June 8, 2015

Warehouse Banking

by

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Introduction

- Which are the second and third oldest professions known to mankind?
  - Pilots
  - Lawyers
  - Bankers
  - Pizza parlor operators

- Invention of banking preceded the invention of coinage by several thousand years.
- Banking seems to have originated in ancient Mesopotamia and some of the earliest recorded laws pertaining to banks (banking regulation) were part of the Code of Hammurabi.
- Deposits: cattle, grain, precious metals
  - Loans made
  - Interest paid
- In ancient Egypt, grain harvests were “deposited” (or stored) in centralized state warehouses ...depositors could write written orders for the withdrawal of a certain quantity of grain as a means of payment.

- Eventually, these warehouses of goods or places for safe storage of commodities evolved into modern-day banks (e.g., Lawson (1855)).
  - However...our contemporary theories of why banks exist (Diamond (1984), Ramakrishnan-Thakor (1984), Allen (1990), Coval-Thakor (2005)) have little to do with these origins of banks.
- Another related issue is the idea that banks exist to create liquidity (not just store it safely).
- To this day...the same institutions that provide safekeeping services also engage in the bulk of lending in the economy and are also responsible for significant liquidity creation.

  ... most modern commercial banks keep deposit accounts, provide payment services, act as custodians, and make corporate and consumer loans.

Research Questions

1. Why do modern banks offer deposit-taking, account-keeping payment, and custodial (warehousing) services within the same institution that provides lending services?
2. *How* does such a bank that combines warehousing and lending create liquidity?
3. What is the role of bank equity capital in liquidity creation by the bank?
4. How does this view of banking inform contemporary regulatory reform proposals: narrow banking and liquidity requirements?

Warehouse Banking

- To answer these questions, we write down a model in which:
  - Warehouses provide safekeeping for deposited goods
  - and issue receipts when they take deposits
- This model takes us back to the roots of banking and the evolution of primitive warehouses into modern-day banks.

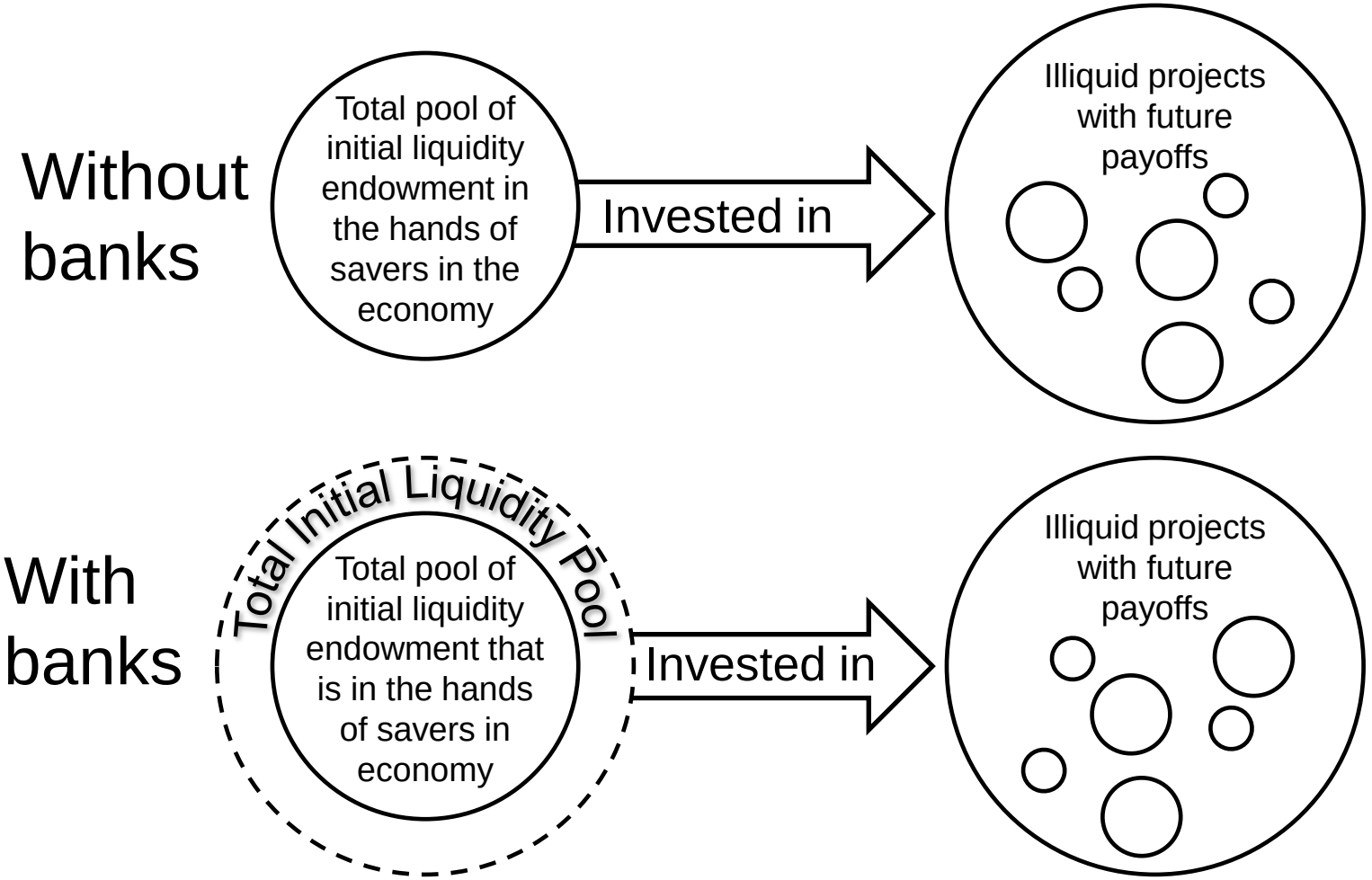
Answer

But... our model shows that:

Warehouses create liquidity when they use deposits to *make loans* and not when they merely *take in deposits*

i.e., the creation of deposit accounts is necessary for liquidity creation by *banks* but not sufficient.

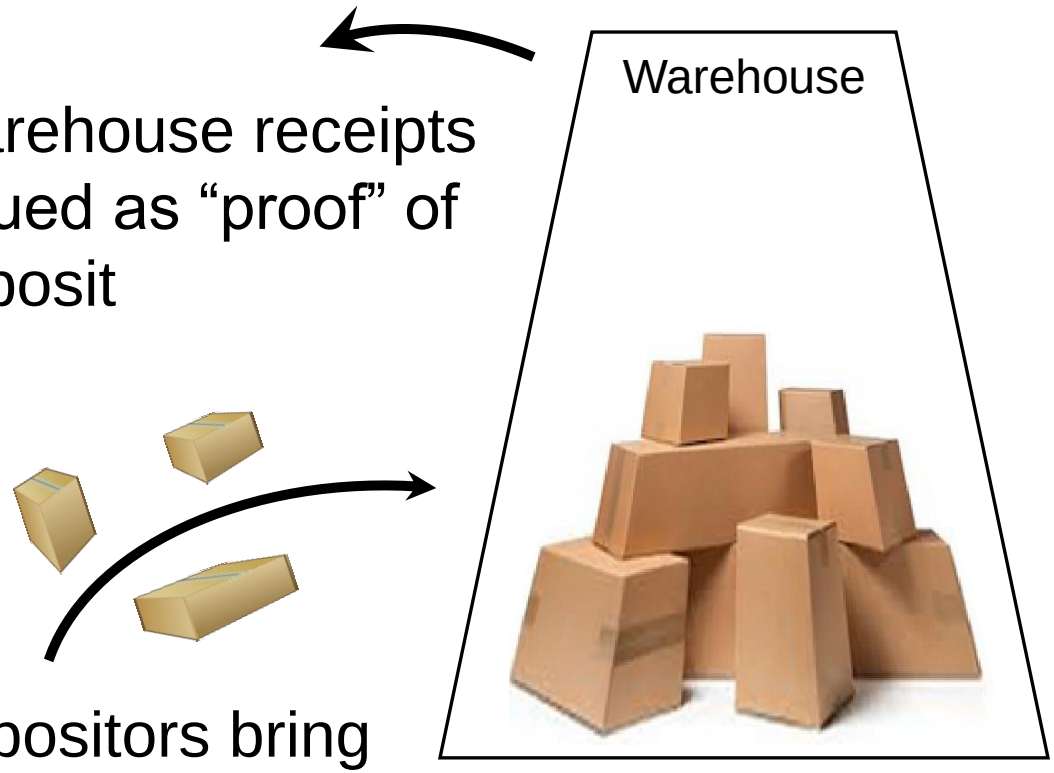
What do we mean by liquidity creation by banks: "Funding liquidity"?



- Thus, our notion of liquidity creation differs from the existing literature that focuses on the improvement in risk sharing for risk-averse depositors who seek consumption insurance (e.g., Bryant (1980), Diamond and Dybvig (1903), and Allen and Gale (1958)).

  ...more detailed comparison later.

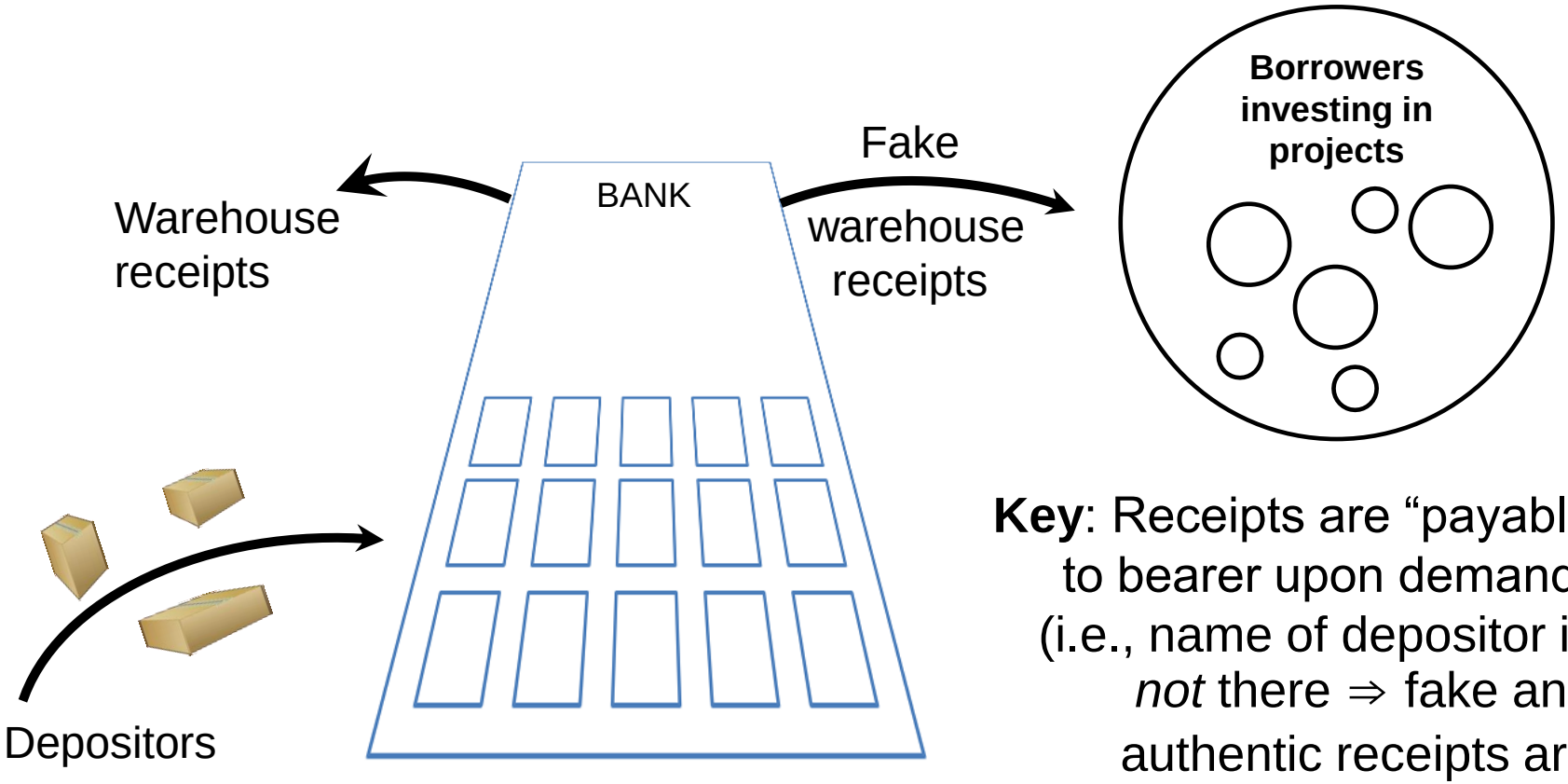
Basic Idea



Warehouse receipts issued as “proof” of deposit

Depositors bring grain or gold bricks to warehouse.

Basic Idea



Key: Receipts are "payable to bearer upon demand" (i.e., name of depositor is *not* there ⇒ fake and authentic receipts are identical.)

Main Results

- In order to create liquidity banks must play two roles:
  1. deposit-taking and warehousing
  2. lending
- Critical for lending will be the creation of private money, that we will call “fake receipts”
- Fake receipts are receipts not backed by deposits... and key is these are indistinguishable from “authentic receipts”
- In the existing literature, the bank takes in deposits and lends them out. That is, deposits create loans. What we show is that loans create deposits!

Our approach is reminiscent of Hahn (1920):

"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, p. 29)

And of Keynes...

"It is not unnatural to think of deposits of a bank as being created by the public through the deposits of cash representing either savings or amounts which are not for the time being required to meet expenditures. But the bulk of the deposits arise out of the action of the banks themselves, for by granting loans, allowing money to be drawn on an overdraft or purchasing securities, a bank creates a credit in its books which is the equivalent of a deposit."

(Keynes in his contribution to the Macmillan Committee, 1931, p. 34)

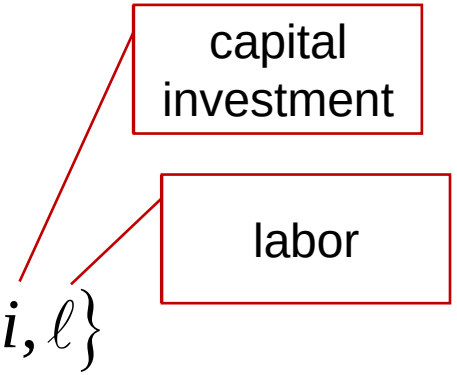
In Our Model

- Liquidity is created only via banks
- Firms can invest over and above depositors' endowments
  - because banks' fake receipts provide working capital to firms

Example: Setup

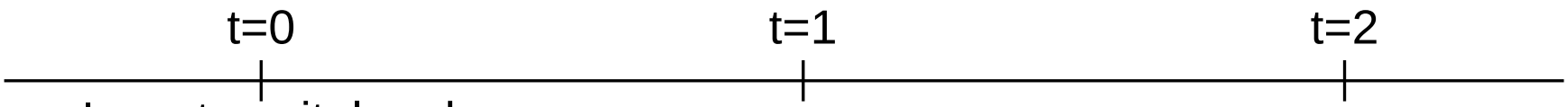
- Three players: one farmer, one warehouse and one laborer
- Three dates: 0, 1, 2: investment/production at t=0, output at t=1, consumption at t=2
- Endowment of grain:
  - Farmer had endowment of 12 grains at Date 0
  - No one else has an endowment
- Endowment of labor:
  - Laborer has marginal cost of 1 of labor-paid wage w=1
- Everyone consumes at Date 2

Example: Setup



- Farmer's technology: Constant-return-to-scale production: $y = 4\min\{i, \ell\}$
  - Transforms 1 unit of grain and 1 unit of labor at Date 0 into 4 units of grain at Date 1
  - No production at Date 1
- Storage technology:
  - Grain depreciates by 20% if stored privately (think of theft)
  - But not if stored in the warehouse (with economies of scale in safeguarding)
  - Consistent with ancient warehouses being places of "power"
    - Temples, sovereign treasuries, etc.— that could safeguard valuables more effectively and enforce contracts (seize output if borrowers don't repay)

Example: Timing



- Invest capital and labor in production.
- Farmer has endowment (e) and borrower *B* from warehouse.
- Farmer invests, i in grain and, $w\ell$ in labor.
- Laborer exerts labor, ℓ and deposits wage, $w\ell$ in warehouse.

- Farmer produces output, y .
- Either repays warehouse and deposits output or diverts and stores privately.
- Needs to be stored until t=2 if he repays.

- Consumption by farmer, laborer and warehouse.

Definition of Liquidity Creation:

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

Example: No Warehouses

- The farmer must pay the worker in grain
- To maximize his Date 2 consumption, he maximizes production at Date 1 and then stores the grain
- Leontief production technology means farmer splits endowment of 12 across capital and labor equally: $i = \ell = 6$ (with $w = 1$) and produces:
  - $4 \times \min\{i, \ell\} = 4 \times 6 = 24$ units of grain at Date 1
- He stores the grain privately, which depreciates so at Date 2 he gets
  - $(1 - 0.2) \times 24 = 19.2$

Example: Warehouses But No Fake Receipts

- Just as in the previous case the farmer can produce 24 units of grain
- But now he can store them in the warehouse
- So the grain does not depreciate so at Date 2
  - He consumes 24 units of grain
- But since $i + w\ell = e = 12,$ in this case is the same as in the case with no warehouse, there is no liquidity creation.

Example: Warehouses With Fake Receipts

- Warehouses now can not only store grain but also lend.
- The farmer again sets his investment in grain equal to his labor investment: $i = \ell$.
- But he holds *all* of the grain endowment already so how can production be scaled up?
- He can pay the laborer with fake receipts!

How?

- By borrowing B receipts from the warehouse:

  $i + w\ell = e + B.$

- Since $w = 1$ and maximizing production needs $i = \ell$, we have $i = w\ell$ (with $w = 1$).

  $\Rightarrow \; i + w\ell = i + i = 2i = e + B$

  $$\Rightarrow \; i = \frac{e+B}{2} = \frac{12+B}{2} = 6 + \frac{B}{2} \qquad (1)$$

  $\Rightarrow$ Corresponding date-1 output is:

  $$y = 4\min\{i, \ell\} = 4i = 24 + 2B \qquad (2)$$

- *Constraint on farmer borrowing:* The amount the farmer can borrow is limited by what he can credibly promise to repay.

- But...farmer's output is NOT pledgeable ⇒ creditor (warehouse) cannot enforce repayment of debt.
- Farmer's deposit of output in warehouse makes it possible for warehouse to seize the deposit.

  ⇒ Farmer faces a tradeoff between depositing (avoid depreciation but forced to repay) and not depositing (private storage: suffer depreciation/theft but avoid repayment).
- This means we need to make it IC for farmer to repay.

IC Constraint

$$y - B \geq [1 - 20\%]\, y$$

$\Rightarrow$ Maximum farmer can borrow satisfies:

$$[24 + 2B] - B = [1 - 0.2][24 + 2B] \qquad (3)$$

$$\Rightarrow \qquad B = 8$$

- Substituting (3) in (1) gives:

$$i = 6 + \frac{B}{2} = 10 = \ell \qquad (4)$$

$\Rightarrow$ Liquidity creation = $\frac{i + w\ell}{e} = \frac{10 + 10}{12} = 5/3$

The warehouse's balance sheet expands when it makes a loan, creating liquidity

Balance sheet before lending

grain	receipts

Liquidity creation →

Balance sheet after lending

grain	receipts
Loan	fake receipts

Notes:

- It is the fake receipts written by the warehouse that allows the farmer to scale up his production when warehouse/bank makes loans.

  ⇒ Liquidity is created on the asset (not the liability) side of the warehouse's balance sheet.

- Key to warehouse/bank playing a role is that farmer cannot credibly pay labor on credit (laborer cannot enforce payment by farmer).

First-Best

- Although evolution of warehouse into a bank moves the economy closer to First-Best in terms of liquidity creation, First-Best is NOT achieved:
- First-Best: farmer invests entire endowment in capital $i = e = 12$ and labor exerts effort $\ell = 12$.

$$\Rightarrow \quad y = 4i = 48$$

$$\Rightarrow \quad \Lambda_{fb} = \frac{i + w\ell}{e} = \frac{12 + 12}{12} = 2$$

Model

- Three dates: Date 0, Date 1 and Date 2
- One good: grain
- Three types of players:
  - Farmers
  - Laborers
  - Warehouses
- Consumption at Date 2

Farmers

- Endowment e
- Leontief technology between Date 0 and Date 1:

$$y(i,\ell) = A\min\{\alpha i, \ell\}$$

where *i* is grain investment and ℓ is labor investment, and $A > 1$.

- Output y is not verifiable.
- Private storage technology at every date:
  - Grain depreciates at rate $\delta \in (0,1)$.

Laborers

- Laborers have no grain endowment.
- Laborers have marginal cost of labor.
- Laborers payoff is $c_2^1 - \ell$.
- ℓ is the total labor exerted at Date 0.
- No labor at other dates.
- They have a private storage technology.
  - Grain depreciates at rate $\delta \in (0,1)$.

Warehouses

- No grain endowment
- Warehouse grain deposits are verifiable
- Storage technology:
  - Grain does not depreciate, thus $1/\alpha$ measures the warehouse's technological (political/economic power) advantage in storage

Competition

- Market is competitive:
  - Deposit rates, loan rates and wages clear the market in a (competitive) Walrasian equilibrium. Farmers get rents.

Contracts

- Deposit contracts (between warehouses and other players and possibly other warehouses):
  - Warehouses pay interest R_t^D on deposits at Date t. If player $j \in \{l, f\}$ makes deposit of d_t^j units of grain at date t, he has the right to withdraw $R_t^j d_t^j$ units at $t+1$.
  - Warehouses issue receipts in exchange for deposits.
- Lending contracts (between warehouses and farmers):
  - At Date 0 warehouses can lend *L to* farmers at rate R^L
  - Lending can be in grain or in receipts.
  - Repayment must be incentive compatible
- Labor contracts (between farmers and laborers):
  - Farmers pay laborers $w\ell$ for labor ℓ.

- When warehouse accepts deposit by 1 unit of grain, it issues a receipt in exchange as “proof” of deposit.
- D_t includes both deposits backed by grain and those granted as fake receipts.
- IC constraint on farmer arises from lack of pledgability of date-1 output. The farmer can divert this output...but then must store grain privately (if kept in warehouse, it can be seized for repayment).

A Subtlety

- What if farmer borrows from one warehouse at t=1 and deposits in a different warehouse?
- Could farmer avoid both grain depreciation and repayment?
- NO!

If farmer borrows from WH A and deposits in WH B, then WH B can buy farmer's debt from WH A and then seize all his grain.

$\Rightarrow$ Farmer will end up repaying his debt (we have formal analysis of interbank market)

Incentive Compatibility (IC) of Farmers

- Lack of uncertainty means we can restrict attention to contracts where default at t=1 never happens in equilibrium.
- If farmers deposit, their output is verifiable and they cannot divert.
- Must prefer to not divert and repay their debt than to divert and store privately or

IC: $R_1^D(y - R^L L) \geq (1-\phi)y$

A Timeline Representation of Sequence of Moves

Date 0	Date 1	Date 2
Warehouses accept deposits D_0 lend L to farmers store s_0^b	**Warehouses** receive T from farmers accept deposits D_1 repay $R_0^D D_0$ to depositors store s_1^b	**Warehouses** repay $R_1^D D_1$ to depositors consume $c^b = s_1^b - R_1^D D_1$
Farmers borrow B from warehouses invest i and ℓ in technology y pay laborers $w\ell$ deposit d_0^f in warehouses store s_0^f	**Farmers** receive cash flow $y(i,\ell)$ transfer T to warehouses receive $R_0^D d_0^f$ from warehouses deposit d_1^f in warehouses store s_1^f	**Farmers** receive $R_1^D d_1^f$ from warehouses consume $c^f = R_1^D d_1^f + (1-\delta)s_1^f$
Laborers exert labor ℓ accept wage $w\ell$ deposit d_0^l in warehouses store s_0^l	**Laborers** receive $R_0^D d_0^l$ from warehouses deposit d_1^l in warehouses store s_1^l	**Laborers** receive $R_1^D d_1^l$ from warehouses consume $c^l = R_1^D d_1^l + (1-\delta)s_1^l$

Equilibrium

- Everyone (warehouses, farmers, laborers) maximizes his payoff at Date 2 taking prices as given, subject to the budget constraints
- Farmers also subject to IC
- Markets must clear:
  - Labor
  - Grain
  - Deposits
  - Debt

Equilibrium (cont'd.)

The equilibrium is a profile of prices $\left\langle R_t^D, R^L, w \right\rangle$ for $t \in \{1,2\}$ and a profile of allocations $\left\langle s_t^j, d_t^f, d_t^l, D_t, L, B, \ell^l, \ell^f \right\rangle$ for $t \in \{1,2\}$ and $j \in \{b, f, l\}$ that solves the warehouses' problem, the farmers' problem, and the laborers' problem defined in Section 3.3 and satisfies the market clearing conditions for the labor market, the lending market, the grain market and deposit market at each date:

$$\ell^f = \ell^l \qquad (\mathrm{MC}^\ell)$$

$$B = L \qquad (\mathrm{MC}^L)$$

$$i + s_0^f + s_0^l + s_0^b = e \qquad (\mathrm{MC}_0^g)$$

$$s_1^f + s_1^l + s_1^b = (1-\delta)s_0^f + (1-\delta)s_0^l + s_0^b + y \qquad (\mathrm{MC}_1^g)$$

$$D_0 = d_0^f + d_0^l \qquad (\mathrm{MC}_0^D)$$

$$D_1 = d_1^f + d_1^l. \qquad (\mathrm{MC}_1^D)$$

Preliminary Results

- Competition implies that interest rates and wages are 1.

$$R^L = R_1^D = R_2^D = w = 1$$

- Laborers deposit $w\ell$ entirely.
- Because of Leontief production function: $\alpha i = \ell$
- So the problem reduces to that of maximizing farmers' date-2 consumption subject to their IC and budget constraints, given the equilibrium prices.

Main Results (Props 1, 2 & 3)

Aggregate investment in:

- 2^{nd} best < 1^{st} best
- 2^{nd} best > when WH cannot issue fake receipts

Equilibrium

Proposition 1:
The equilibrium allocation is as follows:

$$B = \frac{\delta A \alpha e}{1+\alpha\left(a-\delta A\right)},$$

$$\ell = \frac{\alpha e}{1+\alpha\left(a-\delta A\right)},$$

$$i = \frac{e}{1+\alpha\left(a-\delta A\right)}.$$

Proposition 2:

In the benchmark model in which warehouses cannot issue fake receipts, the equilibrium is as follows.

$$\ell_{nr} = \frac{\alpha e}{1+\alpha},$$

$$i_{nr} = \frac{e}{1+\alpha}.$$

Proposition 3:

In the first-best benchmark, the allocation is as follows:

$$\ell_{fb} = \alpha e,$$

$$i_{fb} = e.$$

Liquidity Creation

Definition 1: The liquidity multiplier Λ is the ratio of the equilibrium investment in production $i + w\ell$ to the total grain endowment in the economy e,

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

Proposition 4:

Banks create liquidity only when they can issue fake receipts. In equilibrium, the liquidity multiplier is

$$\Lambda = \frac{1+\alpha}{1+\alpha\left(1-\delta A\right)} > 1,$$

whereas, in the benchmark model with no receipts, the liquidity multiplier is one, denoted $\Lambda_{nr} = 1$.

Corollary 2: The total liquidity created at Date 0 equals the number of fake receipts the warehouse issues

$$(\Lambda - 1)e = D_0 - s_0^b .$$

Corollary 3: The more efficiently warehouses can store grain relative to farmers (the higher is δ), the more liquidity warehouses create by issuing fake receipts.

Endogenous Fractional Reserves

- Even absent legal reserve requirements, warehouses still hold grain deposits in equilibrium.
- These "fractional reserves" come from farmers' IC constraint (this constraint limits how much farmers can borrow and thus how much grain they can invest).

Proposition 5: Warehouses hold

$$S_0^b = e - i = \frac{\alpha(1-\delta A)e}{1+\alpha(1-\delta A)} > 0$$

- This is inefficient, but necessitated by IC.

Policy Implications: Liquidity Requirements and Narrow Banks

$$\text{LCR:} \frac{\text{Liquid assets}}{\text{Total assets}} \geq \theta$$

Proposition 6: Whenever the required liquidity ratio θ is such that $\theta > 1 - \delta A$, liquidity regulation inhibits liquidity creation—and thus farmers' investment—below the first-best level.

Proposition 7: The requirement of narrow banking is equivalent to the benchmark in which warehouse cannot issue fake receipts (Section 5). In this case there is no liquidity creation, $\Lambda_{nr} = 1$.

Bank Capital

- Suppose warehouse must exert costly (unobservable) effort to prevent spoilage of grain.
- Then WH capital affects farmers' IC constraint (through attractiveness of storing/depositing in WH relative to absconding with grain).

Proposition 8: Increasing warehouse equity increases liquidity creation,

$$\frac{\partial \Lambda}{\Lambda E} > 0.$$

Monetary Policy

- R^{CB}=central bank (gross) rate at which WH can deposit with central bank (analogous to storage technology of WH yielding R^{CB}.
- Now grain = CB money
  receipts = private money

Proposition 9: Under some conditions, a tightening of monetary policy (higher R^{CB}) can increase liquidity creation.

Contrast With Diamond-Dybvig (1983) and Other Models of Bank Liquidity Creation

1. In DD, bank does *not* create aggregate *funding* liquidity. In our model, it does.
2. In DD, aggregate investment in illiquid projects with banks ≤ aggregate initial endowment of liquidity. In our model,

[aggregate investment in illiquid projects with banks] > [aggregate initial endowment]

3. In existing literature, deposits create loans as they are loaned out. In our model, loans also create deposits: so focus of liquidity creation is on the asset side of bank B/S.
4. DD focuses on bank's interactions with risk-averse depositors ⇒ liquidity creation synonymous with consumption insurance for depositors.
5. In DD, liquidity creation ⇒ bank runs. NOT here.

6. In existing models, bank capital either plays no role in liquidity creation or impedes it. In our model, higher bank capital leads to more liquidity creation.

Conclusion

- Banks create funding liquidity only when they use deposits to make loans, not merely when they take in deposits, i.e. it is necessary for liquidity creation by banks that aggregate ex ante investment in projects exceeds that possible without banks.
- That is, banks must perform both deposit-taking/account-keeping and lending functions
  - Need repayment to be incentive compatible
- Must be able to issue fake receipts: loans create deposits!
- Regulation on reserve/liquidity requirements and narrow banking will prevent banks from creating liquidity by making loans