MONEY RUNS

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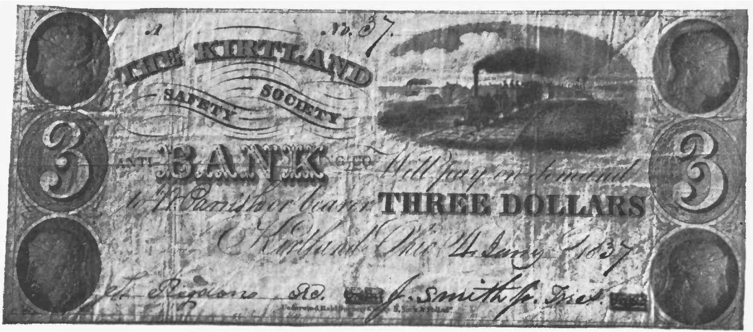
MAIN FUNCTION OF BANKS: MONEY CREATION

Bank of England estimates 97% of money created by banks

M3 includes deposits, repos, and money market fund shares


THE KIRTLAND
SAFETY SOCIETY
BANK
THREE DOLLARS
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19TH CENTURY MONEY—BANKNOTES

Banknotes were tradeable OTC

To get beer from barman, passed banknotes over the counter

Banknotes were fragile means of payment

"Note that passed freely yesterday rejected this morning"

Banknotes were redeemable on demand, exposing banks to runs

Bank runs followed failure banknotes to circulate

QUESTION

Why is it optimal for banks to issue demandable debt?

Especially since exposes them to sudden redemptions—runs

THIS PAPER

Model how banks create money given two assumptions

Assumption 1: Horizon mismatch

Creditors may need liquidity before investment payoff

Assumption 2: Decentralized trade

Bank debt traded bilaterally OTC in secondary market

RESULTS

1. New rationale for why bank debt is demandable

   Bright side of demandability: increases value as money

2. New type of bank run—“money run”

   Dark side of demandability: increases fragility as money

3. Ability to create demandable money leads to “banking”

   Endogenous intermediation, maturity/liq. transformation

NEW PERSPECTIVE ON POLICY

New perspective on conventional policies

E.g. costs/benefits of capital/liquidity requirements

Suggest to improve bank stability, improve market liquidity

E.g. CCP for repos (a form of contemporary private money)

MODEL

MODEL OVERVIEW

Discrete time infinite horizon $t \in \{0, 1, 2, ...\}$, no discounting

Two types of risk-neutral player: borrower B, creditors C_0, C_1, ...

B has investment, creditors have wealth

BORROWER B

B is penniless but has a positive NPV investment

Costs c and pays off y at random maturity, arrival rate ρ

$$\text{NPV} = y - c > 0$$

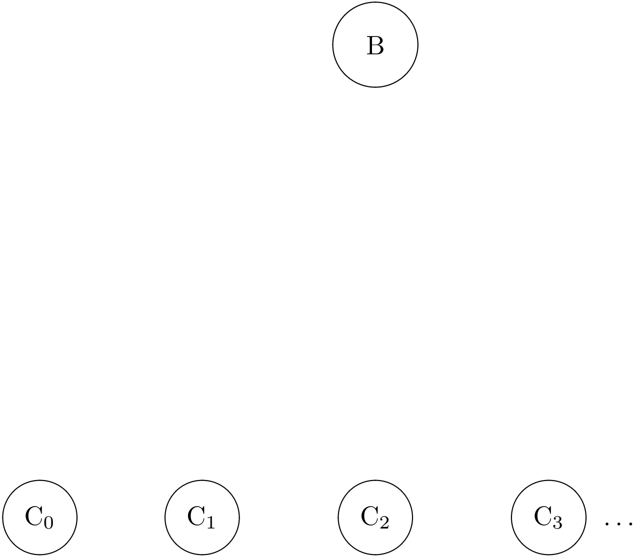
Can be liquidated early for $\ell < c/2$

CREDITORS C_0, C_1,...

Deep-pocketed

Liquidity shock at random time, arrival rate θ

PLAYERS



BORROWING INSTRUMENTS

B borrows c via debt with face value $R \leq y$ at maturity

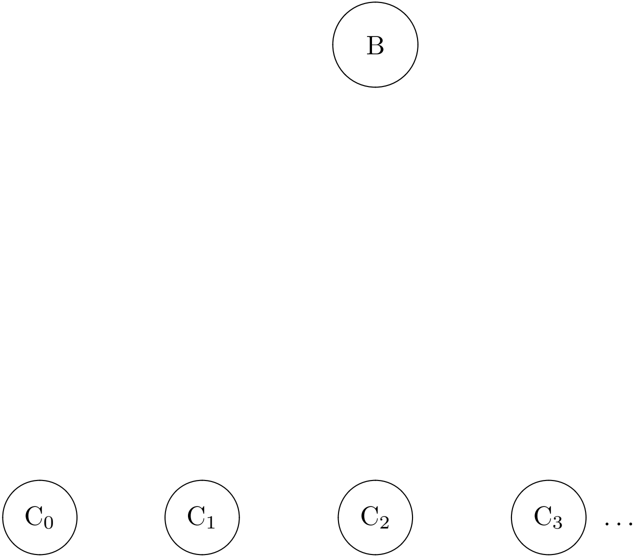
Long term or demandable

Tradeable or non-tradeable

v_t denotes value of debt to not-shocked creditor

p_t denotes its secondary market price

DEMANDABLE DEBT



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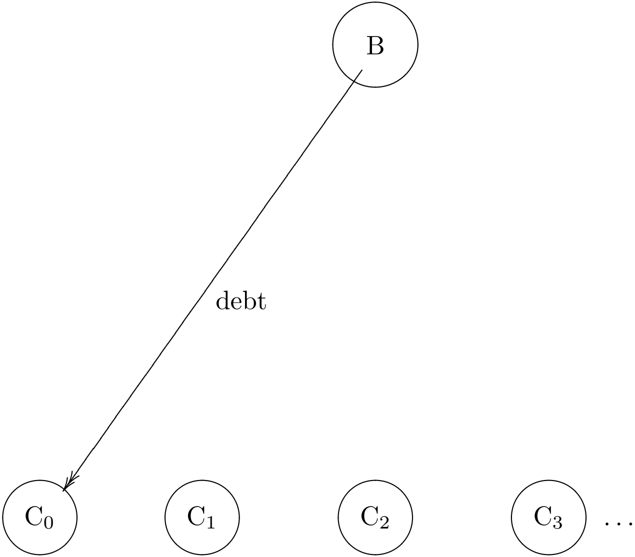

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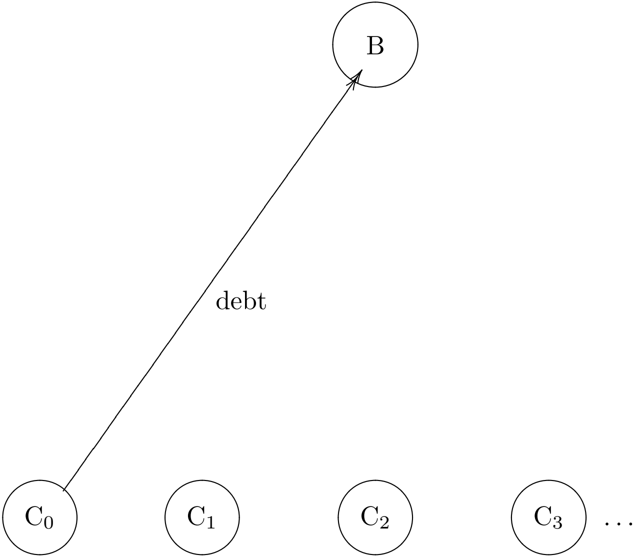
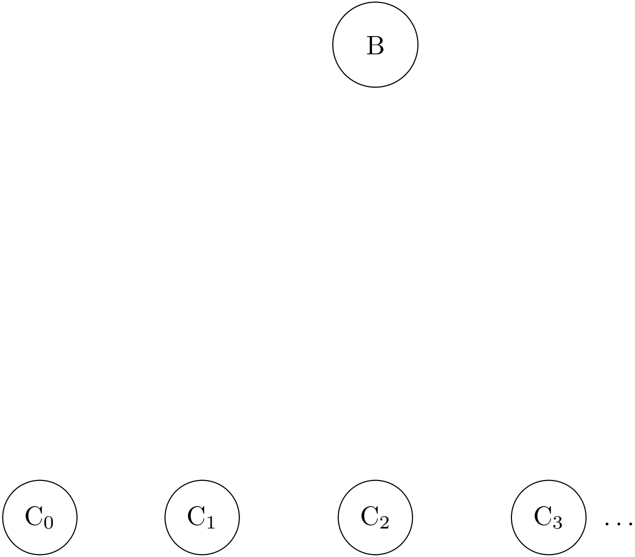


TRADEABLE DEBT



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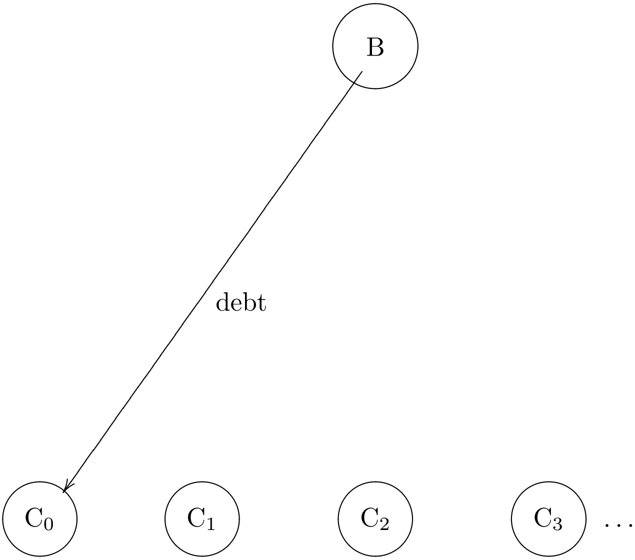

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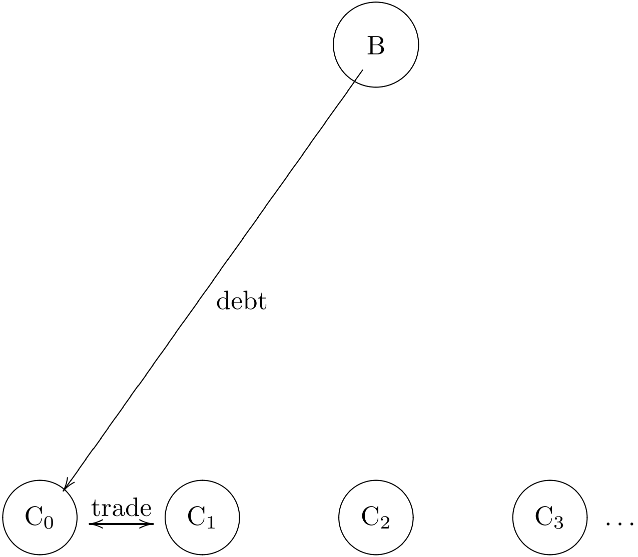

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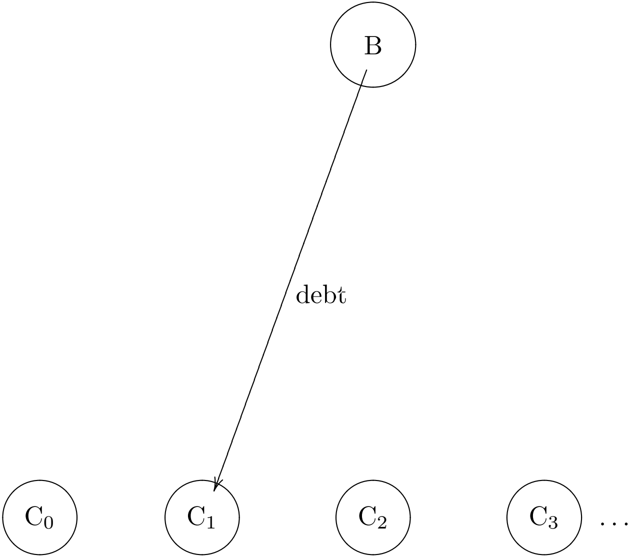

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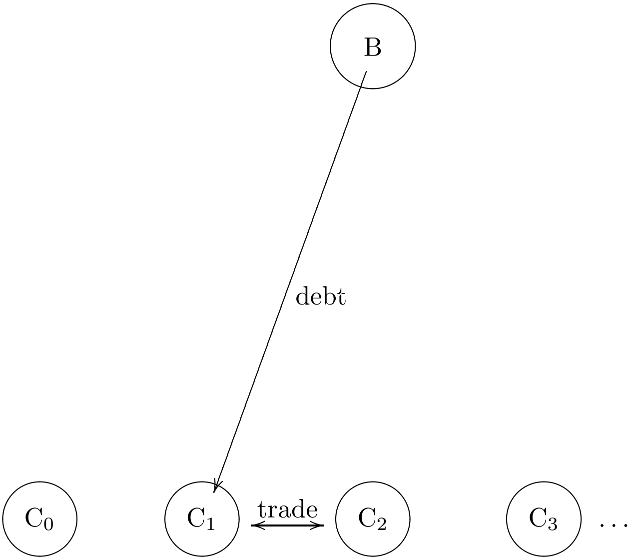

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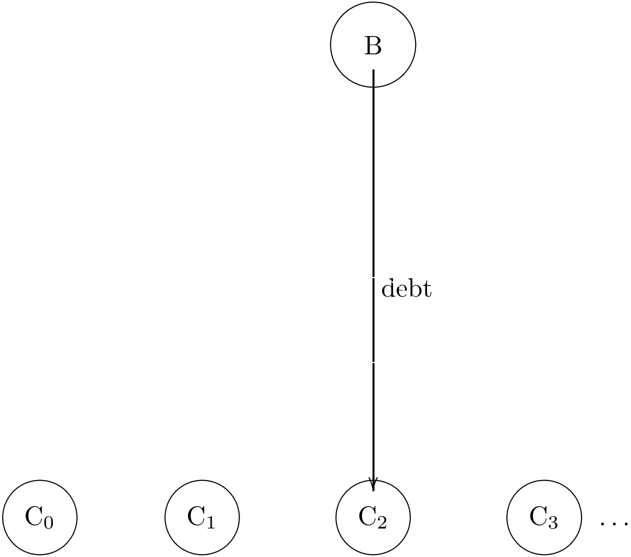

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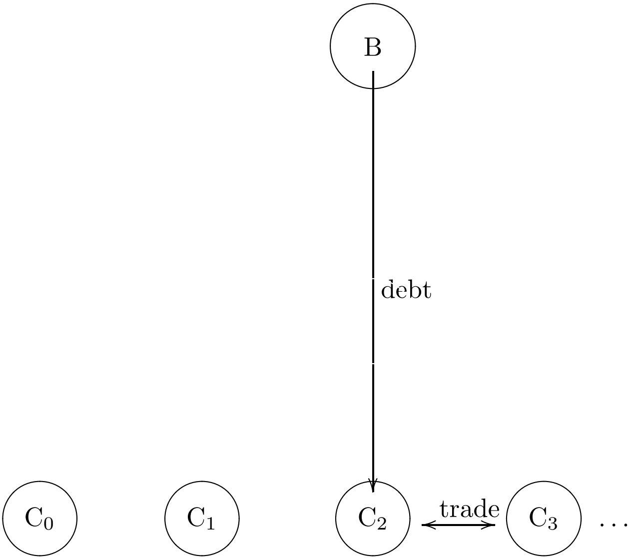

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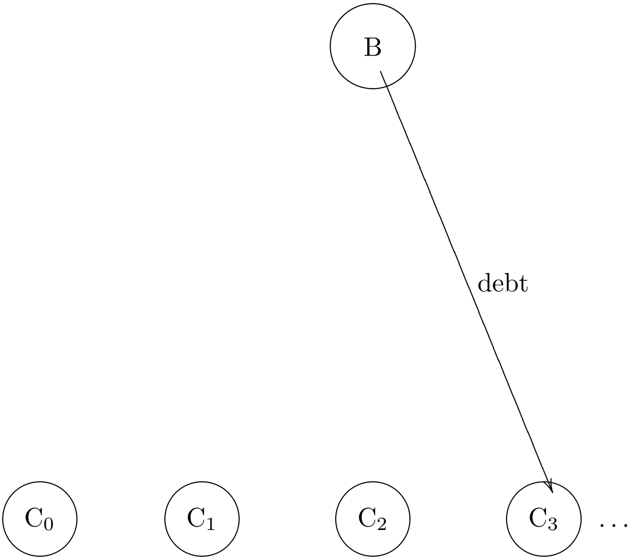

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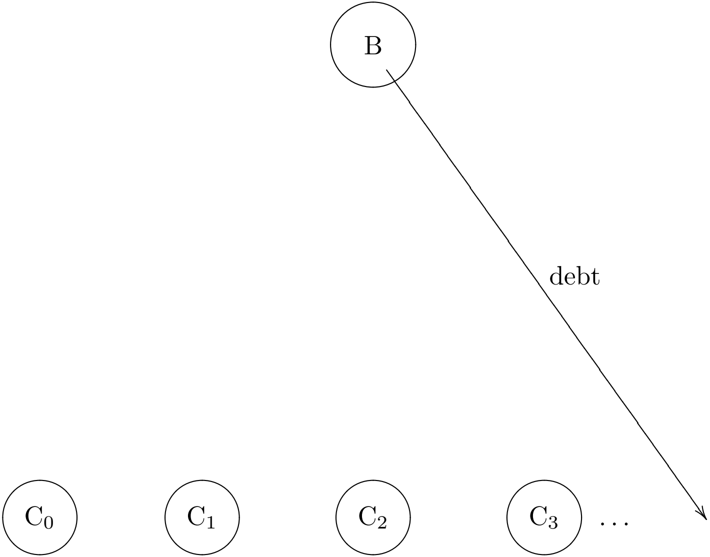


TIMELINE

Date 0

B borrows from C_0 and invests or does not

Date $t > 0$: if B's investment pays off

B repays R

Date $t > 0$: if B's investment does not pay off

Secondary debt market entry, bargaining, settlement

TRADEABILITY AND DEMANDABILITY

Entry

counterparty C_t
can enter at cost k

Bargaining

debtholder and C_t
determine price p_t
50-50 Nash bargaining

Settlement

debt traded
or demanded

Date $t \rightarrow$

Date $t+1 \rightarrow$

EQUILIBRIUM CONCEPT

Subgame perfect equilibrium

At Date 0, C_0 lends to B or does not

At Date $t > 0$, C_t enters with probability σ_t

σ_t is C_t's best response to others' strategies $\sigma_{\neg t}$

R and p_t outcomes of Nash bargaining

(Assume wlog C_t can enter iff debtholder has liquidity shock)

STATIONARY EQUILIBRIA

Focus on stationary equilibria: $\sigma_t = \sigma$ for all t

$\sigma = 1$ is circulating debt

$\sigma = 0$ is non-circulating debt

RESULTS

POSSIBLE INSTRUMENTS

	long-term	demandable
non-tradeable	“loan”	“puttable loan”
tradeable	“bond”	“banknote”

(All feasible Markovian instruments)

WHICH INSTRUMENT WILL B CHOOSE?

B chooses instrument to maximize payoff

s.t. borrowing constraint $v_0 \geq c$

Let's compute v_0 for each instrument in turn

LOAN

LOAN (NON-TRADEABLE LONG-TERM DEBT)

Value v_t of loan solves

$$v_t = \rho R + (1-\rho)\Big(\theta \times 0 + (1-\theta)v_{t+1}\Big)$$

So

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

LOAN (NON-TRADEABLE LONG-TERM DEBT)

Value v of loan solves

$$v = \rho R + (1-\rho)\left(\theta \times 0 + (1-\theta)v \qquad \right)$$

So

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

PUTTABLE LOAN

PUTTABLE (NON-TRADEABLE DEMANDABLE)

Value v of puttable loan solves

$$v = \rho R + (1 - \rho)\Bigg(\theta \ell + (1 - \theta)v\Bigg)$$

So

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

VS. CALOMIRIS–KAHN (1991)

Puttable loan does better than loan

Option to demand in "bad" state gives liquidity insurance

Analogous to rationale for demandable debt in Calomiris–Kahn

Option to demand in "bad" state prevents moral hazard

BOND

BOND (TRADEABLE LONG-TERM DEBT)

Bond traded OTC, price p_t determined by 50-50 Nash bargaining

Debtholder bargains with C_t to get

$$p_t = \text{ outside option } + \frac{1}{2} \times \text{ gains from trade}$$

Outside option zero (not demandable)

Gains from trade v_t

Thus $p_t = v_t/2$

BOND VALUE

Value v of bond solves

$$v = \rho R + (1-\rho)\Big(\theta\big(\sigma p + (1-\sigma)\times 0\big) + (1-\theta)v\Big)$$

So

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

BOND VS. LOAN

Like puttable loan, bond does better than loan

Trade is providing insurance in case of liquidity shock

But trading frictions in OTC market depress price $p \ll v$

BANKNOTE

BANKNOTE (TRADEABLE DEMANDABLE) PRICE

Banknote traded OTC, price p_t determined by Nash bargaining

Debtholder bargains with C_t to get

$$p_t = \text{ outside option } + \frac{1}{2} \times \text{ gains from trade}$$

Outside option ℓ (demandable)

Gains from trade $v_t - \ell$

Thus $p_t = \ell + \frac{1}{2}\big(v_t - \ell\big) = \dfrac{v_t + \ell}{2}$

BANKNOTE VALUE

Value v of banknote solves

$$v = \rho R + (1-\rho)\left(\theta\Big(\sigma p + (1-\sigma)\ell\Big) + (1-\theta)v\right)$$

So

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

INSTRUMENT VALUES

	long-term	demandable
non-tradeable	$v_{\text{loan}} = \dfrac{\rho R}{\rho + (1-\rho)\theta}$	$v_{\text{putt.}} = \dfrac{\rho R + (1-\rho)\theta \ell}{\rho + (1-\rho)\theta}$
tradeable	$v_{\text{bond}} = \dfrac{\rho R}{\rho + (1-\rho)\theta\big(1 - \frac{\sigma}{2}\big)}$	$v_{\text{note}} = \dfrac{\rho R + (1-\rho)\theta\big(1 - \frac{\sigma}{2}\big)\ell}{\rho + (1-\rho)\theta\big(1 - \frac{\sigma}{2}\big)}$

R and σ endogenous, cannot compare values directly

But can compare debt capacities, $v\big|_{R=y,\sigma=1} =: \text{DC}$

INSTRUMENT DEBT CAPACITIES, $\mathrm{DC} := v\Big|_{R=y,\sigma=1}$

	long-term	demandable
non-tradeable	$\mathrm{DC}_{\mathrm{loan}} = \dfrac{\rho y}{\rho + (1-\rho)\theta}$	$\mathrm{DC}_{\mathrm{putt.}} = \dfrac{\rho y + (1-\rho)\theta\ell}{\rho + (1-\rho)\theta}$
tradeable	$\mathrm{DC}_{\mathrm{bond}} = \dfrac{\rho y}{\rho + (1-\rho)\theta/2}$	$\mathrm{DC}_{\mathrm{note}} = \dfrac{\rho y + (1-\rho)\theta\ell/2}{\rho + (1-\rho)\theta/2}$

B can borrow only if debt capacity exceeds cost, $\mathrm{DC} \geq c$

BRIGHT SIDE OF DEMANDABLE DEBT

NEW RATIONALE FOR DEMANDABLE DEBT

Suppose ℓ not too small and

$$\frac{1}{\rho} > \frac{1}{\theta} \cdot \frac{2\big(y - c\big)}{c(1-\rho)} \qquad (\star)$$

B can borrow <u>only</u> with banknote

$$\mathrm{DC}_{\mathrm{note}} > c > \mathrm{DC}_{\mathrm{loan/putt./bond}}$$

NEW RATIONALE FOR DEMANDABLE DEBT

Demandable debt increases secondary market price

Improves bargaining position of debtholder

Demandable debt increases primary market price

Higher secondary price leads to higher primary price

Demandable debt increases B's debt capacity

MATURITY TRANSFORMATION: B LIKE A BANK

Recall B can borrow only with banknote if

$$\frac{1}{\rho} > \frac{1}{\theta} \cdot \frac{2\big(y - c\big)}{c(1-\rho)} \qquad (\star)$$

$(\star)$ says the horizon mismatch is sufficiently severe

B does maturity transformation, so B is like a bank

Banks issue banknotes, firms don't

DARK SIDE OF DEMANDABLE DEBT

DARK SIDE OF DEMANDABLE DEBT

If C_t doubts future liquidity, won't enter

Debtholder needs liquidity but can't trade in secondary market

Debtholder redeems note on demand, B must liquidate

Bank run—or <u>money run</u>

MONEY RUNS AS MULTIPLE EQUILIBRIA

Money runs whenever multiple equilibria in secondary market

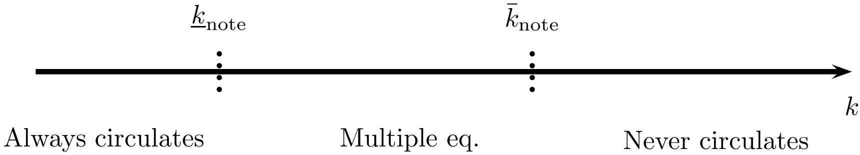
I.e. σ is best-response to σ for both $\sigma = 0$ and $\sigma = 1$

$$v - p \Big|_{\sigma=0} \ \leq \ k \ \leq \ v - p \Big|_{\sigma=1}$$

or

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

MULTIPLE EQUILIBRIA FOR $k \in [\, \underline{k}_{\text{note}} \,, \, \bar{k}_{\text{note}} \,]$



MONEY RUNS ARE NECESSARY EVIL

If ($\star$), must borrow via demandable debt to fund investment

Necessarily exposed to money runs and inefficient liquidation

Contrasts with Diamond–Rajan where run exposure is good

DEMANDABILITY AND TRADEABILITY

Jacklin (1987) says demandability and tradeability are substitutes

- You don't need option to demand debt if can trade it
- Tradeable debt gets efficiency without risk of runs

We say demandability and tradeability are complements

- Your option to demand debt increases the price you trade at
- Need demandable debt for efficiency despite risk of runs

MONEY RUN VS. DIAMOND-DYBVIG RUN

Money run

- Dynamic coordination problem in secondary market
- "Self-fulfilling liquidity dry-up" leads to redemption

Diamond-Dybvig run

- Static coordination problem among depositors

EQUILIBRIUM RUNS

MARKOV EQUILIBRIA

Introduce "sunspot" Markov state $s_t \in \{0, 1\}$

Look for Markov equilibrium $\sigma_t = \sigma^{s_t}$ with $\sigma^1 = 1$ and $\sigma^0 = 0$

I.e. $s_t = 1$ is "normal times," $s_t = 0$ is a "confidence crisis"

Assume: $s_0 = 1,\ \mathbb{P}[s_{t+1} = 0 | s_t = 1] =: \lambda,\ \mathbb{P}[s_{t+1} = 1 | s_t = 0] = 0$

VALUES IN STATE $s_t \in \{0, 1\}$

$$v^0 = \rho R + (1-\rho)\left(\theta \ell + (1-\theta) v^0\right)$$

$$v^1 = \rho R + (1-\rho)\left(\theta p^1 + (1-\theta)\left(\lambda v^0 + (1-\lambda) v^1\right)\right)$$

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

EQUILIBRIUM RUNS

For λ small, there is k s.t. $\sigma^1 = 1$, $\sigma^0 = 0$ is a Markov eq. with

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

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

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

Confidence crises ($s_t = 0$) cause trade failure and runs in eq.

DEMANDABLE DEBT DESPITE RUNS

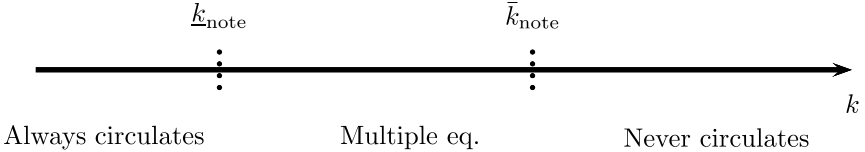
B could avoid runs by issuing a bond

May need to issue run-prone instrument to raise funds

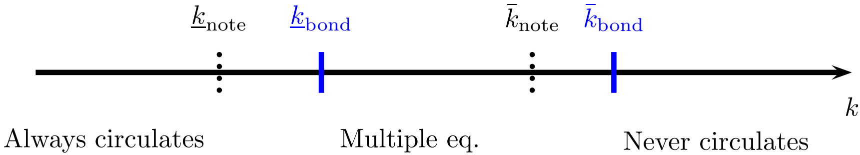
Even in anticipation of runs occurring in equilibrium

OPTIMAL BOND BORROWING

BOND VS. BANKNOTE



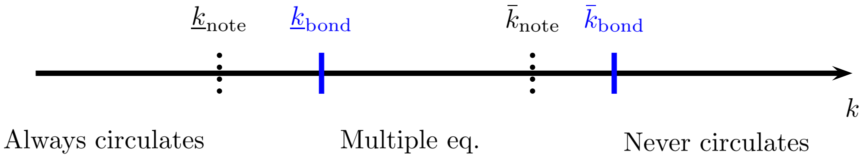
BOND VS. BANKNOTE



For same face value R, bond circulates better than banknote

Since bond has lower p

BOND VS. BANKNOTE



For same face value R, bond circulates better than banknote

Since bond has lower p

Even with equilibrium R, bond circulates better than banknote

Since bond has higher R

BOND VS. BANKNOTE

Suppose $(\star)$ violated

If $k \in \left(\bar{k}_{\text{note}}, \bar{k}_{\text{bond}}\right]$: only bond feasible; banknote illiquid

If $k \leq \bar{k}_{\text{note}}$: bond socially optimal; liquid, not run-prone

BUT B MAY STILL CHOOSE BANKNOTE

For $k \leq \bar{k}_{\text{note}}$, B may choose banknote (inefficiently)

- If B borrows from C_0 via banknote, externality on C_1
- Weakens C_1's bargaining position, benefiting C_0 and B

Rent from C_1 can outweigh deadweight cost of runs (liquidation)

TWO SIDES OF DEMANDABILITY

Banknote makes Date-0 efficiency easier

C_0 pays c, since sells at high price later

But banknote makes Date-t efficiency harder

C_t won't pay k, since must buy at high price

Thing that allows B to fund itself is thing that exposes it to runs

INTERMEDIATION

WHAT IF DIRECT FINANCE IMPOSSIBLE?

So far, if $(\star)$ and ℓ not too small, B raises c directly via banknote

B looks like a bank because it does maturity transformation

Now suppose $(\star)$ and ℓ small

B cannot raise c directly, even via banknote

Direct finance impossible, but what about intermediated finance?

INTERMEDIATION

N parallel, identical (perfectly correlated) versions of model

Borrowers $\mathrm{B}^1, ..., \mathrm{B}^N$, creditors $\mathrm{C}_t^1, ..., \mathrm{C}_t^N$ at each Date t

Suppose $\mathrm{B}^1, ..., \mathrm{B}^N$ form an intermediary

Pooling increases redemption value

Can issue N banknotes, each demandable for $r > \ell$

INTERMEDIARY DEBT REDEMPTION VALUE

Intermediary maximizes r s.t. C_t^i enters, or $v - p\,\big|_{\sigma=1} \geq k$, so

$$\frac{\rho(R - r^{\max})}{2\rho + (1-\rho)\theta} = k$$

or

$$r^{\max} = R - \frac{2}{\rho}\Big(\rho + (1-\rho)\theta/2\Big)k$$

INTERMEDIARY DEBT CAPACITY

Given $r^{\max}$, debt capacity of each banknote

$$\begin{aligned}\mathrm{DC}_{\text{note}} &= \frac{\rho y + (1-\rho)\theta r^{\max}/2}{\rho + (1-\rho)\theta/2} \\ &= y - \frac{(1-\rho)\theta}{\rho} k \\ &= \ \text{PV} \ - \mathbb{E}\big[\,\text{entry costs}\,\big]\end{aligned}$$

Invest iff $\mathrm{DC}_{\text{note}} \geq c$ or $\text{PV} - \mathbb{E}[\,\text{entry costs}\,] \geq c$

Can do all (and only) efficient investments if fund via banknotes

But must set r so large that is very vulnerable to runs

BANKING

$B^1, ..., B^N$ form intermediary just to create valuable money

Get intermediary that looks like bank

Borrows demandable, lends longer—maturity transformation

Borrows liquid, lends illiquid—liquidity transformation

Pools loans—creates value without diversification

Prone to runs—demandable debt fragile medium of exchange

EXTENSIONS

ASSET CHOICE

Suppose B can choose type of investment before borrowing

B chooses between high-NPV (y, ℓ) and low-NPV (y', ℓ')

If ℓ' large, there is c s.t. B chooses low-NPV investment

I.e. B chooses low-NPV investment for its liquidation value

Even when there is no liquidation in equilibrium

PARTIAL ROLLOVER: PREVIEW

Many debtholders and many counterparties at each date

- Some redeem at each date—not every redemption is run
- But runs can still occur (same mechanism as in baseline)

EMPIRICAL CONTENT

REPOS—CONTEMPORARY PRIVATE MONEY

Repos analog of banknotes—demandable and tradeable

Demandable: open tenor, i.e. position closed only if "withdrawal"

> Unlike short-term debt (commercial paper), necessarily rolled

Tradeable: "spend" repos by rehypothecating collateral

> "collateral can be 'spent'—used as collateral in another, unrelated, transaction.... Same collateral can support multiple transactions, just as one dollar of cash can. The collateral is functioning like cash."
>
> —Gorton and Metrick (2010)

RUNS ON BACKED ASSETS

19th century banknotes (and repos today) backed by collateral

> In the case of a bank failure...state bonds would be sold (by the state government) and the note holders paid off pro rata
>
> So, strategic considerations about coordinating with other agents do not arise.... Yet there was a run
>
> 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
>
> —Gorton (2012)

EMPIRICAL CONTENT

Explanation for why bank debt both run-prone and demandable

Also casts light on a number of other stylized facts:

(i) Demandable debt likely medium of exchange

(ii) Bank debt more likely to be demandable than corporate debt

(iii) 19th-century banknotes often traded at a discount

Discounts increased with distance from issuer

(iv) Debt runs occur in isolation (typically are not market-wide)

POLICY

CONVENTIONAL POLICIES?

Capital requirements are a double-edged sword

- Curb banks' incentive to use too much demandable debt
- But inefficiently constrain borrowing

Suspension of convertability likewise

- Prevents inefficient liquidation
- But also inefficiently constrains borrowing (via resale price)

MARKET-ORIENTED POLICIES

Financial fragility necessary evil given secondary market frictions

Decreasing these frictions decreases reliance on demandable debt

To improve <u>bank</u> stability, improve <u>market</u> liquidity

E.g. CCP for repos?

CONCLUSION

CONCLUSION

Focus on how banks create private money

New reason why bank debt is demandable

- High secondary-market price, hence high debt capacity

New type of run

- Failure of secondary-market circulation

Endogenous intermediation, liquidity transformation, pooling

MONEY RUNS

APPENDIX

FEASIBLE MARKOVIAN INSTRUMENTS

Loan/Putt. loan/Bond/Banknote feasible Markov instruments

Transfers T between B and debt holder

T depends only on state of B's investment, i.e.

$$T : \{\, \text{pays}\, , \, \text{not}\, \} \to \mathbb{R}$$

s.t. limited liability:

$$T\big(\text{pays}\big) \leq y \quad , \quad T\big(\text{not}\big) \leq \ell$$

(Go back)

EFFICIENCY

Maximize output s.t.

C$_0$'s participation constraint, $v_0 \geq c$

C$_t$'s participation constraint, $v_t - p_t \geq k$

Implemented by feasible circulating instrument s.t. no liquidation

NB: C$_t$'s PC equivalent to requiring market always "liquid"

I.e. there is always a (living) debtholder

(Go back)

OPTIMAL SECURITY DESIGN

Maximize joint surplus between B and C_0

Equivalently, maximize price paid by C_t s.t. no liquidation

Maximize bargaining position of C_0 as debtholder

s.t. to C_t's entry (participation constraint)

Maximize redemption value s.t. $v_t - p_t \geq k$

(Go back)