WAREHOUSE BANKING

Jason Roderick Donaldson Giorgia Piacentino Anjan Thakor

Washington University in St Louis

FACTS

The first banks evolved from ancient warehouses

Claims on deposited goods were used as means of payment

- I.e. warehouse receipts were early money

Warehouses made loans by printing new receipts

- I.e. not lending real deposited goods

"Warehousing" services are important for modern banks

- E.g., custody, deposit-taking, account-keeping

QUESTIONS

Why are warehousing and lending within the same institution?

How do banks that do warehousing and lending create liquidity?

THIS PAPER

Build a model based on the warehousing function of banks

Model is based on two assumptions

- Warehouses have an efficient storage technology
- Firms' output is not pledgeable

(No risk or asymmetric information)

RESULTS

<u>Warehouses do the lending</u>

Firms deposit in warehouses to access storage technology

Warehouses can seize firms' deposits

Circumvents non-pledgeability problem

<u>Warehouses create liquidity when make loans</u>

Not when they merely take in deposits

Loans are in "fake warehouse receipts"

<u>Loans create deposits and not the other way around</u>

REMINISCENT OF KEYNES (1931)

It is not unnatural to think of deposits of a bank as being created by the public through the deposits of cash

But the bulk of the deposits arise out of the action of the banks themselves

for by granting loans...a bank creates a credit in its books which is the equivalent of a deposit

NEW POLICY PRESCRIPTIONS

Our perspective in-line with history

But contrasts with most contemporary banking theory

Leads to new regulatory policy prescriptions

- Higher bank capital ratios increase liquidity
- "Tighter" monetary policy increases lending
- Liquidity requirements decrease liquidity, increase fragility

MODEL

MODEL OVERVIEW

Three dates: $t \in \{0, 1, 2\}$

Three types of risk-neutral player: farmers, laborers, warehouses

One good: "grain," a numeraire

Output is not pledgeable

Solution concept: Walrasian eq. s.t. IC from non-pledgeability

PLAYERS

FARMERS

Endowment of grain e^f at Date 0

Short-term Leontief technology at Date 0

Takes grain investment i and labor ℓ with productivity $A > 2$

$$y = A \min\{\, i \,,\, \ell \,\}$$

Output is non-pledgeable

No labor, so must hire labor at Date 0

Consume at Date 2, so must save at Date 1

Storage technology lets grain depreciate at rate $\delta < 1/A$

LABORERS

No grain endowment, but labor at Date 0 at marginal cost one

Storage technology lets grain depreciate at rate δ

Consume at Date 2

WAREHOUSES

No endowment

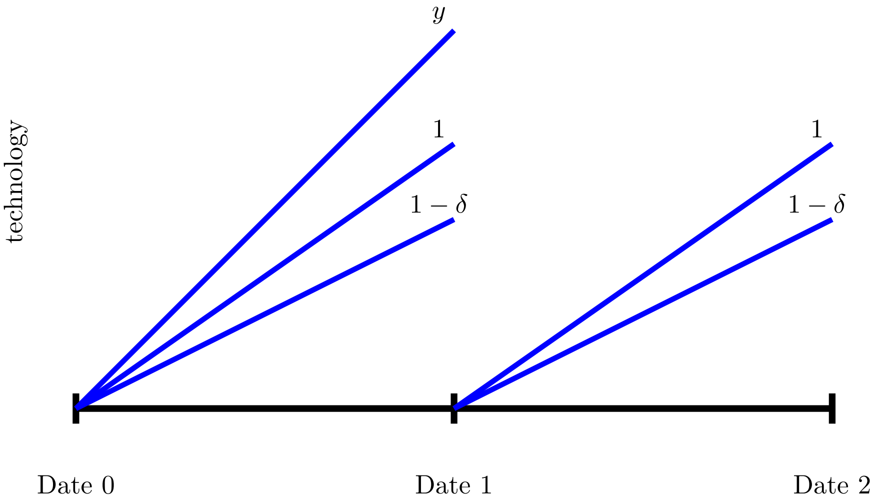
Storage technology that preserves grain, no depreciation

Can seize grain deposited in them

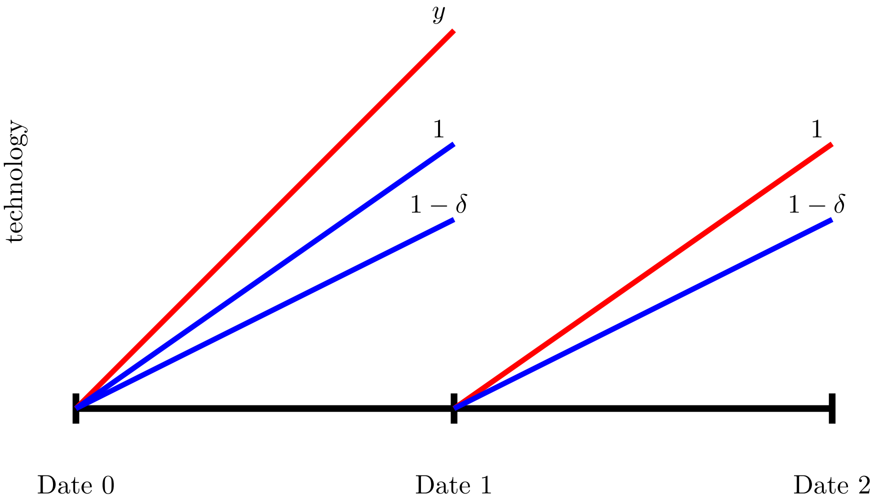
Stored grain is pledgeable

Consume at Date 2

TECHNOLOGIES



TECHNOLGIES



CONTRACTS

CONTRACTS

Labor contracts at Date 0

Deposit contracts at Date 0 and Date 1

Lending contracts at Date 0

LABOR CONTRACTS

Farmers pay laborers wage w per unit of labor invested

DEPOSIT CONTRACTS

Warehouses promise return R_t^D for deposits at Date t

Promises backed by warehoused grain

LENDING CONTRACTS

Warehouses lend L to farmers at Date 0 at rate R^L

They can lend in receipts or grain

TIMELINE

TIMELINE

Date 0

Farmers borrow L, invest i in grain, pay laborers $w\ell$

Date 1

Farmers produce $y = A \min\{ i , \ell \}$

Farmers deposit and repay or divert and store privately

Date 2

Farmers, laborers, and warehouses consume

SOLUTION CONCEPT

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Farmers, laborers, and warehouses maximize utility

subject to

- budget constraints
- promised repayments being incentive compatible

Markets for grain, labor, loans and deposits clear at each date

LIQUIDITY CREATION DEFINITION

LIQUIDITY CREATION DEFINITION

The liquidity multiplier is farmers' investment over endowment

$$\Lambda := \frac{i + w\ell}{e^f}$$

RESULTS

PRICES LEMMA

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Interest rates and wages are all one,

$$R_0^D = R_1^D = R^L = w = 1$$

Deposit, lending, and labor markets are competitive

Warehouses' marginal cost of storage is one

Laborers' marginal cost of labor is one

BENCHMARKS

BM 1: first best allocation

BM 2: no fake receipts

Our model: warehouses can lend in fake receipts

BENCHMARK 1: FIRST BEST

BM 1: FIRST BEST ALLOCATION

Farmers' technology Leontief, $y = A \min\{\, i \,,\, \ell \,\}$

Thus $i = \ell$

Since output is pledgeable pay laborer on credit

So $i = e^f = \ell$

Liquidity creation is thus $\Lambda_{\text{fb}} = \dfrac{i + w\ell}{e^f} = \dfrac{2e^f}{e^f} = 2$

Efficient storage in the warehouse at Date 1

BENCHMARK 2: NO FAKE RECEIPTS

BM2: NO FAKE RECEIPTS

Farmers' technology Leontief, $y = A \min\{\, i \,,\, \ell \,\}$

Thus $i = \ell$

But output is not pledgeable so can't pay on credit

Warehouse can't lend: they have no grain or receipts

Budget constraint $i + w\ell = e^f$ implies $i = \ell = e^f/2$

Liquidity creation is thus $\Lambda_{\mathrm{nr}} = \dfrac{i + w\ell}{e^f} = 1$

Deposit at Date 1 and avoid depreciation

WAREHOUSES LEND IN FAKE RECEIPTS

WAREHOUSES LEND IN FAKE RECEIPTS

Suppose warehouses can write receipts when they lend

Circumvents non-pledgeability: pay laborer in receipts

But now pledgeability problem between farmer and warehouse

Repayment to warehouses must be incentive compatible

INCENTIVE CONSTRAINT

FARMERS' INCENTIVE CONSTRAINT

Farmers can borrow L at Date 0 only if IC to repay at Date 1 or

$$\text{repay, store at } R_1^D \;\succeq\; \text{divert, store at } 1-\delta$$

or, if a farmer has grain y at Date 1,

$$R_1^D\big(y - R^L L\big) \geq (1-\delta)y$$

or, since $R_1^D = R^L = 1$,

$$L \leq \delta y$$

Proportion δ of output has now become pledgeable

WHY NOT DEPOSIT IN ANOTHER WAREHOUSE?

Farmer can borrow from one warehouse (W0) at Date 0

Divert output and deposit in another warehouse (W1) at Date 1

So farmer can avoid both repayment and depreciation

But this is not possible if there is an interbank market

Now W1 has incentive to buy debt from W0 and seize output

So farmer will end up repaying its debt no matter what

INTERBANK MKT IMPLEMENTS EXCLUSIVITY

We could get our outcome if:

- Warehouses competitively offer 2-date exclusive contracts
- Commit at $t = 0$ not to deposit in other warehouse at $t = 1$

We can do better...

Alternatively:

- Warehouses competitively offer 1-date loan contracts at $t = 0$
- There is an interbank market

EQUILIBRIUM CHARACTERIZATION

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In equilibrium, loans L, labor ℓ, and investment i are

$$L = \frac{\delta A e^f}{2 - \delta A},$$
$$\ell = \frac{e^f}{2 - \delta A},$$
$$i = \frac{e^f}{2 - \delta A}.$$

FAKE RECEIPTS CREATE LIQUIDITY

FAKE RECEIPTS CREATE LIQUIDITY

Fake receipts allow farmer to invest more

When warehouses lend in fake receipts, the liquidity multiplier is

$$\Lambda = \frac{2}{2 - \delta A} > 1$$

Farmer's investment exceeds total grain endowment

LIQUIDITY CREATION

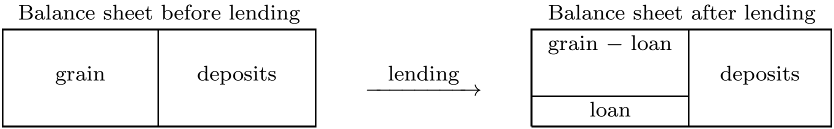
The total amount of liquidity created is increasing in δ

The more desirable for farmers to store, the looser is IC

And warehouses are more willing to lend

LOANS CREATE DEPOSITS

DEPOSITS CREATE LOANS?



LOANS CREATE DEPOSITS

Balance sheet before lending

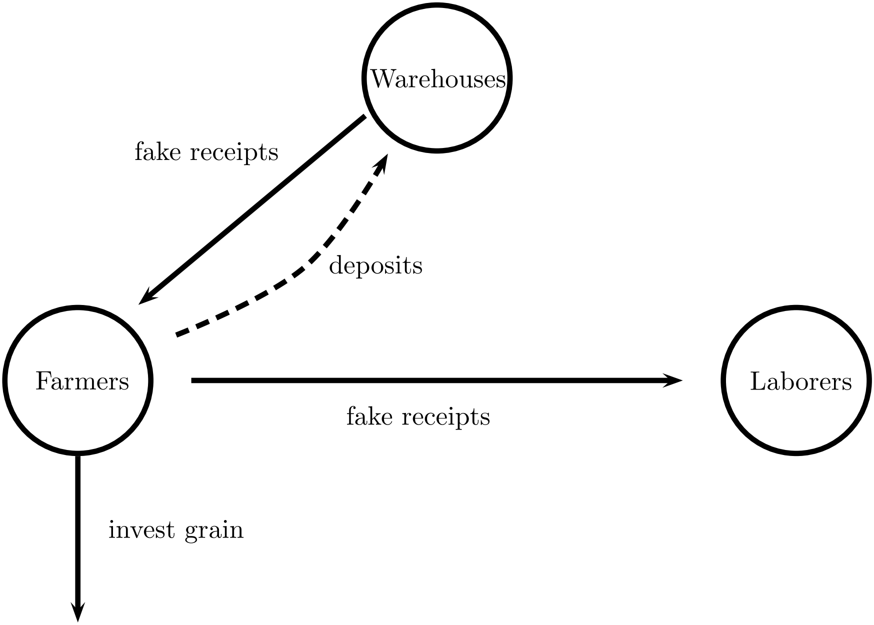
grain	deposits

$\xrightarrow{\text{liquidity creation}}$

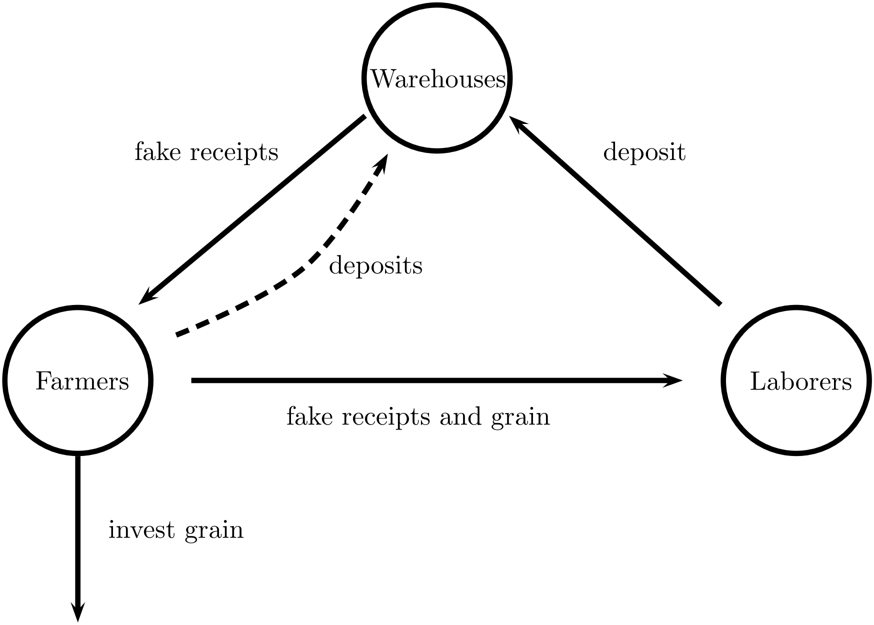
Balance sheet after lending

grain	old deposits
loan	new deposits

SUMMARY


Warehouses
fake receipts
deposits
Farmers
Laborers
fake receipts
invest grain

SUMMARY


Warehouses
fake receipts
deposit
deposits
Farmers
Laborers
fake receipts and grain
invest grain

ENDOGENOUS FRACTIONAL RESERVES

ENDOGENOUS FRACTIONAL RESERVES

Farmer's IC puts endogenous limit to amount it can borrow

Since L is max farmer can borrow, he could set $L = i$

And store $e^f - L$

But he can do better

- Can split $e^f - L$ between i and $w\ell$
- Laborer then stores $(e^f - L)/2$ in warehouse

WAREHOUSE-BANK EQUITY

EXTENSION: WAREHOUSE DIVERSION

Suppose warehouses can now divert grain

If divert store privately, but grain depreciates at δ

Suppose warehouses have endowment e^w at <u>Date 1</u>

WAREHOUSE INCENTIVE CONSTRAINT

Deposit-taking is IC at Date 1 if

repayment and storage at 1 $\succeq$ diversion and storage at $1-\delta$

or, for deposits D,

$$e^w + D - R_1^D D \geq (1-\delta)(e^w + D)$$

or, since $R_1^D = 1$,

$$\frac{e^w}{D} \geq \frac{1-\delta}{\delta}$$

LIQUIDITY DEPENDS ON WAREHOUSE EQUITY

The second-best is attained only if

$$e^w \geq \frac{1-\delta}{\delta} \, \frac{\alpha\big[1+(1-\delta)A\big]}{1+\alpha(1-\delta A)} \, e^f,$$

Otherwise warehouses constrain lending

Warehouse-banks need capital only at Date 1

No capital or initial deposits necessary at Date 0

WAREHOUSE'S IC BINDS

Warehouse's binding IC

$$D = \frac{\delta}{1-\delta} e^{w}$$

and market clearing

$$D = y + R_0^D \left(e^f - i\right) = Ai + e^f - i$$

give the liquidity multiplier

$$\Lambda = \frac{i + w\ell}{e^f} = \frac{2}{A-1} \left(\frac{\delta}{1-\delta} \frac{e^w}{e^f} - 1 \right)$$

LIQUIDITY & WAREHOUSE EQUITY

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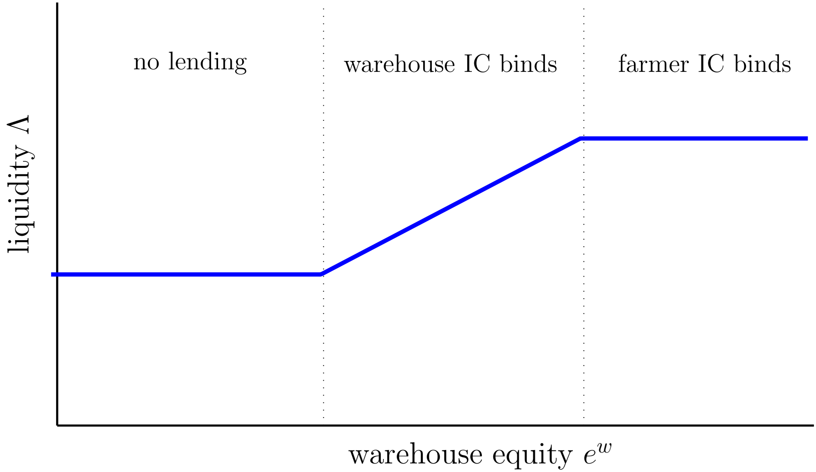


CAPITAL INJECTIONS

Increasing capital increases lending only if warehouse IC binds

Only Date 1 capital matters

- Increasing today's capital does not affect lending directly

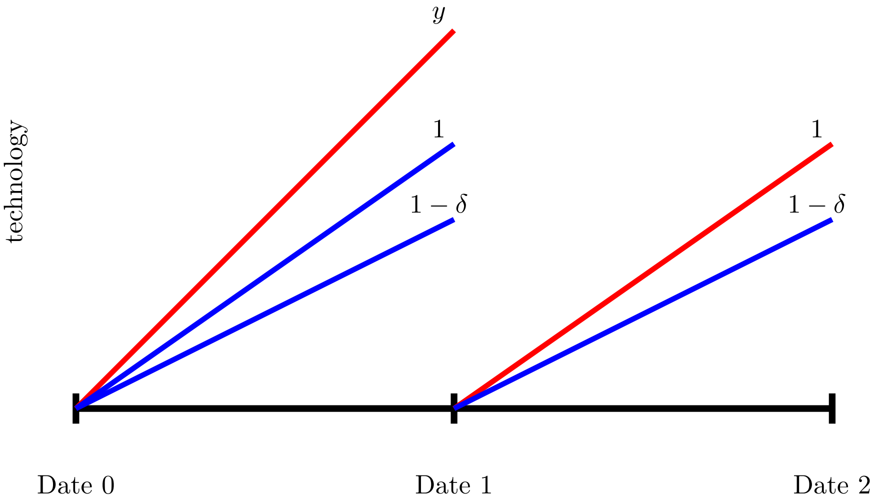
Casts light on why credit tight after crisis, despite intervention

MONETARY POLICY

MONETARY POLICY

Suppose warehouse can deposit in central bank at rate R^{CB}

TECHNOLGIES



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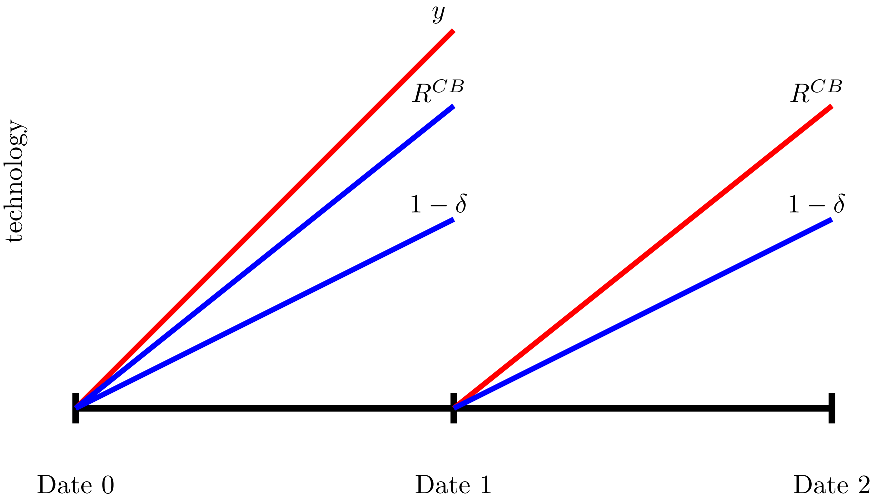

MONETARY POLICY: PRICES LEMMA

Interest rates are

$$R_0^D = R_1^D = R^L = R^{CB}$$

Wages

$$w = (R^{CB})^{-2}$$

MONETARY POLICY: FARMER'S IC

The IC becomes

$$R^{CB}(y - R^{CB}L) \geq (1-\delta)y$$

or

$$L \leq \frac{1}{R^{CB}}\left(1 - \frac{1-\delta}{R^{CB}}\right)y$$

Increasing R^{CB} can loosen IC

So tighter monetary policy can increase funding liquidity

LIQUIDITY REQUIREMENTS AND FINANCIAL FRAGILITY

LIQUIDITY REQUIREMENTS

Basel III requires that banks hold sufficient liquidity

$$\text{Liquidity Coverage Ratio} = \frac{\text{Liquid assets}}{\text{Total assets}} \geq \theta$$

Basically forces banks to invest some assets in cash

In our model this imposes a limit on loans it can make

In other words, a limit on fake receipts

Thus, hindering liquidity creation

LIQUIDITY REQUIREMENTS & FRAGILITY

Idea behind liq. requirements is that it reduces risk of runs

We show that liq. requirements *may* make banks fragile to runs

The higher are liq. requirements, the higher *may* be risk of runs

LIQUIDITY REQUIREMENTS & FRAGILITY

Add a Date 1/2 to our model

At Date 1/2 depositors may withdraw

Suppose warehouses have grain reserves θ at Date 0

Question: how does increasing θ affect the risk of a run?

LIQUIDITY REQUIREMENTS & RUNS

Call λ the proportion of grain that is withdrawn early

Call $g(\theta)$ the liquidation value of the warehouse's reserves

	$\lambda \leq \theta$	$\lambda > \theta$
Withdraw	$1 - \delta$	$\dfrac{(1-\delta)g(\theta)}{\lambda}$
$\neg$ Withdraw	1	0

Consider the choice of a depositor to withdraw 1 unit of grain

MULTIPLE EQUILIBRIA

	$\lambda \leq \theta$	$\lambda > \theta$
Withdraw	$1 - \delta$	$\frac{(1-\delta)g(\theta)}{\lambda}$
$\neg$ Withdraw	1	0

EQUILIBRIUM SELECTION

Use global games to select equilibrium

There is a "run" (everyone withdraws) when $\delta < \delta^*$

There is not a run (everyone does not withdraw) when $\delta > \delta^*$

So, $\mathbb{P}(\text{run}) = \mathbb{P}(\delta < \delta^*)$

Interpretation: δ^* measures financial fragility

Question: how do liquid reserves θ affect fragility δ^*?

EQUILIBRIUM SELECTION

The global games technique says that δ^* solves

$$\int_0^1 \text{don't withdraw payoff}\,(\delta)\, d\lambda = \int_0^1 \text{withdraw payoff}\,(\delta)\, d\lambda$$

i.e.

$$\int_0^1 \mathbb{1}_{\{\lambda \leq \theta\}} d\lambda = \int_0^1 \left[\mathbb{1}_{\{\lambda \leq \theta\}} (1-\delta) + \mathbb{1}_{\{\lambda > \theta\}} \frac{(1-\delta) g(\theta)}{\lambda} \right] d\lambda$$

or

$$\delta^* = \frac{g(\theta)\log(\theta)}{g(\theta)\log(\theta) - \theta}$$

DO RESERVES INCREASE FRAGILITY?

Recall that higher δ^* implies higher fragility

How does θ affect δ^*?

$$\frac{\partial \delta^*}{\partial \theta} > 0$$

if

$$g'(\theta) > \frac{g(\theta) + g(\theta)|\log \theta|}{\theta|\log \theta|};$$

higher reserve requirements lead to higher fragility

RESERVES INCREASE FRAGILITY: INTUITION I

Increase in θ has two effects

"Buffer effect": bank can withstand more withdrawals

"Incentive effect": higher expected payoff from withdrawing

RESERVES INCREASE FRAGILITY: INTUITION II

Consider a warehouse with no reserves, $\theta = 0$

	$\lambda \leq \theta$	$\lambda > \theta$
Withdraw	$1 - \delta$	0
$\neg$ Withdraw	1	0

No incentive to withdraw, since always get 0

High reserves increase withdraw payoff, making runs likely

NARROW BANKING

Narrow banks: banks should hold only liquid securities

Effectively, 100% reserves

Equivalent to BM in which warehouses can't issue fake receipts

And no liquidity being created

MECHANISM DESIGN

MECHANISM DESIGN (À LA HURWITZ)

How can we implement second-best?

- Maximize welfare s.t. ICs

To find second-best outcome, consider the strongest punishment

- Punish with autarky at Date 1
- I.e. exclusion from efficient storage or warehousing

Warehouse banking implements exclusion, hence second-best

- A warehouse can seize what is deposited in it
- There is an interbank market for farmers' debt

EXTENSION: CONSUMPTION AT DATE 1

WHAT IF FARMERS CONSUME AT DATE 1?

Seems that results are driven by timing of consumption

While true that farmers' need to save is driving results

Results robust to inclusion of farmer's consumption at $t = 1$

    If farmers have decreasing marginal utility

WHAT IF FARMERS CONSUME AT DATE 1?

Does IC hold if farmer consumes at Date 1?

Suppose farmer has log utility $U = \log c_1 + \log c_2 = \log c_1 c_2$

RISK-AVERSE FARMER

Repayment is IC if

$$\text{depositing} \succeq \text{diversion}$$

where, payoff from depositing is maximum of

$$\begin{aligned}&u(c_1) + u(c_2)\\ &\text{s.t. } c_2 = R_D\,(y - R_L L - c_1)\end{aligned}$$

and payoff from diversion is maximum of

$$\begin{aligned}&u(c_1) + u(c_2)\\ &\text{s.t. } c_2 = (1-\delta)(y - c_1)\end{aligned}$$

RISK-AVERSE FARMER: IC

Solution to the deposit program is

$$c_1 = \frac{y - R_L L}{2}$$
$$c_2 = \frac{R_D(y - R_L L)}{2}$$

Solution to the diversion program is

$$c_1 = \frac{y}{2}$$
$$\text{s.t. } c_2 = \frac{(1-\delta)y}{2}$$

RISK-AVERSE FARMER: IC

Repayment is IC if

$$\log\left[\frac{y - R_L L}{2} \cdot \frac{R_D(y - R_L L)}{2}\right] > \log\left[\frac{y}{2} \cdot \frac{(1-\delta)y}{2}\right]$$

or

$$L < \frac{\sqrt{R_D} - \sqrt{1-\delta}}{\sqrt{R_D} R_L} y$$

Substituting for $R_D = R_L = 1$

$$L < \left(1 - \sqrt{1-\delta}\right) y \approx \frac{\delta y}{2}$$

LITERATURE

LITERATURE

Gu–Mattesini–Monnet–Wright 2013

Institutions that can keep promises better endogenously

1. Take deposits and make delegated investments

2. Their liabilities facilitate exchange

LITERATURE ON BANKING

In traditional models banks transfer from depositors to borrowers

But in reality banks lend by creating deposits

Borrowers are simultaneously depositors

Papers that takes this view:

Bianchi–Bigio 2015

Jakab–Kumhof 2015

LITERATURE ON LIQUIDITY CREATION

Bryant 1980, Diamond–Dybvig 1983

- Banks implement efficient risk sharing
- Create liquidity by providing insurance, increasing loan value
- Investment in illiquid projects $<$ initial liquidity endowment

Gorton–Ordoñez 2012, Dang–Gorton–Holmström–Ordoñez 2015

- Banks create liquid assets by issuing info incentive claims
- Liquidity created on right-hand side of banks' balance sheet

LITERATURE ON LIQUIDITY FROM LENDING

> We thus maintain—contrary to the entire literature on banking and credit—that the primary business of banks is not the liability business, especially the deposit business
>
> But in general and in each and every case an asset transaction of a bank must have previously taken place, in order to allow the possibility of a liability business and to cause it
>
> The liability business of banks is nothing but a reflex of prior credit extension....
>
> —Hahn (1920)

CONCLUSIONS

CONCLUSIONS

Warehouses are the natural banks

- Historical origin and raison d'être of banks
- Intermediation is endogenous

Create private money ("fake receipts") when <u>lending</u>

- Provides liquidity and enhances investment efficiency
- Casts doubt on new regulatory proposals

WAREHOUSE BANKING

APPENDIX

FIRST-BEST

In first-best, all grain invested in farmers' technology

$$i = e^f$$

Leontief technology implies $\ell = i = e^f$

Liquidity creation is thus

$$\Lambda_{\text{nr}} = \frac{i + w\ell}{e^f} = 2$$