MONEY RUNS*

Jason Roderick Donaldson[†] Giorgia Piacentino[‡]

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Abstract

We present a banking model in which bank debt circulates in secondary markets, facilitating trade. The key friction is that secondary market trade is decentralized, i.e. bank debt is traded over the counter like banknotes were in the nineteenth century and repos are today. We find that bank debt is susceptible to runs because secondary market liquidity is fragile, and subject to sudden, self-fulfilling dry-ups. When debt fails to circulate it is redeemed on demand in a "money run." Even though demandable debt exposes banks to costly runs, banks still choose to issue it because it increases their debt capacity: the option to redeem on demand increases the price of debt in the secondary market and hence allows banks to borrow more in the primary market—i.e. demandability and tradeability are complements, unlike in existing models.

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[†]Washington University in St Louis; jasonrdonaldson@gmail.com.

[‡]Washington University in St Louis and CEPR; piacentino@wustl.edu.

In the use of money, every one is a trader.

David Ricardo (1876)

1 Introduction

Bank debt was a major form of money in the nineteenth century United States. To get beer from the barman, you would exchange banknotes over the counter. Banknotes were redeemable on demand and sudden redemptions—bank runs—were common. Bank debt remains a major form of money today. To get liquidity from a financial counterparty, you exchange repos in an over-the-counter (OTC) market. Repos are effectively redeemable on demand and sudden redemptions—repo runs—were a salient event of the 2008–2009 financial crisis.[1,2] In summary, when you hold bank debt, you can get liquidity either by trading OTC or, alternatively, by demanding redemption from the issuing bank. But demanding redemption comes with the risk of a run. Why would you run on a bank rather than trade its debt in the market? In other words, why is bank debt susceptible to costly runs, even though it is tradeable? Moreover, why do banks choose to borrow via demandable debt, even though it exposes them to costly runs?

To give a new perspective on these questions, we focus on how banks create money by issuing liabilities that circulate in OTC markets, like banknotes did in the nineteenth-century and repos do today. In the model, bank debt is susceptible to runs because liquidity in the OTC market is fragile, and subject to sudden, self-fulfilling dry-ups.

[1]Gorton and Metrick (2009, 2012) and Krishnamurthy, Nagel, and Orlov (2014) provide descriptions of repo runs.

[2]Gorton (2012b) argues that it remains a theoretical challenge to understand how these runs arise and how they affect the design of bank liabilities that circulate as money. He suggests that, because banknotes and repos are backed by collateral, there is no "common pool problem" inducing depositors to race to withdraw first in the event of a crisis:

> In the U.S. under state free banking laws banks were required to back their notes with state bonds. In the case of a bank failure—an inability to honor requests for cash from noteholders—the state bonds would be sold (by the state government) and the note holders paid off pro rata. Note holders were paid off pro rata, so there was no common pool problem. Yet, there was a run on banks (banknotes and deposits) during the Panic of 1857 (p. 15).

And he goes on to say:

> Generating such [a run] event in a model seems harder when...the form of money [is such that] each "depositor" receives a bond as collateral. There is no common pool of assets on which bank debt holders have a claim. So, strategic considerations about coordinating with other agents do not arise. This is a challenge for theory and raises issues concerning notions of liquidity and collateral, and generally of the design of trading securities—private money (p. 2).

We generate such runs on bank debt in a model in which banks optimally design securities the circulate in secondary markets. These runs occur because strategic considerations about coordinating with other agents do arise in the secondary market. (Other papers, such as Martin, Skeie, and Thadden (2014a, 2014b) and Kuong (2015) study other mechanisms by which runs runs on backed debt can occur.)

When debt fails to circulate it is redeemed on demand in a bank run, or "money run." Such runs were common in the nineteenth century US, when depositors ran on banks after "the bank note that passed freely yesterday was rejected this morning" (Treasury Secretary Howell Cobb (1858), quoted in Gorton (2012a) p. 36). Even though demandable debt exposes banks to costly runs, banks still choose to issue it. In our model, this is because it increases banks' debt capacity: the option to redeem on demand props up the price of debt in the *secondary market*. In other words, we find that demandability and tradeability are complements. This contrasts with Jacklin's (1987) argument that, roughly, you do not need the option to redeem debt on demand if you can just sell it in the secondary market. In our model, on the contrary, you do: the option to redeem debt on demand increases the price at which you trade it in the secondary market. This benefits the issuing bank by allowing it to borrow more. As a result, financial fragility is a necessary evil—it is the cost incurred for the increased debt capacity afforded by demandable debt. Overall, our model exposes a new type of run and a new rationale for demandable debt, both of which are based on the circulation of bank liabilities in the secondary market.

Model preview. In the model, a borrower B has an investment opportunity and needs to borrow from a creditor C_0 to fund it. The model is based on two key assumptions. First, there is a horizon mismatch, similar to that in Diamond and Dybvig (1983): C_0 may be hit by a liquidity shock before B's investment pays off. This mismatch implies that B does maturity transformation, and therefore resembles a bank. Second, B's debt is traded in an OTC market, similar to those in Trejos and Wright (1995) and Duffie, Gârleanu, and Pedersen (2005): if C_0 is hit by a liquidity shock before B's investment pays off, C_0 can match with a counterparty C_1 and bargain bilaterally to trade B's debt. Likewise, C_1 may be hit by a liquidity shock before B's investment pays off, in which case it can match with a counterparty C_2 and bargain bilaterally to trade B's debt, and so on. If B's debt is demandable, then a creditor may redeem it before the investment pays off, forcing B to liquidate inefficiently.

Results preview. Our first main result is that B's debt capacity is highest if it issues tradeable, demandable debt, which we refer to as a "banknote." In particular, as long as the horizon mismatch is sufficiently severe, B cannot fund its investment with non-tradeable debt (e.g. a bank loan), even if it is demandable, or with non-demandable debt (e.g. a bond), even if it is tradeable. To see why this is, consider C_0's decision whether or not to lend to B. C_0 knows that he may be hit by a liquidity shock before B's investment pays off, in which case C_0 liquidates B's debt, either by redeeming on demand or by trading in the OTC market. If B's debt is not tradeable (but is demandable), then C_0 must redeem on demand, forcing B into inefficient liquidation and recovering less than his initial investment. If the horizon mismatch is severe, then this loss from early redemption is so likely that C_0 is unwilling to lend in the first place. In contrast, if B's debt is tradeable (but is not demandable), then C_0 can avoid early redemption by trading with C_1 in the OTC market. However, C_0's liquidity shock puts him in a weak bargaining position with C_1: C_0 has a low outside option because he has no way to get liquidity if trade fails. As a result, he sells B's debt at a discounted price, recovering less than his initial investment. If the horizon mismatch is severe, then this loss from selling at a discount is so likely that C_0 is unwilling to lend in the first place. But if B's debt is demandable as well as tradeable, then debt does not trade at such a high discount in the secondary market. This is because demandability improves C_0's bargaining position with C_1. It increases his outside option, since he can redeem on demand when trade fails. As a result, C_0 can trade B's debt at a high price following a liquidity shock. Thus, C_0 is insured against liquidity shocks, making him willing to fund B's investment. In contrast to existing models of demandable debt, our model suggests that demandability complements tradeability—just the option to redeem on demand props up the resale price of debt in secondary markets even if the debt is never actually redeemed on demand in any state of the world.

Our second main result is that banknotes are susceptible to runs, in the sense that a sudden (but rational) change in beliefs can lead a creditor to redeem on demand, forcing B into inefficient liquidation. Observe that this run occurs even though B has only a single creditor—there is no static coordination problem in which multiple creditors race to be the first to withdraw from an issuing bank as in Diamond and Dybvig (1983); rather, there is a dynamic coordination problem in the secondary market in which a counterparty does not accept B's debt today because he is worried that his future counterparty will not accept B's debt tomorrow. Due to this self-fulfilling liquidity dry-up, B's creditor is suddenly unable to trade when he is hit by a liquidity shock and, thus, he must demand redemption from B. We refer to this run as a "money run" because it is the result of the failure of B's debt to function as a liquid money in the secondary market.

Policy. Our analysis suggests that financial fragility may be a necessary evil given secondary market trading frictions—money runs are the cost of the increased debt capacity afforded by demandable debt. However, decreasing secondary market trading frictions can make banks less reliant on demandable debt, decreasing the likelihood of runs. Thus, we suggest that to improve bank stability, a policy maker may be better off decreasing secondary market frictions than regulating banks directly. In contemporary markets, we think that centralized exchanges and clearing houses for bank bonds, like those for stocks, could decrease trading frictions in a way that decreases banks' reliance on overnight (effectively demandable) debt.

Unlike in Diamond and Dybvig's (1983) model of bank runs, in which suspension of convertibility restores efficiency, in our model suspension of convertibility may have an adverse effect. Since it prevents creditors from redeeming on demand to meet their liquidity needs, it leads to lower secondary market debt prices and, hence, constrained bank borrowing and inefficient investment.

Empirical content. As mentioned above, our model is motivated by empirical observations about financial fragility and circulating bank debt, such as banknotes and repos. In particular, our model offers an explanation of the following facts: (i) runs on bank debt are relatively common, even when the debt is backed by collateral; (ii) runs are often precipitated by the failure of debt to circulate in secondary markets; and (iii) banks choose to borrow via demandable debt even though it exposes them to costly runs.

Our model also casts light on several other stylized facts. (i) Demandable bank instruments, such as banknotes, deposits, and repos, are more likely to serve as media of exchange than other negotiable instruments, such as bonds and shares. In the model, this is because the option to redeem on demand props up the secondary market price of bank debt. Thus, if you hold a variety of instruments, you prefer to use demandable instruments to raise liquidity in the secondary market and to hold long-term instruments till maturity. (ii) Our model casts light on why bank debt is more likely to be demandable than corporate debt. Banks, almost by definition, have a horizon mismatch between their assets and liabilities—they perform maturity transformation. In the model, this horizon mismatch prevents you from borrowing via other instruments. Corporates are less likely to suffer from the horizon mismatch, and are therefore more likely to fund themselves with bonds or bank loans, which do not expose them to costly runs/liquidation. (iii) Our model casts light on why nineteenth-century banknotes traded at a greater discount in markets farther away from the issuing bank: distance from the issuer made the notes harder to redeem on demand, weakening note holders' bargaining positions in the secondary market and decreasing the price of banknotes (see Gorton (1996)). (iv) Our model generates runs even with a single depositor, consistent with the fact that many runs are not market-wide, but rather occur in isolation. Indeed, Krishnamurthy, Nagel, and Orlov (2014) find that repo runs occurred in relative isolation during the financial crisis.

Application to repos. Formally, repos are collateralized bilateral contracts, not circulating negotiable instruments like the banknotes in our model. However, repos share the key features of our banknotes: in addition to being exchanged OTC, they are effectively demandable and tradeable. They are effectively demandable because they are continuously rolled over (not settled and reopened daily). Thus, not rolling over a repo position is effectively redeeming on demand. They are effectively tradeable because repo collateral is constantly rehypothecated[3] (see Singh and Aitken (2010) and Singh (2010)). Thus, repo creditors use repos to get liquidity from third parties in the event of a liquidity shock, as creditors use tradeable debt to get liquidity in our model.

Related literature. Jacklin (1987) shows that tradeability substitutes for demandability in Diamond and Dybvig's (1983) environment. Intuitively, he suggests that you do not need to redeem debt on demand if you can just sell it in the secondary market. Indeed, he finds that demandability is useful only if there are trading restrictions on bank debt. Absent such trading restrictions, the bank can both implement the constrained-efficient outcome and eliminate the risk of runs by designing appropriate tradeable securities (which turn out to be dividend-paying equity shares). However, in practice bank debt is traded constantly—it is so liquid that bank debt such as banknotes, deposits, and repos are referred to as private money.[4] We show that Jacklin's conclusions hinge on his assumption that trade occurs in a centralized market. If bank debt is traded in an OTC market, like banknotes, deposits, and repos are, then demandability serves another purpose: it improves sellers' bargaining positions and thus increases the secondary market price of bank debt. As a result, banks optimally fund themselves with demandable debt to increase their debt capacity. Thus, demandability complements tradeability when debt is traded over the counter.

Our finding that demandability complements tradeability also contrasts with models such as Allen and Gale (2004), Antinolfi and Prasad (2008), Diamond (1997), and von Thadden (1999). In these models banks issue demandable debt *in spite of* trade in secondary markets, e.g. because banks help to overcome trading frictions, such as limited participation in financial markets. In our model, banks issue demandable debt *because of* trade in secondary markets—the option to redeem on demand improves the terms of trade in the secondary market.

Calomiris and Kahn (1991) and Diamond and Rajan (2001a, 2001b) present theories of demandable debt based on the idea that the option to redeem on demand can mitigate moral hazard problems.[5] They do not connect debt maturity to secondary market trade. Like us, Gorton and Pennacchi (1990) and He and Milbradt (2014) do.

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[3]So whereas the repo contract itself technically does not circulate, the repo collateral does. See Lee (2015) for a model focusing on collateral circulation.

[4]Theory papers that focus on how banks create money include Donaldson, Piacentino, and Thakor (2016), Gu, Mattesini, Monnet, and Wright (2013), and Kiyotaki and Moore (2001).

[5]In their conclusion, Diamond and Rajan (2001a) make the link between demandability and circulating bank notes informally, saying that

> deposits are readily transferable, and liquid, because buyers of deposits have no less ability to extract payment than do sellers of deposits. Thus, the deposits can serve as bank notes or checks that circulate between depositors. This could explain the special role of banks in creating inside money (p. 425).

We make this link formally in this paper.

Gorton and Pennacchi (1990) argue that short maturity makes debt information insensitive, and therefore mitigates adverse selection problems in secondary markets.[6] He and Milbradt (2014) study the interaction between bond market liquidity and corporate default. They suggest that secondary market liquidity is relatively high for short-maturity bonds and this encourages firms to borrow short-term.[7] Relatedly, our results suggest that demandable debt minimizes OTC trading frictions. Thus, our focus on secondary market liquidity allows us to rationalize demandable debt as an optimal contract and, further, to generate a new type of coordination-based bank runs, or "money runs." These runs are the result of dynamic coordination failures among counterparties in the secondary market. Thus, our analysis complements models in which runs are the result of dynamic coordination failures among depositors in the primary market, such as He and Xiong (2012).

Layout. In Section 2, we present the model. In Section 3, we present the main results. Section 4 is the conclusion. The Appendix contains all proofs and a table of notations.

2 Model

In this section, we present the model.

2.1 Players, Dates, and Technologies

There is a single good, which is the input of production, the output of production, and the consumption good. Time is discrete and the horizon is infinite, $t \in \{0, 1, ...\}$.

There are two types of players, a single penniless borrower B and infinitely many deep-pocketed creditors C_0, C_1, ... Everyone is risk-neutral and there is no discounting. B is penniless but has a positive-NPV investment. The investment costs c at Date 0 and pays off $y > c$ at a random time in the future, which arrives with intensity ρ. Thus, the investment has NPV $= y - c > 0$ and expected horizon $1/\rho$. B may also liquidate the investment before it pays off; the liquidation value is $\ell < c/2$.

B can fund its project by borrowing from a creditor. However, there is a horizon mismatch similar to that in Diamond and Dybvig (1983): creditors may need to consume before B's investment pays off. Specifically, creditors consume only if they suffer

[6] A number of other papers explore this idea further, including Dang, Gorton, and Hölmstrom (2015a, 2015b), Dang, Gorton, Hölmstrom, and Ordoñez (2015), and Gorton and Ordoñez (2014). Jacklin (1989) and Vanasco (2016) also explore the implications of secondary market trade for security design in environments with asymmetric information.

[7] He and Milbradt (2014) restrict attention to models of corporate bonds following Leland and Toft (1996). Therefore they do not consider contracts with the option to redeem on demand before maturity.

"liquidity shocks," which arrive at independent random times with intensity θ (after which they die). In other words, a creditor's expected "liquidity horizon" is $1/\theta$.

2.2 Borrowing Instruments

At Date 0, B borrows the investment cost c from its initial creditor C_0 and negotiates a repayment $R \leq y$ to make when the investment pays off. We refer to this promised repayment as B's "debt." (However, it can also represent an equity claim; debt and equity have equivalent payoffs, since the terminal payoff y is deterministic.)

In addition to the repayment R, two other characteristics define B's debt: *tradeability* and *demandability*. If B's debt is non-tradeable, then B must repay C_0. In contrast, if B's debt is tradeable, creditors can exchange the debt among themselves—the debtholder at Date t, denoted H_t, may not be the initial creditor C_0—and B must repay whichever creditor H_t holds its debt. If B's debt is not demandable, i.e. it is "long-term," then B repays only when its investment pays off. In contrast, if B's debt is demandable, then the debtholder can demand repayment at any date. In this case, if B's investment has not paid off, B liquidates its investment and repays the liquidation value ℓ.

In summary, B borrows via one of four types of debt instrument: (i) non-tradeable long-term debt, which we refer to as a "loan"; (ii) non-tradeable demandable debt, which we refer to as a "puttable loan"; (iii) tradeable long-term debt, which we refer to as a "bond"; or (iv) tradeable demandable debt, which we refer to as a "banknote," although it also resembles a bank deposit or a repo. These instruments are summarized in Figure 1. These instruments are effectively all of the feasible Markovian instruments, i.e. contracts that can depend on the state of B's investment at Date t, but not on the date itself, and do not violate B's limited-liability constraint.[8]

[8] Here we are making two implicit assumptions that may be worth highlighting. (i) We have implicitly ruled out contracts that depend on creditors' liquidity shocks. This is an important assumption to generate a reason for a seconardary market—if liquidity shocks were contractable, then there would be no role for retrade since the first best could be implemented with contingent contracts à la Arrow–Debreu. In other words, we assume that the Markov state is the state of B's investment only. (ii) We have implicitly ruled out contracts in which B promises a repayment less that the liquidation value ℓ in the event that debt is demanded early. This is just for simplicity—it helps to streamline the analysis but does not substantively affect the equilibrium.

Figure 1: Debt Instruments

	not demandable	demandable
non-tradeable	"loan"	"puttable loan"
tradeable	"bond"	"banknote" (deposits or repos)

We let v_t denote the Date-t value of B's debt to a creditor not hit by a liquidity shock.

2.3 Secondary Debt Market: Search, Bargaining, and Settlement

If B has borrowed via tradeable debt, then creditors can trade it bilaterally in an OTC market. At each Date t, C_t is the (potential) counterparty with whom the debtholder H_t may trade B's debt. C_t can pay a search cost[9] k to be matched with the debtholder H_t. If matched, C_t and H_t Nash bargain[10] to determine the price p_t at which they trade. If they agree on a price, then trade is settled: C_t becomes the debtholder in exchange for p_t units of the good. Otherwise, H_t retains the debt. If the debt is demandable, H_t can demand redemption from B or he can remain the debtholder at Date $t+1$. This sequence of search, bargaining, and settlement is illustrated in Figure 2.

We let σ_t denote C_t's mixed strategy if H_t is hit by a liquidity shock, so $\sigma_t = 1$ means that C_t searches for sure and $\sigma_t = 0$ means that C_t does not search. Thus, σ_t also represents the probability that H_t finds a counterparty when hit by a liquidity shock. Observe that we restrict attention to C_t's strategy given H_t is hit by a liquidity shock without loss of generality.[11]

2.4 Timeline

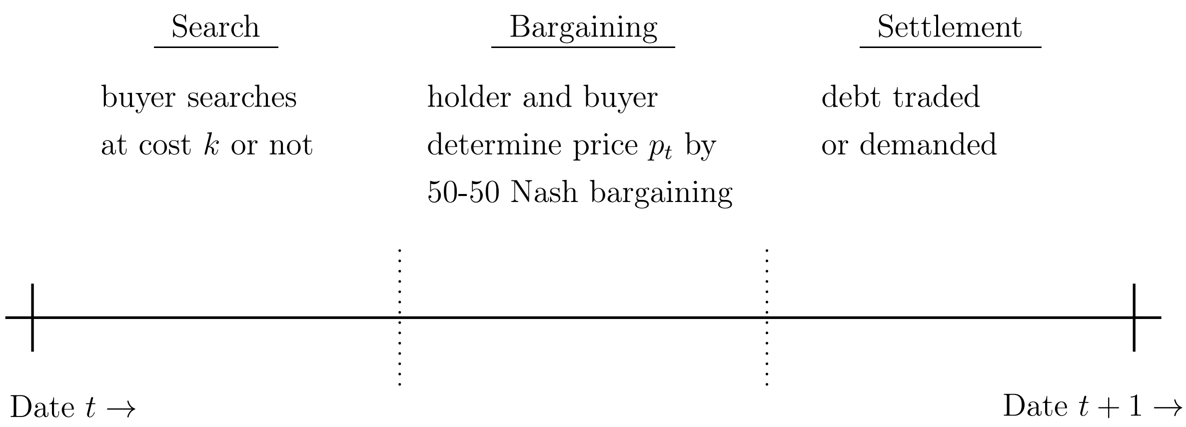
First, B chooses a debt instrument—a loan, a puttable loan, a bond, or a banknote, as described in Subsection 2.2 above. Next, B and the initial creditor C_0 negotiate the

[9] Our results also obtain if the search cost is zero but the debtholder must pay a per-period holding cost δ as in Duffie, Gârleanu, and Pedersen (2005). Indeed, the model is equivalent if $\delta = \big(\rho + (1-\rho)\theta\big)k$. To see this, compute the expected holding cost of the counterparty C_t. If he becomes the debtholder, he holds the debt as long as B's project does not pay off and he is not hit by a liquidity shock. Thus, at a given date he continues to hold B's debt with probability $1-(1-\rho)(1-\theta)$. From the formula for the expectation of a geometric distribution, the expected holding cost is thus $[1-(1-\rho)(1-\theta)]^{-1}\delta$. Setting this equal to k gives the expression above.

[10] To economize on notation, we assume that all bargaining is "symmetric" or "50-50" Nash bargaining as in Nash (1950).

[11] The reason that this is without loss of generality is that C_t would never search for H_t if he were not hit by a liquidity shock: if H_t is not hit by a liquidity shock, H_t and C_t are identical and there are no gains from trade, so it is never worth it to pay the search cost k for the opportunity to trade.

Figure 2: Secondary Market Trade



repayment R or fail to reach an agreement. If B and C_0 agree on R, then C_0 becomes the initial debtholder. Depending on the instrument, the debtholder may redeem on demand or may trade in the secondary market, as described in Subsection 2.3 above. Formally, the extensive form is as follows.

Date 0
- B chooses a debt instrument
- B is matched with C_0; B and C_0 Nash bargain to determine the repayment R
- If B and C_0 agree on R, then B invests c. C_0 is the initial debtholder, $\mathrm{H}_1 = \mathrm{C}_0$

Date $t > 0$
- If B's investment pays off
  - B repays R to H_t and B consumes $y - R$
- If B's investment does not pay off: C_t and H_t search, bargain, and settle as described in Subsection 2.3
  - If there is trade, C_t becomes the new debtholder, $\mathrm{H}_{t+1} = \mathrm{C}_t$
  - If there is no trade, H_t either holds the debt, $\mathrm{H}_{t+1} = \mathrm{H}_t$, or redeems on demand, in which case B repays ℓ to H_t and B consumes zero

2.5 Equilibrium

The solution concept is subgame perfect equilibrium. An equilibrium constitutes (i) the instrument and associated repayment R, (ii) the price of debt in the secondary market p_t at each date, and (iii) the search strategy σ_t of the potential counterparty C_t[12] such

[12] Formally, we could also include the debtholder's choice whether to redeem on demand. We omit this, however, and just assume that the debtholder redeems on demand whenever he is hit by a liquidity shock and does not trade the debt. This assumption is just for simplicity; it does not affect the equilibrium.

that B's choice of instrument and C_t's choice to search are sequentially rational, R and p_t are determined by Nash bargaining, and each player's beliefs are consistent with other players' strategies and the outcomes of Nash bargaining.

We focus on pure, stationary equilibria, i.e. $\sigma_t \equiv \sigma \in \{0,1\}$ and $p_t \equiv p$.

2.6 Assumption: Horizon Mismatch

We assume that parameters are such that there is a relatively severe horizon mismatch between B's investment and creditors' liquidity needs, as in Diamond and Dybvig (1983). In our infinite-horizon environment, this implies that the expected investment horizon $1/\rho$ must be sufficiently large relative to the expected liquidity horizon $1/\theta$. Specifically, we assume that the following condition holds:

$$\frac{1}{\rho} > \frac{1}{\theta}\,\frac{2(y-c)}{c\,(1-\rho)}. \tag{$\star$}$$

This assumption implies that B intermediates between short-horizon creditors and a long-horizon investment, making B resemble a bank. (We make this assumption to focus on the results that we think are most interesting/novel; we do not need it to characterize the equilibrium.)

3 Results

In this section, we present our main results.

3.1 Borrowing Constraint

We begin the analysis with a necessary condition for B to be able to borrow enough to fund its investment.

Lemma 1. *For a given instrument, B can borrow and invest if and only if the Date-0 value of its debt exceeds the cost of investment, i.e. if and only if*

$$v_0 \geq c \tag{\$}$$

for some repayment R.

We make use of this borrowing constraint repeatedly below when we consider each type of debt instrument in turn and ask whether B can borrow enough to undertake its investment.

3.2 Loan

First, we consider a loan, i.e. non-tradeable long-term debt. At Date t, the value v_t of the loan can be written recursively:

$$v_t = \rho R + (1-\rho)(1-\theta)v_{t+1}. \tag{1}$$

The terms are determined as follows. With probability ρ, B's investment pays off and B repays R. With probability $(1-\rho)\theta$, B's investment does not payoff and the debtholder H_t is hit by a liquidity shock. Since the loan is neither tradeable nor demandable, H_t gets zero. With probability $(1-\rho)(1-\theta)$, B's investment does not pay off and H_t is not hit by a liquidity shock. H_t retains B's debt at Date $t+1$, which has value v_{t+1} at Date t since there is no discounting.[13] By stationarity ($v_t = v_{t+1} \equiv v$), equation (1) gives

$$v = \frac{\rho R}{\rho + (1-\rho)\theta}. \tag{2}$$

Given the horizon mismatch assumption ($\star$), the expression above is always less than the cost of investment c. Thus, if B borrows via a loan, B cannot satisfy its borrowing constraint (\$) and therefore cannot invest.

LEMMA 2. *If B borrows via a loan, it cannot fund its investment.*

B cannot borrow from C_0 via a loan even though its project has positive NPV. This is because, given the horizon mismatch, C_0 is likely to be hit by a liquidity shock and need to consume before the project pays off, in which case C_0 gets zero, since the loan is neither tradeable nor demandable.

3.3 Puttable Loan

Now we consider a puttable loan, i.e. non-tradeable demandable debt. At Date t, the value v_t of the puttable loan can be written recursively:

$$v_t = \rho R + (1-\rho)\Big(\theta\ell + (1-\theta)v_{t+1}\Big). \tag{3}$$

The terms are determined as follows. With probability ρ, B's investment pays off and B repays R. With probability $(1-\rho)\theta$, B's investment does not payoff and the debtholder H_t is hit by a liquidity shock. Since the loan is demandable, but not tradeable, H_t redeems on demand and gets ℓ. With probability $(1-\rho)(1-\theta)$, B's investment does

[13] Formally, the value of holding B's debt is the Date-t *expected* value of B's debt at Date $t+1$, i.e. we should write $\mathbb{E}_t[v_{t+1}]$ instead of v_{t+1}. For now, we focus on deterministic equilibria. Thus, this difference is immaterial and we omit the expectation operator for simplicity. (In Subsection 3.7, we do keep track of the expectation operator.)

not pay off and H_t is not hit by a liquidity shock. H_t retains B's debt at Date $t+1$, which has value v_{t+1} at Date t since there is no discounting.

By stationarity ($v_t = v_{t+1} \equiv v$), equation (3) gives

$$v = \frac{\rho R + (1-\rho)\theta\ell}{\rho + (1-\rho)\theta}. \tag{4}$$

Given the horizon mismatch assumption ($\star$), the expression above is always less than the cost of investment c. Thus, if B borrows via a puttable loan, B cannot satisfy its borrowing constraint ($) and therefore cannot invest.

Lemma 3. *If B borrows via a puttable loan, it cannot fund its investment.*

Note that the value of the puttable loan (equation (4)) is greater than the value of the standard loan (equation (2)). Thus, demandability (i.e. "puttability") is adding value and loosening B's borrowing constraint. This is because it offers C_0 partial insurance against liquidity shocks: if C_0 is hit by a liquidity shock, he cannot necessarily get the full repayment R, but he can still demand redemption and at least get ℓ. This liquidity insurance may rationalize demandability in some circumstances. Indeed, it is reminiscent of the rationale for demandable debt in Calomiris and Kahn (1991), in that inefficient liquidation on the equilibrium path insures the creditor against bad outcomes.[14] In our setting, however, the horizon mismatch is so severe that early liquidation is relatively likely. Thus, it is too expensive for B to insure C_0 by liquidating its investment whenever C_0 needs liquidity. If B makes its debt tradeable, however, the secondary debt market provides C_0 with insurance, even without liquidation. We turn to this next.

3.4 Bond

Now we consider a bond, i.e. tradeable long-term debt. At Date t, the value v_t of the bond can be written recursively:

$$v_t = \rho R + (1-\rho)\Big(\theta\sigma_t p_t + (1-\theta)v_{t+1}\Big). \tag{5}$$

The terms are determined as follows. With probability ρ, B's investment pays off and B repays R. With probability $(1-\rho)\theta$, B's investment does not payoff and the debtholder H_t is hit by a liquidity shock. Since the bond is tradeable, but not demandable, H_t gets p_t if he finds a counterparty, which happens with probability σ_t, and nothing otherwise. With probability $(1-\rho)(1-\theta)$, B's investment does not pay off and H_t is not hit by a

[14] In Calomiris and Kahn (1991), "bad outcomes" are associated with moral hazard problems, rather than liquidity shocks.

liquidity shock. H_t retains B's debt at Date $t+1$, which has value v_{t+1} at Date t since there is no discounting.

To solve for the value v_t, we must first give the secondary market price of the bond p_t.

Lemma 4. *The secondary market price of the bond is $p_t = v_t/2$.*

The bond price splits the gains from trade fifty-fifty between H_t and C_t, given that H_t is hit by a liquidity shock. Since H_t has value zero in this case (H_t dies at the end of the period and the bond is not demandable), the gains from trade are just the value v_t of the bond to the new debtholder C_t.

By stationarity ($v_t = v_{t+1} \equiv v$ and $\sigma_t \equiv \sigma$), the preceding lemma implies $p_t \equiv p \equiv v/2$, so equation (5) gives

$$v = \frac{\rho R}{\rho + (1-\rho)\theta\big(1 - \sigma/2\big)}. \tag{6}$$

Given the horizon mismatch assumption ($\star$), the expression above is always less than the cost of investment c, even if the bond circulates (i.e. $\sigma = 1$). Thus, if B borrows via a bond, B cannot satisfy its borrowing constraint (\$) and therefore cannot invest.

Lemma 5. *If B borrows via a bond, it cannot fund its investment.*

As in the case of the puttable loan above, the value of the bond (equation (6)) is greater than the value of the standard loan (equation (2)).[15] Thus, tradeability is adding value, loosening B's borrowing constraint. This is because it offers C_0 partial insurance against liquidity shocks: if C_0 is hit by a liquidity shock, it cannot necessarily get the full repayment R, but it can still sell the bond in the secondary market and at least get $p = v/2$. This is the first step in showing that tradeability in the secondary market, or "market liquidity," helps loosen borrowing constraints in the primary market, or improves "funding liquidity." However, trading frictions in the OTC market depress the secondary market bond price ($p << v$). Thus, despite tradeability, liquidity shocks are costly for creditors and ultimately tradeability alone is not enough for B to get its investment up and running.

3.5 Banknote

Now we consider a banknote, i.e. tradeable, demandable debt. At Date t, the value v_t of the banknote can be written recursively:

[15] The value of the bond is strictly greater than the value of the loan as long as the bond circulates ($\sigma > 0$). Otherwise the values coincide.

$$v_t = \rho R + (1-\rho)\Big(\theta\big(\,\sigma_t p_t + (1-\sigma_t)\ell\,\big) + (1-\theta)v_{t+1}\Big). \tag{7}$$

The terms are determined as follows. With probability ρ, B's investment pays off and B repays R. With probability $(1-\rho)\theta$, B's investment does not payoff and the debtholder H_t is hit by a liquidity shock. Since the banknote is both tradeable and demandable, H_t gets p_t if he finds a counterparty, which happens with probability σ_t, and otherwise redeems on demand and gets ℓ. With probability $(1-\rho)(1-\theta)$, B's investment does not pay off and H_t is not hit by a liquidity shock. H_t retains the banknote at Date $t+1$, which has value v_{t+1} at Date t since there is no discounting.

To solve for the value v_t, we must first give the secondary market price of the banknote p_t.

LEMMA 6. *The secondary market price of the banknote is* $p_t = (v_{t+1} + \ell)/2$.

The price of the banknote splits the grains from trade fifty-fifty between H_t and C_t, given that H_t is hit by a liquidity shock. Since H_t has value ℓ (H_t redeems on demand and gets ℓ if he does not trade with C_t), the grains from trade are $v_t - \ell$, the value to the new debtholder C_t minus the value to the current debtholder H_t. The price that splits these gains is $p_t = \ell + (v_t - \ell)/2 = (v_t + \ell)/2$. Critically, the secondary market price of the banknote is higher than the secondary market price of the bond. This is because the option to redeem on demand improves H_t's bargaining position, since H_t gets a higher payoff if bargaining breaks down. Even if no debtholder ever demands redemption from B in the primary market, the option to do so can have important implications for the price of debt in the OTC secondary market.

This result suggests that the more costly it is to liquidate (the lower is ℓ), the lower is the secondary market price p_t. This may cast light on the fact that nineteenth-century banknotes traded at a discount in markets far from the issuing bank, and that this discount was increasing in the distance to the issuer (Gorton (1996)): the farther you were from the issuer, the costlier it was for you to liquidate on demand and thus the weaker your bargaining position in the OTC market.

By stationarity ($v_t = v_{t+1} \equiv v$ and $\sigma_t \equiv \sigma$), the preceding lemma implies that $p_t \equiv p \equiv (v+\ell)/2$, so equation (7) gives

$$v = \frac{\rho R + (1-\rho)\theta\big(1-\sigma/2\big)\ell}{\rho + (1-\rho)\theta\big(1-\sigma/2\big)}. \tag{8}$$

Despite the horizon mismatch assumption ($\star$), the expression above may be greater than the cost of investment c. Thus, if B borrows via a banknote, B may be able to satisfy his borrowing constraint ($) and therefore invest.

Proposition 1. (Demandability increases debt capacity.) *Suppose that*

$$\frac{1}{\theta}\frac{2(y-c)}{(c-\ell)(1-\rho)} \geq \frac{1}{\rho}. \tag{9}$$

If B borrows via a banknote and the banknote circulates ($\sigma = 1$), then B can fund its investment.

B can increase its debt capacity by borrowing via demandable debt, even if it is never redeemed on demand on the equilibrium path. This proposition thus suggests a new rationale for demandable debt: it props up the price in secondary markets and thereby loosens borrowing constraints in primary markets. Demandability increases the market liquidity of B's debt, which provides creditors with insurance against liquidity shocks in the future. This makes them more willing to provide B with funding liquidity today. Thus, market liquidity and funding liquidity are complements and, likewise, tradeability and demandability are complements.

Further, we think this result casts light on why bank debt is more likely to be demandable than corporate debt: banks are more likely to have a horizon mismatch between their assets and liabilities, i.e. the horizon mismatch assumption ($\star$) is more likely to hold for banks than for other firms. This is because banks, almost by definition, transform maturity to meet the needs of short-term depositors and long-term borrowers. Thus, other firms may prefer to borrow via long-term debt, especially since borrowing via tradeable, demandable debt makes B vulnerable to runs, as we describe next.

3.6 Money Runs

Having established that B can borrow only with tradeable, demandable debt (banknotes), we now turn to secondary market liquidity and the possibility that a debtholder demands early redemption. To do this, we assume that B has issued a banknote with promised repayment R and look at the equilibria of the subgames for $t > 0$.

First, observe that B's banknote indeed circulates as long as $\sigma_t = 1$ is a best response to the belief that $\mathrm{C}_{t'}$ plays $\sigma_{t'} = 1$ for all $t' > t$. This is the case as long as C_t is willing to pay the search cost k to gain the surplus $v - p$ given $\sigma = 1$, or

$$k \;\leq\; v - p\,\Big|_{\sigma=1} = \frac{\rho(R-\ell)}{2\rho + (1-\rho)\theta}, \tag{10}$$

having substituted in from Lemma 6 and equation (8).

But there may also be another equilibrium in which B's banknote does not circulate. B's banknote does not circulate as long as $\sigma_t = 0$ is a best response to the belief that $\mathrm{C}_{t'}$ plays $\sigma_{t'} = 0$ for all $t' > t$. This is the case as long as C_t is *not* willing to pay the search cost k to gain the surplus $v-p$ given $\sigma=0$, or

$$k \geq v-p\,\Big|_{\sigma=0} = \frac{1}{2}\frac{\rho(R-\ell)}{\rho+(1-\rho)\theta}, \tag{11}$$

again having substituted in from Lemma 6 and equation (8).

Proposition 2. (Money runs.) *Suppose that B borrows via a banknote with promised repayment R and the search cost k is such that*

$$\frac{1}{2}\frac{\rho(R-\ell)}{\rho+(1-\rho)\theta} \leq k \leq \frac{\rho(R-\ell)}{2\rho+(1-\rho)\theta}. \tag{12}$$

The $t>0$ subgame has both an equilibrium in which B's debt debt circulates ($\sigma=1$) and there is no early liquidation and an equilibrium in which B's debt does not circulate ($\sigma=0$) and there is early liquidation.

Thus demandable debt has a dark side: if a counterparty C_t doubts future liquidity, i.e. he doubts that he will find a counterparty in the future, then C_t will not search. As a result, the debtholder H_t indeed will not find a counterparty. There is a self-fulfilling dry-up of secondary market liquidity. With demandable debt, this has severe real effects: unable to trade, H_t redeems its debt on demand, leading to costly liquidation of B's investment. In other words, a change in just the beliefs about future liquidity leads to the failure of B's debt as a medium of exchange in the secondary market—the failure of B's debt as money. As a result, there is sudden withdrawal of liquidity from B, i.e. a bank run, or a *money run.*

Corollary 1. *Suppose k satisfies condition (12). If C_t's beliefs change from $\sigma_{t'}=1$ to $\sigma_{t'}=0$ for $t'>t$, the debtholder H_t "runs" on B, i.e. H_t unexpectedly demands redemption of his debt, forcing B to liquidate its investment.*

Demandability cuts both ways in the secondary market. It increases B's debt capacity by creating market liquidity, propping up the price of B's debt. But it also exposes B to money runs, since B must provide liquidity on demand if market liquidity dries up. Thus, financial fragility may be a necessary evil, resulting from the need to overcome funding constraints given a horizon mismatch between the investment and the creditors' liquidity needs.

3.7 Equilibrium Runs

We now turn to characterizing an equilibrium in which B borrows via a banknote and money runs arise on the equilibrium path. To do this, we expand the model slightly to introduce a "sunspot" coordination variable at each date, $s_t \in \{0,1\}$. We will interpret $s_t = 1$ as "normal times" and $s_t = 0$ as a "confidence crisis," since the sunspot does not affect economic fundamentals, but serves only as a way for agents to coordinate their beliefs. We assume that $s_0 = 1$, that $\mathbb{P}[s_{t+1} = 0 \,|\, s_t = 1] =: \lambda$, and that $\mathbb{P}[s_{t+1} = 0 \,|\, s_t = 0] = 1$, where we think about λ as a small number. In words: the economy starts in normal times and a permanent confidence crisis occurs randomly with small probability λ.

We now look for a Markov equilibrium, i.e. an equilibrium in which the sunspot (rather than the whole history) is a sufficient statistic for C_t's action:

$$\sigma_t = \begin{cases} \sigma^1 & \text{if } s_t = 1, \\ \sigma^0 & \text{if } s_t = 0. \end{cases} \tag{13}$$

Note that the baseline case of a stationary equilibrium is the special case of $\lambda = 0$. We can now write the banknote's value v^0 when $s_t = 0$ and v^1 when $s_t = 1$ (cf. the analogous equation for the stationary case in equation (7)):

$$v^0 = \rho R + (1-\rho)\Bigg(\theta\Big(\sigma^0 p^0 + \big(1-\sigma^0\big)\ell\Big) + (1-\theta)v^0\Bigg), \tag{14}$$

$$v^1 = \rho R + (1-\rho)\Bigg(\theta\Big(\sigma^1 p^1 + \big(1-\sigma^1\big)\ell\Big) + (1-\theta)\Big(\lambda v^0 + (1-\lambda)v^1\Big)\Bigg). \tag{15}$$

The next proposition characterizes an equilibrium in which the "confidence crisis" induces a money run.

Proposition 3. (Equilibrium with sunspot runs.) *Suppose that the condition in equation (9) is satisfied. As long as λ is sufficiently small, there exists k such that B can fund its investment only with tradeable, demandable debt (a banknote), even though it admits a money run when $s_t = 0$. Specifically, C_t plays $\sigma_t = s_t$, and the value of the banknote when $s_t = 0$ is*

$$v^0 = \frac{\rho R + (1-\rho)\theta\ell}{\rho + (1-\rho)\theta} \tag{16}$$

the value of the banknote when $s_t = 1$ is

$$v^1 = \frac{\rho R + (1-\rho)\Big(\theta\ell/2 + (1-\theta/2)\lambda v_0\Big)}{\rho + (1-\rho)\big(\theta/2 + (1-\theta/2)\lambda\big)}, \tag{17}$$

and the promised repayment is

$$R = y - \frac{\big(\rho + (1-\rho)\theta\big)\big(\rho + (1-\rho)\lambda\big)}{\rho\Big(\rho + (1-\rho)\big(\theta + (1-\theta)\lambda\big)\Big)}\big(v^1 - c\big). \tag{18}$$

We have written the system recursively, expressing v^1 as a function of v^0 and R as a function of v^1, for simplicity. We give a closed-form expression for R in terms of primitives in Appendix 3.

4 Conclusion

One important function of banks is to create money, i.e. to issue debt that circulates in OTC markets. By focusing on this function of banks, we found a new type of bank runs—"money runs"—and a new rationale for demandable debt, both of which are the result of how bank debt circulates—or fails to circulate—in secondary markets. Money runs occur because secondary-market liquidity is fragile and self-fulfilling. Banks issue demandable debt because its secondary-market price is high. Our results provide a counterpoint to the literature. They suggest that financial fragility may be a necessary evil and that regulating markets may be a better way to mitigate it than regulating banks themselves.

A Proofs

A.1 Proof of Lemma 1

The result follows immediately from C_0's participation constraint: B and C_0 find an agreement point if and only if bargaining gives both more than their disagreement utilities. Since C_0 receives v_0 from bargaining, this must exceed its cost c. $\square$

A.2 Proof of Lemma 2

By Lemma 1, B can invest only if $v_0 = v \geq c$ or, by equation (2),

$$\frac{\rho R}{\rho + (1-\rho)\theta} \geq c. \tag{19}$$

This says that

$$\frac{1}{\theta}\frac{R-c}{c\,(1-\rho)} \geq \frac{1}{\rho} \tag{20}$$

which violates the assumption ($\star$) since $R \leq y$. $\square$

A.3 Proof of Lemma 3

By Lemma 1, B can invest only if $v_0 = v \geq c$ or, by equation (4),

$$\frac{\rho R + (1-\rho)\theta\ell}{\rho + (1-\rho)\theta} \geq c. \tag{21}$$

Since $\ell < c/2$, a necessary condition for this is that

$$\frac{\rho R + (1-\rho)\theta c/2}{\rho + (1-\rho)\theta} \geq c. \tag{22}$$

This says that

$$\frac{1}{\theta}\frac{2\,(R-c)}{c\,(1-\rho)} \geq \frac{1}{\rho} \tag{23}$$

which violates the assumption ($\star$) since $R \leq y$. $\square$

A.4 Proof of Lemma 4

When C_t and H_t are matched H_t has been hit by a liquidity shock. Thus, C_t's value of the bond is v_t and H_t's value of the bond is zero (since H_t consumes only at Date t and the bond is not demandable). The total surplus is thus v_t, which C_t and H_t split fifty-fifty in accordance with the Nash bargaining solution. Thus the price is $p_t = v_t/2$.

A.5 Proof of Lemma 5

By Lemma 1, B can invest only if $v_0 = v \geq c$ or, by equation (6),

$$\frac{\rho R}{\rho + (1-\rho)\theta\big(1-\sigma/2\big)} \geq c. \tag{24}$$

This is increasing in σ, so a necessary condition is that the above holds for $\sigma = 1$, or

$$\frac{\rho R}{\rho + (1-\rho)\theta/2} \geq c. \tag{25}$$

This says that

$$\frac{1}{\theta}\frac{2\,(R-c)}{c\,(1-\rho)} \geq \frac{1}{\rho} \tag{26}$$

which violates the assumption ($\star$) since $R \leq y$. $\square$

A.6 Proof of Lemma 6

When C_t and H_t are matched H_t has been hit by a liquidity shock. Thus, C_t's value of the banknote is v_t and H_t's value of the banknote is ℓ (since H_t consumes only at Date t, it redeems on demand if it does not trade). The grain from trade are thus $v_t - \ell$, which C_t and H_t split fifty-fifty in accordance with the Nash bargaining solution, i.e. p_t is such that

$$\mathrm{H}_t \text{ gets} \quad \frac{1}{2}\big(v_t - \ell\big) + \ell = p_t, \tag{27}$$

$$\mathrm{C}_t \text{ gets} \quad \frac{1}{2}\big(v_t - \ell\big) = v_t - p_t, \tag{28}$$

or $p_t = (v_t + \ell)/2$.

A.7 Proof of Proposition 1

By Lemma 1, B can invest if $v_0 = v \geq c$ or, by equation (8) with $\sigma = 1$,

$$\frac{2\rho R + (1-\rho)\theta\ell}{2\rho + (1-\rho)\theta} \geq c. \tag{29}$$

This says that

$$\frac{1}{\theta}\frac{2\,(R-c)}{(c-\ell)\,(1-\rho)} \geq \frac{1}{\rho}. \tag{30}$$

This is feasible for any $R \leq y$, i.e. as long as

$$\frac{1}{\theta}\frac{2\,(y-c)}{(c-\ell)\,(1-\rho)} \geq \frac{1}{\rho}, \tag{31}$$

which is the condition in the proposition (note this is mutually compatible with the horizon mismatch assumption ($\star$)). $\square$

A.8 Proof of Proposition 2

The argument is in the text.

A.9 Proof of Corollary 1

The result follows immediately from Proposition 2.

A.10 Proof of Proposition 3

We first solve for the values v^0 and v^1 given the strategies $\sigma^0 = 0$ and $\sigma^1 = 1$. We then show that these strategies are indeed best responses (for some k). Finally, we compute the repayment R in accordance with the Nash bargaining solution.

Values. From equation (14) with $\sigma^0 = 0$, we have immediately that

$$v^0 = \frac{\rho R + (1-\rho)\theta\ell}{\rho + (1-\rho)\theta} \tag{32}$$

(this is just the value of the puttable loan in equation (4)). From Lemma 6 (the logic of which is not affected by the presence of sunspots), we have the price

$$p^1 = \frac{\lambda v^0 + (1-\lambda)v^1 + \ell}{2}. \tag{33}$$

Thus, equation (15) with $\sigma^1 = 1$ reads

$$v^1 = \rho R + (1-\rho)\left(\theta\,\frac{\lambda v^0 + (1-\lambda)v^1 + \ell}{2} + (1-\theta)\Big(\lambda v^0 + (1-\lambda)v^1\Big)\right), \tag{34}$$

so

$$v^1 = \frac{\rho R + (1-\rho)\Big(\theta\ell/2 + (1-\theta/2)\lambda v_0\Big)}{\rho + (1-\rho)\big(\theta/2 + (1-\theta/2)\lambda\big)} \tag{35}$$

Best responses. $\sigma^1 = 1$ and $\sigma^0 = 0$ are best response if

$$v^0 - p^0 \;\leq\; k \;\leq\; v^1 - p^1 \tag{36}$$

or

$$v^0 - \frac{v^0 + \ell}{2} \;\leq\; k \;\leq\; v^1 - \frac{\lambda v^0 + (1-\lambda)v^1 + \ell}{2}. \tag{37}$$

This is satisfied for some k as long as $v^1 \geq v^0$, which is the case as long as $R \geq \ell$, which must be the case.

Repayment. The repayment R is determined by Nash bargaining between B and C_0. Now denote B's value in state s by u^s. Since the state is $s = 1$ at Date 0, B and C_0 agree on a repayment R such that B's value is u^1 and C_0's value is v^1. The gains from trade are thus $u^1 + v^1 - c$. R is thus such that

$$\text{B gets} \quad \frac{1}{2}\big(u^1 + v^1 - c\big) = u^1, \tag{38}$$

$$\text{C}_0 \text{ gets} \quad \frac{1}{2}\big(u^1 + v^1 - c\big) + c = v^1, \tag{39}$$

so $u^1 = v^1 - c$.

From the expressions above we can compute R in terms of primitives. First we compute B's value u^0 in state 0. In this case, the banknote does not circulate and the banknote is effectively like the puttable loan in Subsection 3.3. Whenever the creditor is hit by a liquidity shock, he redeems on demand and B liquidates and gets zero. B's value is thus

$$u^0 = \rho(y - R) + (1 - \rho)(1 - \theta)u^0 \tag{40}$$

or

$$u^0 = \frac{\rho(y - R)}{\rho + (1 - \rho)\theta}. \tag{41}$$

Now, B's value in state 1 is given by

$$u^1 = \rho(y - R) + (1 - \rho)\Big((1 - \lambda)u^1 + \lambda(1 - \theta)u^0\Big) \tag{42}$$

or, substituting in for u^0 from equation (41) above,

$$u^1 = \frac{\rho(y - R)}{\rho + (1 - \rho)\lambda}\left(1 + \frac{(1 - \rho)\lambda(1 - \theta)}{\rho + (1 - \rho)\theta}\right). \tag{43}$$

Substituting for this into the bargaining outcome $u^1 = v^1 - c$ gives the expression for the repayment R in terms of v_1 as stated in the proposition.

Now we can also substitute for v^1 from equation (35) and v_0 from equation (32) above to get

$$R = \frac{Ay + Bc - C\ell}{D} \tag{44}$$

where the constants A, B, C, and D are defined as follows:

$$
\begin{aligned}
A &= \Big(2\big(\rho + (1-\rho)\lambda + (1-\rho)(1-\lambda)\theta\Big)\Big(\big(\rho + (1-\rho)\theta\big)\big(\rho + (1-\rho)\lambda\big) - (1-\rho)\theta\lambda\Big), \\
B &= \Big(2\big(\rho + (1-\rho)\lambda + (1-\rho)(1-\lambda)\theta\Big)\big(\rho + (1-\rho)\theta\big)\big(\rho + (1-\rho)\lambda\big), \\
C &= \big(\rho + (1-\rho)\lambda\big)(1-\rho)\Big(\rho + (1-\rho)\big(2\lambda + (1-\lambda)\theta\big)\Big), \\
D &= \rho\Big(\theta(5+4\lambda)(1-\rho)\big(\rho + (1-\rho)\lambda\big) + \theta^2(1-\lambda)^2(1-\rho)^2 + 4\big(\rho + (1-\rho)\lambda\big)^2\Big).
\end{aligned}
$$

B Table of Notations

	Players and Indices
t	time index
B	borrower or “bank”
C_t	(potential) creditor/counterparty at Date t
H_t	debtholder at Date t
	Technologies and Preferences
y	payoff of B’s investment
c	cost of B’s investment
ℓ	liquidation value of B’s investment
ρ	probability B’s investment pays off each date
θ	probability with which creditor is hit by liquidity shock at each date
	Prices, Values, and Strategies
R	B’s promised repayment (face value of debt)
v_t	value of B’s debt to a creditor at Date t
p_t	secondary market price of B’s debt at Date t
σ_t	mixed strategy of counterparty C_t
	Other Variables
s_t	sunspot at Date t (Subsection 3.7)
λ	$\mathbb{P}\left[s_{t+1}=0 \mid s_t=1\right]$, “confidence crisis” probability (Subsection 3.7)

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