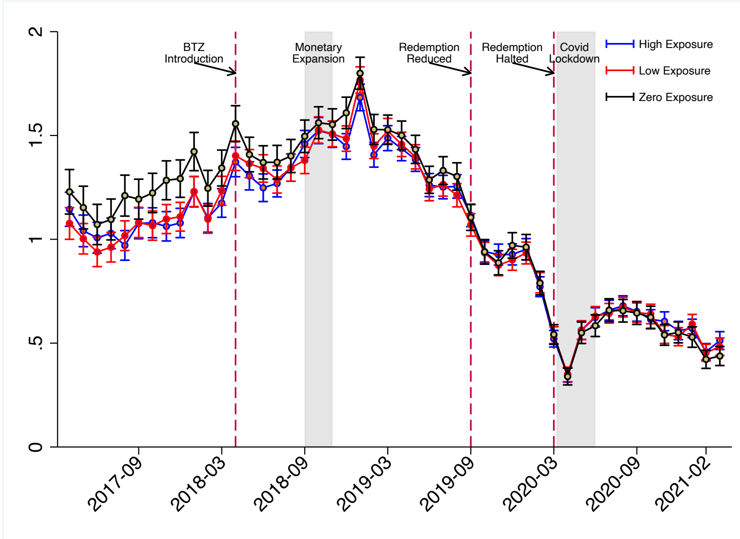
one increase in the number of merchants within 1 km of them will only further correspond to statistically insignificant 0.1% less tokens holdings.

User activeness. Figure 8 displays suggestive evidence redemption convenience reduced user attrition. Specifically, even though users in the zero-exposure group in the early stage of token introduction have higher activity levels, the gap narrows after the introduction of the token. After the redemption reduced, the gap between users in the two exposure groups disappeared completely. Table A10 confirms that users' activity level drop significantly after the redemption collapse but the regression coefficients of the interaction term are relatively small and do not have significance.

6 Conclusion

Redemption is central to the successful circulation of many currencies and payment tools. However, rigorous economic analysis has been missing in the literature, partially because of the data limitations and lack of appropriate empirical context. By carefully

Figure 8. Time series trend of activeness by exposure



Notes: The figure shows the asinh total item posts for frequent users with high, low and zero redemption exposure, respectively, over time. Frequent users are defined as users with 20 item posts from April 2018 to August 2019.

documenting the redemption rollout and collapse in the Bunz economy using transaction-level data, we find that redemption promises serve as more than backing for the value of a currency; they affect the cross-sectional distribution of money acceptance as well as money and good flows. We show evidence that redemption convenience increases users' desire to accept a new currency. Moreover, strategic complementarities generate positive spillovers for currency adoption through the transaction network. These findings suggest that redemption can be a cost-effective way to encourage currency adoption. However, there are systemic risks involved. When redemption volume is nonzero and currency issuers renege on their redemption promises, circulation can collapse.

The recent rise of cryptocurrency has encouraged central banks to experiment with blockchain-based digital currency (CBDC) and token-based financial systems. One of the main policy endeavors is to study use cases and decide where early adoption can happen for tokenized money and the optimal subsidy strategy to incentivize people to adopt the new type of currency. Our paper advances this goal by highlighting that currency redemption is crucial for early adoption, and that the transition toward monetary equilibrium can be fragile, especially when the issuer has difficulty sustaining redemption promises. Our novel approach, which combines transaction-level field evidence with a micro-founded model of money, elevates the level of rigor and can help improve the design of real-world currencies.

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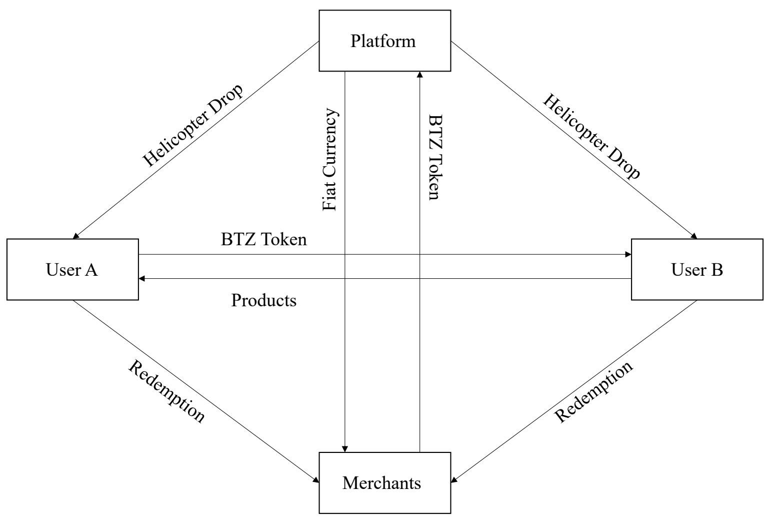
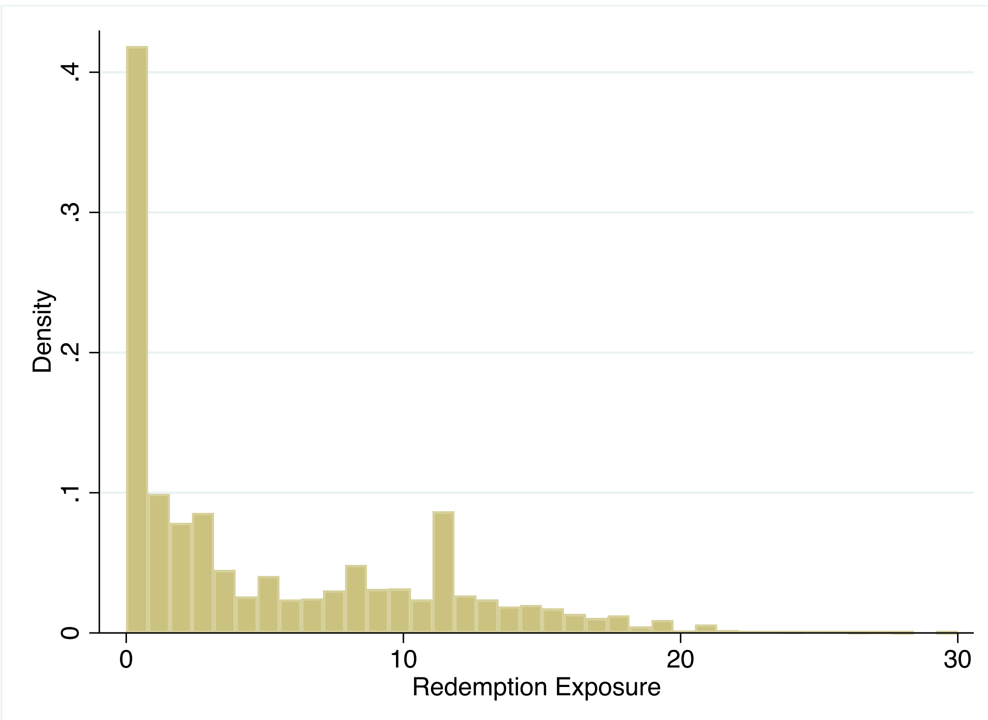
Figure A1. Token circulation within Bunz community



Notes: The figure plots the BTZ circulation in the BUNZ community.

Figure A2. Distribution of redemption exposure



Notes: The figure plots the distribution of the average number of merchants within 1 km of active users from April 2018 to August 2019.

Table A1. Redemption stores, summary statistics

Merchant Type	Redemption Volume (Percentage of Toal)	Redemption Transaction (Percentage of Toal)	Amount Per Transaction (CAD)	# Transactions Per Merchant
	Panel A: All users			
Cafes	19%	38%	7.92	46.2
Retail Shop	41%	21%	31.76	15.7
Bars	8%	13%	10.25	28.1
Restaurants	23%	25%	15.25	33.9
Service Shop	9%	4%	37.78	8.2
Total	1,134,767 CAD	70,439	16.11	26.4
	Panel B: Analysis sample			
Cafes	15%	32%	8.74	17.4
Retail Shop	47%	27%	33.49	9.0
Bars	5%	9%	11.04	9.0
Restaurants	23%	27%	16.50	16.8
Service Shop	10%	5%	39.51	4.4
Total	600,250 CAD	31,388	19.12	11.8

Notes: The table provides a comprehensive overview of the redemption patterns of all users and frequent users. Only users and redemption stores located in an area with a longitude between 79.11524° W and 79.63926° W and a latitude between 43.58100° N and 43.85546° N are included. Frequent users are defined as users with 20 item posts from April 2018 to August 2019.

Table A2. Sample Checking

	Full Sample	Analysis Sample	Percentage
Number of users	193,989	7,162	3.69%
Total items posted (2018/04-2019/08)	1,044,234	834,194	79.89%
Total ratings received	772,328	466,050	60.34%
Total BTZ sent	390,282,261	221,650,823	56.79%
Total BTZ received	555,008,838	262,127,349	47.23%
Total BTZ holding	393,724,786	40,476,526	10.28%

Notes: The table provides a comprehensive comparison between the full sample users and analysis sample users. Full sample users are defined as users located in an area with a longitude between 79.11524° W and 79.63926° W and a latitude between 43.58100° N and 43.85546° N. Analysis sample users are defined as users with 20 item posts from April 2018 to August 2019.

Table A3. Effect of redemption exposure on extensive margin of token circulation

	(1) Asinh redemption transactions	(2) Any redemption transaction	(3) Asinh issuance transactions	(4) Any issuance transactions	(5) Asinh transactions with token inflow	(6) Any transactions with token inflow	(7) Asinh transactions with token outflow	(8) Any transactions with token outflow
Exposure	0.007***	0.003***	-0.0003	0.001	0.006***	0.003***	0.001	0.0003
	(0.001)	(0.000)	(0.002)	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)
Baseline mean	0.116	0.059	3.387	0.737	0.435	0.212	0.428	0.232
# Obs	7,162	7,162	7,162	7,162	7,162	7,162	7,162	7,162

Notes: This table reports the effect of redemption exposure on token circulation. Columns (1), (3), (5), and (7) report the asinh ($asinh(x) = ln(x + \sqrt{x^2 + 1})$) number of transactions with token inflow and outflow. The analysis period is from April 2018 to August 2019. Robust standard deviations are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A4. Robustness: alternative redemption exposure measurement

	(1) Share of Item Posts with BTZ Price	(2) Log BTZ Holdings	(3) Log BTZ Redeemed	(4) Log BTZ Issuance	(5) Log BTZ Inflow	(6) Log BTZ Outflow
# merchants within 1 km	0.339***	0.003	0.026***	0.002	0.023***	0.003
	(0.060)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)
R^2	0.004	0.000	0.015	0.000	0.005	0.000
log # merchants within 1 km	1.822***	-0.004	0.156***	-0.013	0.113***	0.0001
	(0.316)	(0.020)	(0.013)	(0.019)	(0.020)	(0.019)
R^2	0.005	0.000	0.019	0.000	0.005	0.000
log average BTZ redeemed within 1 km	0.228***	-0.007*	0.023***	-0.006*	0.016***	0.001
	(0.055)	(0.004)	(0.002)	(0.003)	(0.003)	(0.003)
R^2	0.002	0.000	0.013	0.000	0.003	0.000
log average redemption transactions within 1 km	0.512***	-0.012	0.052***	-0.010	0.037***	0.005
	(0.122)	(0.008)	(0.005)	(0.007)	(0.007)	(0.007)
R^2	0.002	0.000	0.014	0.000	0.003	0.000
log average distance from merchants	-3.427***	0.102**	-0.285***	0.089**	-0.203***	-0.015
	(0.665)	(0.044)	(0.026)	(0.041)	(0.041)	(0.040)
R^2	0.003	0.001	0.014	0.001	0.003	0.000
log average distance from merchants weighted by redemption volume	-3.524***	0.094**	-0.285***	0.080*	-0.218***	-0.031
	(0.679)	(0.045)	(0.026)	(0.042)	(0.042)	(0.041)
R^2	0.003	0.000	0.013	0.000	0.003	0.000
# Obs	7,162	7,162	7,162	7,162	7,162	7,162

Notes: This table reports the effect of alternative measurements of redemption exposure on users' token related behavior. The analysis period is from April 2018 to February 2020. Robust standard deviations are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A5. Robustness: controlling more variables

	(1) Token acceptance	(2) Asinh BTZ Holdings	(3) Asinh token redeemed	(4) Asinh token issued	(5) Asinh token inflow	(6) Asinh token outflow
	Panel A: Controlling demographic characteristics					
Exposure	0.004***	0.004	0.091***	-0.000	0.035***	0.005
	(0.001)	(0.005)	(0.014)	(0.002)	(0.008)	(0.008)
# Obs	2,204	2,204	2,204	2,204	2,204	2,204
	Panel A: Controlling activeness level					
Exposure	0.003***	0.001	0.066***	-0.001	0.037***	-0.009*
	(0.001)	(0.004)	(0.007)	(0.003)	(0.005)	(0.005)
	Panel A: Controlling distance to city center					
Exposure	0.003***	0.014**	0.042***	0.003	0.025***	-0.013
	(0.001)	(0.006)	(0.009)	(0.004)	(0.008)	(0.008)
# Obs	7,162	7,162	7,162	7,162	7,162	7,162

Notes: This table reports the impact of redemption exposure on users' token related behavior controlling the demographic characteristics, activeness level, and distance to city center. The demographic characteristics include the age, income, and education of users. The measurements for users' activeness level are the number of items posted and the ratings sent to other users. The redemption exposure is defined as the number of merchants within 1 km of users. The analysis period is from April 2018 to August 2019. Robust standard deviations are two-way clustered at individual and month levels in Panel C and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A6. Robustness: analysis on active users before BTZ introduction

	(1) Token acceptance	(2) Asinh BTZ Holdings	(3) Asinh token redeemed	(4) Asinh token issued	(5) Asinh token inflow	(6) Asinh token outflow
Exposure	0.003***	0.007	0.085***	0.002	0.046***	-0.001
	(0.001)	(0.007)	(0.013)	(0.005)	(0.011)	(0.011)
# Obs	2,824	2,824	2,824	2,824	2,824	2,824

Notes: This table reports the impact of redemption exposure on token related behavior of the active users before token introduction. The redemption exposure is defined as the number of merchants within 1 km of users. The analysis period is from April 2018 to August 2019. Robust standard deviations are two-way clustered at individual and month levels in Panel C and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A7. Redemption collapse and token circulation

	(1) Asinh token issued	(2) Asinh token inflow	(3) Asinh token outflow
Post	-2.301***	-0.939***	-1.059***
	(0.193)	(0.092)	(0.103)
Exposure × *Post*	-0.006	-0.021***	-0.007
	(0.004)	(0.005)	(0.005)
# Obs	136,078	136,078	136,078

Notes: This table reports the DID analysis of redemption collapse on BTZ transaction related to BUNZ platform. The redemption exposure is defined as the number of merchants within 1 km of users. The analysis period is from September 2019 to February 2021 and the redemption system collapse on February 26th, 2020. Panel A reports the regression results of the redemption transactions. Panel B reports the regression results of the BTZ issuance. Robust standard deviations are two-way clustered at individual and month levels in Panel C and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A8. Redemption collapse and extensive margin of token circulation

	(1) Asinh issuance transactions	(2) Any issuance transactions	(3) Asinh transactions with token inflow	(4) Any transactions with token inflow	(5) Asinh transactions with token outflow	(6) Any transactions with token outflow
Post	-1.599***	-0.350***	-0.165***	-0.116***	-0.172***	-0.131***
	(0.147)	(0.040)	(0.017)	(0.011)	(0.017)	(0.012)
Exposure × *Post*	-0.002	-0.002**	-0.004***	-0.002***	-0.001	-0.001
	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
# Obs	136,078	136,078	136,078	136,078	136,078	136,078

Notes: This table reports the DID analysis of redemption collapse on BTZ transaction related to BUNZ platform. The redemption exposure is defined as the number of merchants within 1 km of users. The analysis period is from September 2019 to February 2021 and the redemption system collapse on February 26th, 2020. Panel A reports the regression results of the redemption transactions. Panel B reports the regression results of the BTZ issuance. Robust standard deviations are two-way clustered at individual and month levels in Panel C and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A9. Redemption collapse and token acceptance

	(1) Token acceptance	(2) Token acceptance	(3) Asinh BTZ Holdings
Post	-0.145***	-0.141***	0.081***
	(0.010)	(0.012)	(0.020)
Exposure × *Post*	-0.003***	-0.002	-0.001
	(0.001)	(0.001)	(0.002)
# Obs	38,459	18,893	136,078

Notes: This table reports the DID analysis of redemption collapse on BTZ transaction related to BUNZ platform. The redemption exposure is defined as the number of merchants within 1 km of users. The analysis period is from September 2019 to February 2021 and the redemption system collapse on February 26th, 2020. Panel A reports the regression results of the redemption transactions. Panel B reports the regression results of the BTZ issuance. Robust standard deviations are two-way clustered at individual and month levels in Panel C and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A10. Redemption collapse and user activeness

	(1) Ratings	(2) Item posts	(3) Any item posts
Post	-0.266***	-0.374***	-0.160***
	(0.032)	(0.045)	(0.017)
Exposure × *Post*	-0.001	0.0001	-0.001
	(0.001)	(0.002)	(0.001)
# Obs	136,078	136,078	136,078

Notes: This table reports the DID analysis of redemption collapse on BTZ transaction related to BUNZ platform. The redemption exposure is defined as the number of merchants within 1 km of users. The analysis period is from September 2019 to February 2021 and the redemption system collapse on February 26th, 2020. Panel A reports the regression results of the redemption transactions. Panel B reports the regression results of the BTZ issuance. Robust standard deviations are two-way clustered at individual and month levels in Panel C and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

A Proofs

Proof of Proposition 1. The proof strategy follows the framework of Kiyotaki and Wright (1993). To fully solve for equilibrium, we rearrange the Bellman equations and write them in terms of steady state values.

$$V_1 = \max_{\rho} B + \beta V_0 + u_R + (1-\rho)\left(l\Pi(1-\mu_1)u_C - u_R + \beta(1 - l\Pi(1-\mu_1))(V_1 - V_0)\right) \quad (9)$$

$$V_0 = \max_{\pi} B + \beta V_0 + \pi l M\left(\beta(V_1 - V_0) - c\right) \quad (10)$$

Let $\Delta = V_1 - V_0$. Since the objective functions are linear in ρ, π, from an individual agent's perspective, $\rho = 0$ is optimal iff $\Delta > \frac{u_R - l\Pi(1-\mu_1)u_C}{\beta(1-l\Pi(1-\mu_1))}$, note here that $\mu_1 = M$; $\pi = 1$ is optimal iff $\Delta > \frac{c}{\beta}$. Combining the Bellman equations result in

$$\Delta = \frac{\rho u_R + (1-\rho)(l\Pi(1-\mu_1)u_C) + \pi l M c}{1 - (1-\rho)\beta(1 - l\Pi(1-\mu_1)) + \pi l M \beta}. \quad (11)$$

Let us first consider the "monetary equilibrium" where $\pi = 1, \rho = 0$. In this equilibrium, $\Delta = \frac{l(1-\mu_1)u_C + lMc}{1-\beta(1-l(1-\mu_1)) + lM\beta}$. Optimality of $\pi = 1, \rho = 0$ requires that $\Delta > \frac{u_R - l(1-\mu_1)u_C}{\beta(1-l(1-\mu_1))}$ and $\Delta > \frac{c}{\beta}$. These conditions are satisfied if and only if $u_C > \underline{u}$ and $u_R < u_m$, where $\underline{u} = \frac{1}{l(1-\mu_1)}\left(\frac{c(1-\beta+\beta l)}{\beta} - lMc\right)$ and $u_m = Au_C + B$ with $A = \frac{l(1+lMc)(1-\mu_1)}{1-\beta+\beta l-\beta l\mu_1+lMc}$, $B = \frac{lMc\beta(1-l(1-\mu_1))}{1-\beta+\beta l-\beta l\mu_1+lMc}$.

Next we consider the "non-monetary equilibrium" where $\pi = 0, \rho = 0$. In this equilibrium, $\Delta = 0$, and optimality of $\pi = 0, \rho = 0$ requires $\frac{c}{\beta} > \Delta > \frac{u_R}{\beta}$. These conditions are satisfied if and only if $c > 0 > u_R$.

Finally we consider the "currency run equilibrium" $\rho = 1, M = 0$. In this case, $\Delta = u_R$. In order to guarantee individual optimality of $\rho = 1$, the condition $\Delta < \frac{u_R - l\Pi(1-\mu_1)u_C}{\beta(1-l\Pi(1-\mu_1))}$ where $\mu_1 = 0$ must hold. Given that the steady state $M = 0$, the individual action of π is undetermined. Additionally assume that agents' belief of others' probability of accepting money is given by $\Pi = \tilde{\pi} \in (0, 1]$. Then, the optimality condition of $\rho = 1$ can be rewritten as $u_R > u_r$ where $u_r = \frac{l\tilde{\pi}u_C}{1-\beta(1-l\tilde{\pi})}$.

Finally, it only remains to observe that when $\tilde{\pi} = 0$, we have $u_r(0) = 0$, and when $\tilde{\pi} = 1$, we have $u_r(1) = \frac{lu_C}{1-\beta(1-l)}$. Note that in this case, we have $u_r(1) > u_m$. To see this, note that the $u_r(1)$ is linear in u_C with a slope of $\frac{l}{1-\beta(1-l)} > A$. In this case, there exists $\underline{u}$ such that when $u_C > \underline{u}$, we have $u_r(1) > u_m$.

Proof of Lemma 1. To be fully transparent with assumptions embedded in the transition dynamics, we let agents' individual expectations satisfy $E[V^i_{k,t+1}] = V^i_{k,t}$ for $k \in \{0, 1\}, i \in \mathcal{I}$. In equilibrium, this assumption doesn't impose any additional restrictions. The economy initializes with individual and aggregate states $\{\mu^i_1\}_i, W_1, M_1$. At the beginning of period t, agents observe the strategy profiles in period $t-1$, which is equivalent to observing $\{\mu^i_t\}_i, M_t, W_t$. More concretely, the dynamic path is iterated forward as the following. Initializes with $\{\mu^i_1\}_i, W_1, M_1$. Agents best respond and generates $\{\pi^i_1\}_i, \{\rho^i_1\}_i$. Individual and aggregate states are updated overnight and results in $\{\mu^i_2\}_i, W_2, M_2$. Agents best respond and generates $\{\pi_2^i\}_i, \{\rho_2^i\}_i$. So on so forth.

Based on the Bellman equations, first order conditions of π_t^i, ρ_t^i are given by

$$FOC_{\pi_t^i} = lM_t\left(\beta(V_{1,t}^i - V_{0,t}^i) - c\right)$$

$$FOC_{\rho_t^i} = \nu_R^i - lW_t u_C^i - \beta(1 - lW_t)(V_{1,t}^i - V_{0,t}^i)$$

Optimal decisions are corner solutions in $\{0, 1\}$ depending on the sign of the first order condition. We specify the following tie-breaking rules. If $FOC_{\pi_t^i} = 0$, then the optimal $\pi_t^i = 1$. If $FOC_{\rho_t^i} = 0$, then the optimal $\rho_t^i = 0$.

Hence we can characterize the optimal decision rule as the following. Let

$$\Delta_t^i = V_{1,t}^i - V_{0,t}^i = \frac{\rho_t^i \nu_R^i + (1 - \rho_t^i) lW_t u_C^i + \pi_t^i lM_t c}{1 - \beta(1 - \rho_t^i)(1 - lW_t) + \beta\pi_t^i lM_t + \beta\sigma} \tag{12}$$

and $\pi_t^i = 1$ iff $\Delta_t^i \geq \frac{c}{\beta}$, $\rho_t^i = 1$ iff $\Delta_t^i < \frac{\nu_R^i - lW_t u_C^i}{\beta(1 - lW_t)}$. The parametric ranges for the four possible pairs of optimal solutions are given by the following.

Equilibrium	Δ_t^i	Conditions	Simplified
$\pi_t^i = 0, \rho_t^i = 0$	$\Delta_t^i = \frac{lW_t u_C}{1-\beta(1-lW_t)+\beta\sigma}$	$\frac{\nu_R^i - lW_t u_C}{\beta(1 - lW_t)} \leq \frac{lW_t u_C}{1 - \beta(1 - lW_t) + \beta\sigma}$ (13) $\frac{lW_t u_C}{1 - \beta(1 - lW_t) + \beta\sigma} < \frac{c}{\beta}$ (14)	$\frac{\nu_R^i}{1 + \sigma\beta} \leq \boxed{u}$ (15) $\boxed{u} < \frac{c}{\beta}$ (16)
$\pi_t^i = 1, \rho_t^i = 0$	$\Delta_t^i = \frac{lW_t u_C + lM_t c}{1-\beta(1-lW_t)+\beta lM_t+\beta\sigma}$	$\frac{\nu_R^i - lW_t u_C}{\beta(1 - lW_t)} \leq \frac{lW_t u_C + lM_t c}{1 - \beta(1 - lW_t) + \beta lM_t + \beta\sigma}$ (17) $\frac{c}{\beta} \leq \frac{lW_t u_C + lM_t c}{1 - \beta(1 - lW_t) + \beta lM_t + \beta\sigma}$ (18)	$\nu_R^i \leq \textcircled{u}$ (19) $\frac{c}{\beta} \leq \boxed{u}$ (20)
$\pi_t^i = 0, \rho_t^i = 1$	$\Delta_t^i = \frac{\nu_R^i}{1+\beta\sigma}$	$\frac{\nu_R^i}{1 + \beta\sigma} < \frac{\nu_R^i - lW_t u_C}{\beta(1 - lW_t)}$ (21) $\frac{\nu_R^i}{1 + \beta\sigma} < \frac{c}{\beta}$ (22)	$\boxed{u} < \frac{\nu_R^i}{1 + \beta\sigma}$ (23) $\frac{\nu_R^i}{1 + \beta\sigma} < \frac{c}{\beta}$ (24)
$\pi_t^i = 1, \rho_t^i = 1$	$\Delta_t^i = \frac{\nu_R^i + lM_t c}{1+\beta lM_t+\beta\sigma}$	$\frac{\nu_R^i + lM_t c}{1 + \beta lM_t + \beta\sigma} < \frac{\nu_R^i - lW_t u_C}{\beta(1 - lW_t)}$ (25) $\frac{c}{\beta} \leq \frac{\nu_R^i + lM_t c}{1 + \beta lM_t + \beta\sigma}$ (26)	$\textcircled{u} < \nu_R^i$ (27) $\frac{c}{\beta} \leq \frac{\nu_R^i}{1 + \beta\sigma}$ (28)

Table A11. Characterization of Individually Optimal Solutions [updated]

Our goal is to fully characterize the optimal solution π_t^i, ρ_t^i as a function of ν_R^i, u_C^i. The above table might be a lot to take in. We proceed with the following key observations.

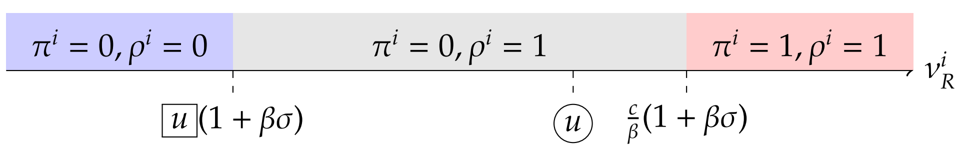
Observation 1. Given W_t, M_t and parameters β, l, c, Equations (R1.2) and Equations (R2.2) are mutually exclusive. To simplify notation, let us denote $\boxed{u} = \frac{lW_t u_C}{1-\beta(1-lW_t)+\beta\sigma}$. Then, Equation (R1.2), row 1 second equation, is equivalent to $\boxed{u} < \frac{c}{\beta}$ and Equation (R2.2) is equivalent to $\frac{c}{\beta} \leq \boxed{u}$. The intuition is straight forward: If the agent is not redeeming, then the decision to accept solely depends on consumption utility u_C. If consumption utility is high, we have (R2.2) and $\pi = 1$, otherwise we have (R1.2) and $\pi = 0$. These two cases are mutually exclusive. We will separately discuss the two cases.

Observation 2. Equation (2.1) is equivalent to $v_R^i \leq \frac{\beta(1-lW_t)lM_t c+(1+\beta lM_t+\beta\sigma)lW_t u_C}{1-\beta(1-lM_t-lW_t)}$. We denote $\textcircled{u} = \frac{\beta(1-lW_t)lM_t c+(1+\beta lM_t+\beta\sigma)lW_t u_C}{1-\beta(1-lM_t-lW_t)}$. In addition, $\textcircled{u}$ has the following property: if $\boxed{u} < \frac{c}{\beta}$, then $\frac{\textcircled{u}}{1+\beta\sigma} < \frac{c}{\beta}$, and if $\boxed{u} \geq \frac{c}{\beta}$, then $\frac{\textcircled{u}}{1+\beta\sigma} \geq \frac{c}{\beta}$.

Given the two observations, we separately discuss two possible cases of the agent.

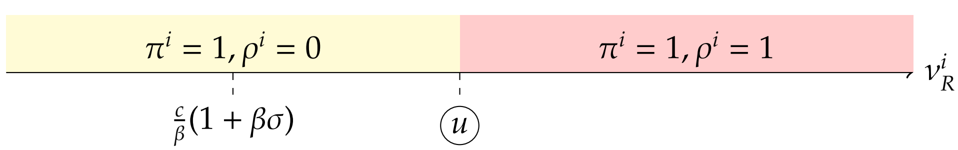
- First, suppose $\boxed{u} < \frac{c}{\beta}$, equivalently $u_C < e(W) = \frac{c}{\beta}\frac{1+\beta\sigma-\beta(1-lW)}{lW}$ indicating that transaction value of money alone is insufficient for agents to accept money.

  By Observation 1, the possible optimal actions for any given agent i includes ($\pi = 0, \rho = 0$), ($\pi = 0, \rho = 1$), and ($\pi = 1, \rho = 1$). By Observation 2, $\textcircled{u} < \frac{c}{\beta}(1+\beta\sigma)$. Thus, the cross-sectional distribution of actions are characterized by the following.



- Second, suppose $\boxed{u} \geq \frac{c}{\beta}$, equivalently $u_C \geq e(W)$, indicating that transaction value of money alone is high enough for agents to accept money.

  By Observation 1, the possible optimal action for any given agent i cannot be ($\pi = 0, \rho_i = 0$). In addition, in the case of $\boxed{u} \geq \frac{c}{\beta}$, the region that supports ($\pi = 0, \rho_i = 1$) as optimal action is empty. Hence the possible actions are ($\pi = 1, \rho = 0$) and ($\pi = 1, \rho = 1$). By Observation 2, $\textcircled{u} \geq \frac{c}{\beta}(1+\beta\sigma)$. Thus, the cross-sectional distribution of actions are characterized by the following.



Combining the two cases produces exactly the result presented in Lemma 1.

Proof of Proposition 2 (1) is a direct result of Lemma 1. (2) and (3) directly follows from

$$S^i = lM\pi^i \frac{\rho^i + (1-\rho^i)}{\pi^i lM + \sigma + \rho^i + (1-\rho^i)} \tag{29}$$

$$P^i = lW(1-\rho^i)\frac{\pi^i lM + \sigma}{\pi^i lM + \sigma + \rho^i + (1-\rho^i)}. \tag{30}$$

Note that for S^i, P^i are pinned down by the optimal decisions π^i, ρ^i. Hence, for agents i, j with $u^i_C = u^j_C, v^i_R < v^j_R$, it is straightforward to enumerate the different possibilities of their optimal decisions based on Lemma 1 and find that $S^i \leq S^j$ and $P^i \geq P^j$.

Proof of Proposition 3 This proof builds upon the proof of Lemma 1. Recall that the aggregate states are determined by

$$W_{t+1} = \int \pi^j_t(1-\mu^j_t)dj = W_t \tag{31}$$

$$M_{t+1} = \int \mu^j_t(1-\rho^j_t)dj = M_t \tag{32}$$

and

$$\mu^i_{t+1} = \mu^i_t(1-\rho^i_t)(1-lW_t) + (1-\mu^i_t)(\pi^i_t lM_t + \sigma) = \mu_t \tag{33}$$

which can be rearranged as $\mu^i_t = \frac{\pi^i_t lM_t + \sigma}{\pi^i_t lM_t + \sigma + \rho^i_t + (1-\rho^i_t)lW_t}$.

Recall

$$e(W) = \frac{c}{\beta}\frac{1 + \beta\sigma - \beta(1-lW)}{lW} \tag{34}$$

we know

$$e'(W) = -\frac{c}{\beta}\frac{1-\beta(1-\sigma)}{lW^2} < 0, \quad e''(W) = \frac{2c(1-\beta(1-\sigma)}{\beta lW^3} > 0 \tag{35}$$

and $e(0) = +\infty$, $e(1) = \frac{c(1-\beta(1-\sigma)+\beta l)}{\beta l}$.

Recall $u^i_C \sim U([\underline{u}_C, \overline{u}_C])$. Additionally we denote $\overline{W}$ s.t. $\overline{u}_C = e(\overline{W})$ and $\underline{W}$ s.t. $\underline{u}_C = e(\underline{W})$. Since e is monotonically decreasing in W, we know that $\overline{W} < \underline{W}$.

Recall **Assumption 1**. The first part assumes that $\underline{W} > 1$, equivalently, $e(1) > \underline{u}_C$ or $\underline{u}_C < \frac{c\left(1+\beta\sigma-\beta(1-l)\right)}{l\beta}$. Note that this is an assumption on primitives. The intuition is that we want there to be at least some people with low u_C that doesn't want to accept money for transaction's sake even if $W = 1$. This suggests that unless they have redemption utility, they won't join. This is important for eliminating the monetary equilibrium in the low-redemption regime. The second part assumes that $\overline{W} < \frac{1}{1+\sigma}$, equivalently $e(\frac{1}{1+\sigma}) < \overline{u}_C$. The intuition is that we want at least some people with high u_C such that they are happy to accept money for transaction's sake even if only $\frac{1}{1+\sigma}$ share of the population can accept their money.

Claim 1. If redemption is distributed as $v_R^i < \frac{c}{\beta} + \sigma$, the only equilibrium is $\pi^* = 0, \rho^* = 1$ for all agents, and aggregate $W^*, M^* = 0$.

Proof. Since $v_R^i < \frac{c}{\beta} + \sigma$, we can disaggregate our equilibrium condition to be

$$W = \frac{lW}{lM + \sigma + lW} P\Big(u_C^i > e(W)\Big) \tag{36}$$

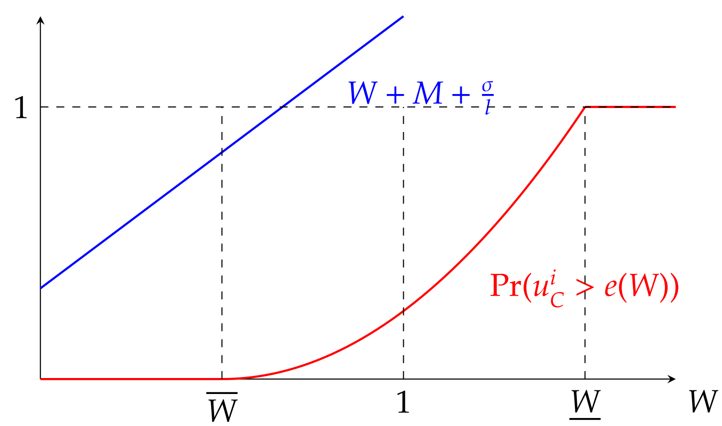
$$M = \frac{lM + \sigma}{lM + \sigma + lW} P\Big(u_C^i > e(W)\Big) + \frac{\sigma}{\sigma + lW} P\Big(u_C^i \leq e(W), v_R^i < \boxed{u}^i(1 + \beta\sigma)\Big) \tag{37}$$

Observe immediately that $W^* = 0, M^* = 0$ satisfies the conditions and we have $e(0) = \infty$ meaning that $\pi^* = 0$ for everyone, which is consistent with the aggregates. We next show that there cannot be $W^* \in (0, 1)$ that solves the system.

Suppose $W \neq 0$, then we can simplify the W condition to be

$$W + M + \frac{\sigma}{l} = P\Big(u_C^i > e(W)\Big) \tag{38}$$

and by the monotonicity and convexity properties of $e(W)$, there is no solution to this equation for $W \in (0, 1)$. The following figure illustrates the intuition.



This concludes the proof of Proposition 3 Part (1).

We next show a more general statement than Proposition 3 Part (2).

Claim 2. Under the following redemption regimes $\{v_R^i\}$, there exists a unique monetary equilibrium where all agents play $\pi^* = 1, \rho^* = 0$ or $\pi^* = 1, \rho^* = 1$, aggregate quantities satisfy $W^* \in (\overline{W}, \frac{1}{1+\sigma})$ and $M^* = 1 - (1 + \sigma)W^*$. The redemption regime must satisfy:

(1) $v_R^i \geq \frac{c}{\beta}(1 + \sigma\beta)$ for all i. This condition ensures that there is enough redemption incentive to encourage acceptance.

(2) $v_R^i \leq \max\left\{\frac{(1+\beta\sigma)l\overline{W}u_C^i}{1-\beta+l}, \frac{c}{\beta}(1 + \sigma\beta)\right\}$ for each i. This condition guarantees that a positive-measure set of agents play $(\pi^i = 1, \rho^i = 0)$ in equilibrium. It suggests that the platform should not allow people to redeem too much, especially should restrict redemption utility of those agents with high u_C^i, since they would have accepted money anyway.

It is straightforward to see that Proposition 3 Part (2) is a direct corollary of this claim, where we choose $\overline{v} = \frac{(1+\beta\sigma)l\overline{W}\overline{u}_C}{1-\beta+l}$.

Proof. Immediately note that any $W \leq \overline{W}$ cannot be an equilibrium given the redemption regimes. If $W \leq \overline{W}$, the redemption regimes guarantee that we shall have $u_C^i \leq e(W), v_R^i \geq \frac{c}{\beta}(1+\sigma\beta)$ for all agents. Then, they optimally chooses $\pi = 1, \rho = 1$ and this results in aggregate $W' = \int \pi(1-\mu) = \frac{1}{1+\sigma} > \overline{W}$ which is a contradiction.

Next, we want to show that there is a unique $W^* \in (\overline{W}, \frac{1}{1+\sigma})$ that solves the system.

We begin with the following observation. The maximal redemption bound given in the claim satisfies the following property, that is, for any i and for any potential equilibrium aggregates $W \in (\overline{W}, 1), M \in [0,1]$, we have

$$\frac{(1+\beta\sigma)l\overline{W}u_C^i}{1-\beta+l} \leq \textcircled{u}^i = \frac{\beta(1-lW_t)lM_tc + (1+\beta lM_t + \beta\sigma)lW_tu_C^i}{1-\beta(1-lM_t-lW_t)} \tag{39}$$

which means that under the redemption regime, all agents have $\frac{c}{\beta}(1+\sigma\beta) \leq v_R^i \leq \max\{\textcircled{u}^i, \frac{c}{\beta}(1+\sigma\beta)\}$ for all agents.

In this case, there can only be two optimal actions in equilibrium, either $\pi = 1, \rho = 0$ for agents with $u_C^i > e(W)$ because we know $v_R^i < \textcircled{u}^i$; or $\pi = 1, \rho = 1$ for agents with $u_C^i < e(W)$ because we know $v_R^i > \frac{c}{\beta}(1+\sigma\beta)$.

Now our equilibrium conditions are given by

$$W = \frac{lW}{lM+\sigma+lW}P\Big(u_C^i > e(W)\Big) + \frac{1}{lM+\sigma+1}\Big(1 - P\Big(u_C^i > e(W)\Big)\Big) \tag{40}$$

$$M = \frac{lM+\sigma}{lM+\sigma+lW}P\Big(u_C^i > e(W)\Big) \tag{41}$$

They can equivalently can be written as

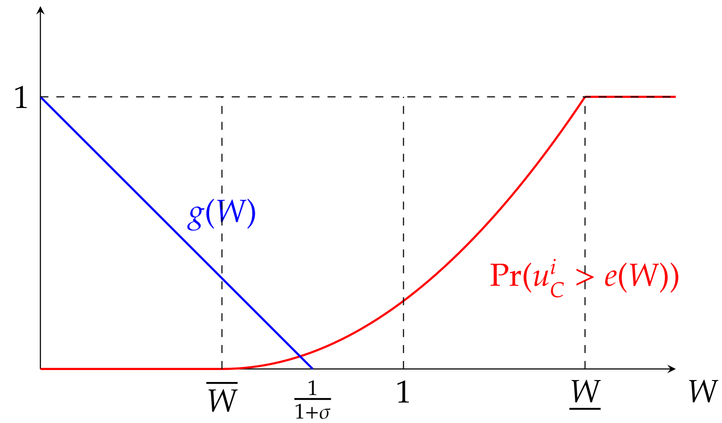
$$\frac{lM}{lM+\sigma}W + M = P\Big(u_C^i > e(W)\Big) \tag{42}$$

$$W = \frac{1-M}{1+\sigma} \tag{43}$$

It's easy to see that the first condition comes from the equation in M. The second condition can be obtained from taking the two equations in M, W and concentrating out the probability term.

It is obvious that the second equation specifies a one-to-one mapping between equilibrium W^*, M^*, we plug this into the first eqation and simplifies the system to a single equation

$$f(W) \equiv -\sigma\frac{(W-\frac{1}{\sigma+1})(W-\frac{\sigma+l}{\sigma l})}{(W-\frac{\sigma+l}{(\sigma+1)l})} = P\Big(u_C^i > e(W)\Big). \tag{44}$$



A few additional observations regarding the left hand side function $f(W)$ yields our result. First note that the $\frac{1}{\sigma+1} < 1 < \frac{\sigma+l}{\sigma l} < \frac{\sigma+l}{(\sigma+1)l}$ and that $f(0) = 1$, $f(\frac{1}{\sigma+1}) = 0$. We also note that on the support $W \in [0,1]$, $f(W)$ is non-negative only on $[0, \frac{1}{1+\sigma}]$ and that on this region $f'(W) < 0$. Therefore we are guaranteed a unique solution to the equation such that $W \in (\overline{W}, \frac{1}{1+\sigma})$.