A Model of Liquidity Hoarding and Term Premia in Inter-Bank Markets
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- Precautionary demand for liquidity leads to reduced volumes and high interest rates for inter-bank lending.
- Need not be connected with counterparty risk: good quality banks appear to suffer.
- Explanation: Leverage combined with asset shocks decreases ability to rollover, leading to liquidity "hoarding"

Model

- Three dates: 0,1,2; two types of banks B (borrowing) and L (lending).
- Periphery of non-bank finance ("depositors"). All agents risk neutral.
- At date 0, each bank has in place investment in one unit of long term asset.
  - Each asset in place is independent draw.
  - Asset pays at date 2, y with probability θ, 0 otherwise. $\theta y \geq 1$.
  - (Later θ itself will be stochastic, revealed at date 1).

Interbank lending

- A **borrowing bank** has an opportunity for additional investment in its asset at date 0
  - up to 1 unit
  - investment requires "liquidity"
- A **lending bank** has additional liquidity but no investment opportunities.
  - It can lend $\ell \leq 1$ to borrowing banks; stores the rest.
- Inter-bank promised interest rate is r. Repayment with probability θ.
- Liquidity receives no interest ("rate of return $= 1$")

Rollover

- At date 1 lending bank has short term obligations $\rho^L \in [1, 2]$ (e.g., depositors)
  - Non stochastic
- To meet obligations, use liquidity and/or new short term debt ("rollover") with face value f^L
- f^L will be paid back in period 2 if bank's own asset in place is successful (probability θ)
- If bank cannot repay or rollover, defaults in period 1 with zero salvage value.
- ρ^L interpreted as leverage
  - at minimum liquidity is sufficient to pay obligations
  - at maximum asset in place is being financed entirely by short term debt

Rollover

- Depositors will rollover if θf^L (expected payment) is greater than unfunded obligation ("individual rationality constraint")

$$\theta f^L \geq \rho^L - (1 - \ell)$$

- As long as rollover occurs, the bank's expected profit is

$$\theta(y + r\ell - f^L)$$

- Given market rate r, the bank chooses
  - date 0 term lending ℓ
  - date 1 borrowing amount (measured by face amount f^L)

  to maximize profits subject to individual rationality of those financing the rollover

Rollover

The lending bank's profit maximizing decision (pretty simple):

- If $r \geq 1/\theta$, lend fully: $\ell^* = 1$.
  - The risk adjusted rate of return on interbank lending θr exceeds 1, the rate of return on storage of liquidity
  - This is the risk associated with the borrowing bank's project
- If $r < 1/\theta$, don't lend: $\ell^* = 0$

Model

At any rate below investment return, borrowing bank wants as liquidity up to its capacity (1, by assumption)

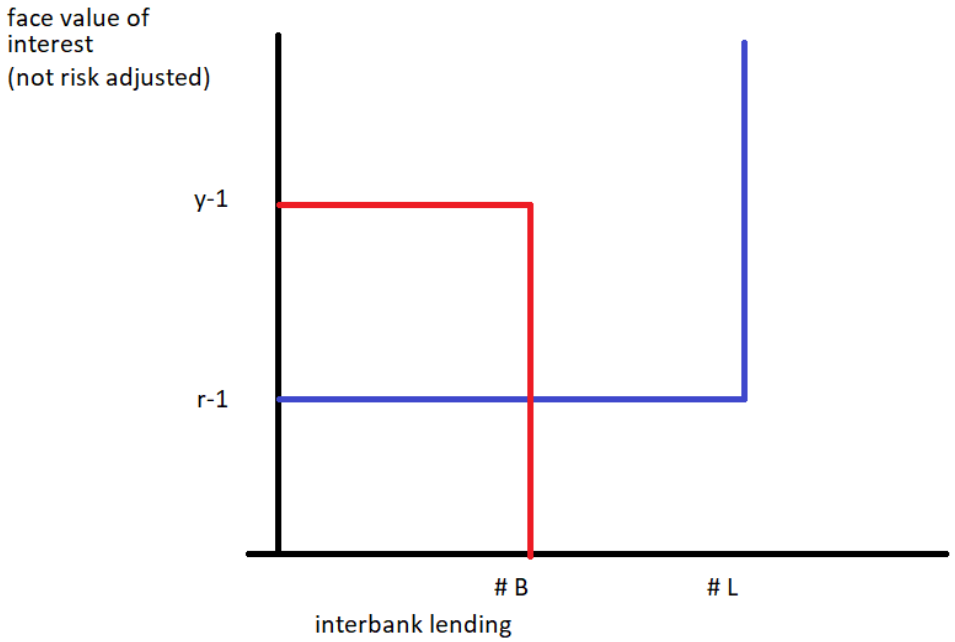
$$\begin{aligned} b^*(r) &= 1 \text{ for } r \leq y \\ &= 0 \text{ otherwise} \end{aligned}$$

Key claims:

- Lending bank lends liquidity at positive rate of return.
- Credit risk of borrower is reflected in term lending rate in interbank market $r^* = 1/\theta > 1$
- Credit risk does not affect interbank lending volume.

Model

Implicitly there must be more lending than borrowing banks



Additional Frictions

Add two problems for the lending bank:
1. Risk shifting assets. After rolling over short term debt, the bank can costlessly and unverifiably increase risks while decreasing the return of asset in place.

- Specifically, individual bank can increase asset payoff from y to y_R^L if successful, but lowering probability of success from θ to θ_R^L,
- Assume expected payoff decreased.
- (Remains independent of other banks' asset returns)

Additional Frictions

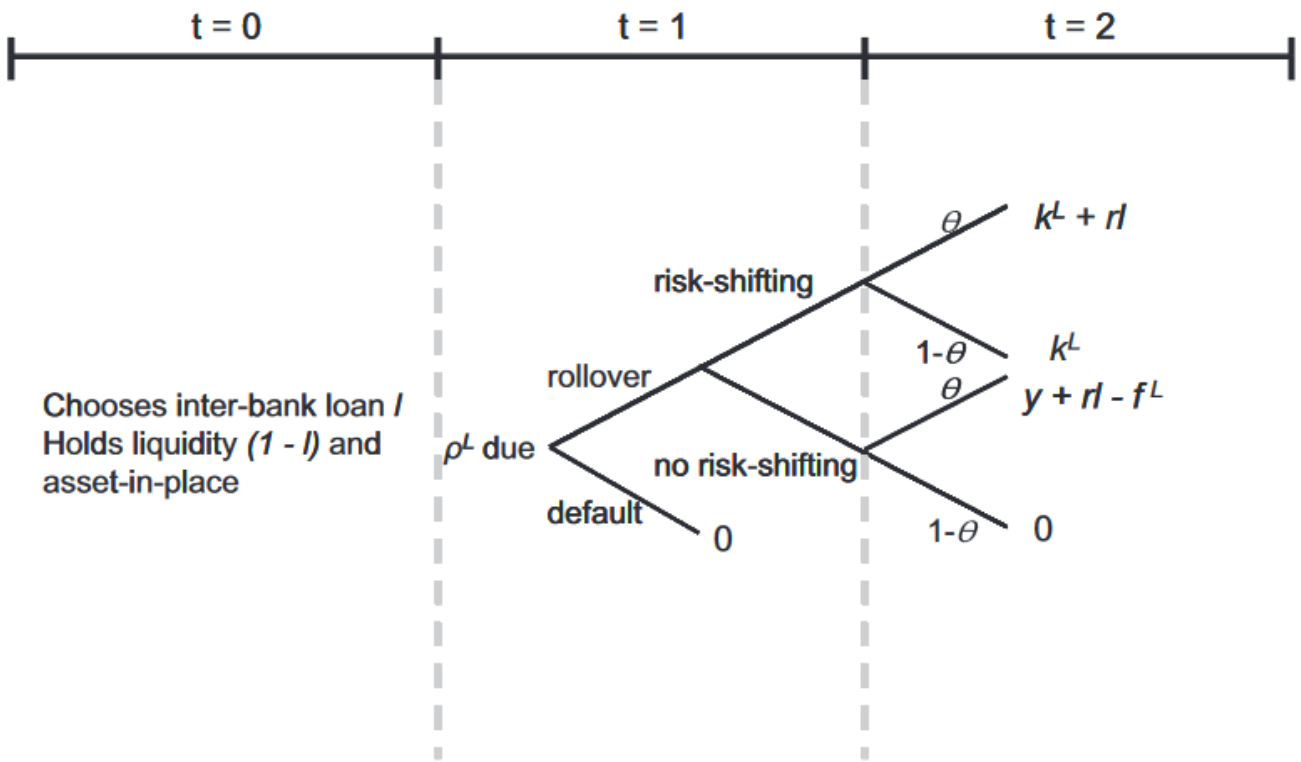
2. Payoff of interbank lending is not pledgeable. Assume a hierarchy of transparency:

- Liquidity held by bank
  - verifiable to depositors and can be paid out to depositors at date 1
- Initial asset in place held by lending bank
  - depositors can verify whether return is positive or zero, but not whether the positive return is y or y_R^L (moral hazard)
- Interbank lending
  - opaque to depositors (although lending bank can verify returns on interbank loan)

Time line

- Period 0
  - Lending bank divides resources between liquidity and interbank loan; also holds assets-in-place.
- Period 1
  - Short term obligations become due; bank rolls over or defaults.
  - If rollover, decides whether to risk shift
- Period 2
  - Borrowing and lending banks realize returns;
  - If lending bank asset in place successful, depositors are paid
  - If borrowing bank asset in place successful, lending bank is paid

Time line


t = 0
t = 1
t = 2
Chooses inter-bank loan *l*
Holds liquidity *(1 - l)* and
asset-in-place
ρ^L due
rollover
default
0
risk-shifting
θ
$k^L + rl$
1-θ
k^L
no risk-shifting
θ
$y + rl - f^L$
1-θ
0

Moral hazard condition

- By assumption, the bank gets to keep proceeds from inter-bank lending if not liquidated (depositors can't see them), so no moral hazard there.
- But risk shifting is a temptation for the assets in place.
- Conditional on rolling over the debt in period 1, the profits are

$$\pi_R^L = \theta_R^L(y_R^L - f^L) + \theta \ell r$$

(recall, the success of the inter-bank loan and of the lending bank's own project are independent)

- Thus to avoid the temptation to risk shift, the amount of new debt f^L must be small enough that

$$\theta(y - f^L) \geq \theta_R^L(y_R^L - f^L)$$

Simplifying assumption

Here they take a short cut—considering what they call a "limiting case." where θ_R^L shrinks to 0 and y_R^L grows without bound in such a way that their product goes to some constant k^L

The case is not particularly realistic. The real advantage is that it allows them to talk about the payoff from risk shifting as a constant exogenous number (because the expected payment to the depositors becomes negligible in those circumstances).

And then they can move this number around and consider the effects of increases in moral hazard.

Essentially this represents the value of non pledgeable assets necessary to maintian incentives, just as in Holmstrom Tirole.

The short cut simplifies the incentive constraint somewhat

$$\theta f_L \leq \theta y - k^L$$

Combining with individual rationality constraint yields the "rollover constraint" — the limits that must be met so that the bank can successfully roll over its debt:

$$\ell \leq \theta y - k^L - \rho^L + 1$$

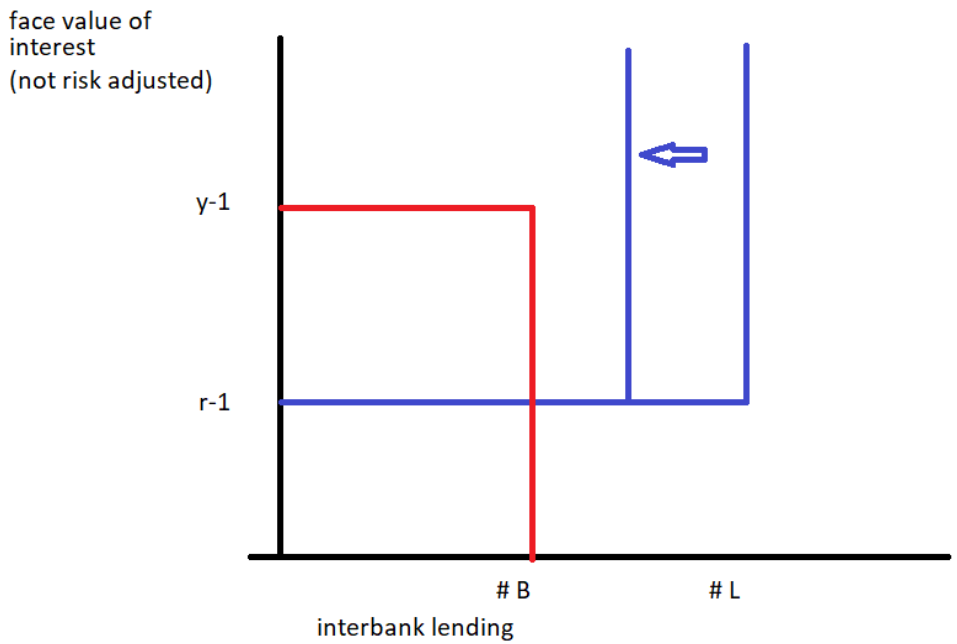
To summarize, new debt must be small enough to deter risk taking, and in turn this limits the amount of term lending the bank can undertake.

Interpretation

If the bank did not hold liquidity into period 1, it would have to borrow an excessive amount to meet its short term needs, and this would cause a moral hazard problem making depositors unwilling to lend to it.
Thus even if there are profits to be had from high interest rates on interbank loans, the bank will be unable to take additional advantage of them. The constraint could even bind so tightly that the bank engages in no interbank lending, regardless of the rate offered.
Note for this result to hold, the key feature in the model is that returns on interbank lending are not verifiable, so that the proceeds cannot be used as collateral for rollover borrowing.

Interpretation

Note the contrast between the counterparty risk as a source of spread of inter-bank lending rates over risk free due to the riskiness of the borrower, but the amount supplied limited by liquidity needs of the lender.



Caution: the authors tend to describe rates in "risk adjusted" terms (i.e., in terms of expectations), not in terms of stated rates

Extension: Precautionary Demand for Liquidity

Question: can we have those liquidity needs also affect the spread? The authors build an extension with additional uncertainty over need for liquidity where this occurs.
As the preceding diagram shows, this is not actually necessary; continued reduction in supply ultimately brings rates up to the borrower reservation value.
The real goal is simply to get a liquidity supply curve that is not L shaped, but instead has some degree of responsiveness to interest rates.

Extension: Precautionary Demand for Liquidity

In the extension asset payoff probability θ itself becomes a random variable realized at period 1.
With ℓ chosen in period 0, low values of θ mean that the rollover constraint

$$\ell \leq \theta y - k^L - \rho^L + 1$$

may not be met.
(Warning: I believe there is a minor but confusing typo at this point in the Lemma, for "probability of default θ" read "probability of payoff θ")

Extension: Precautionary Demand for Liquidity

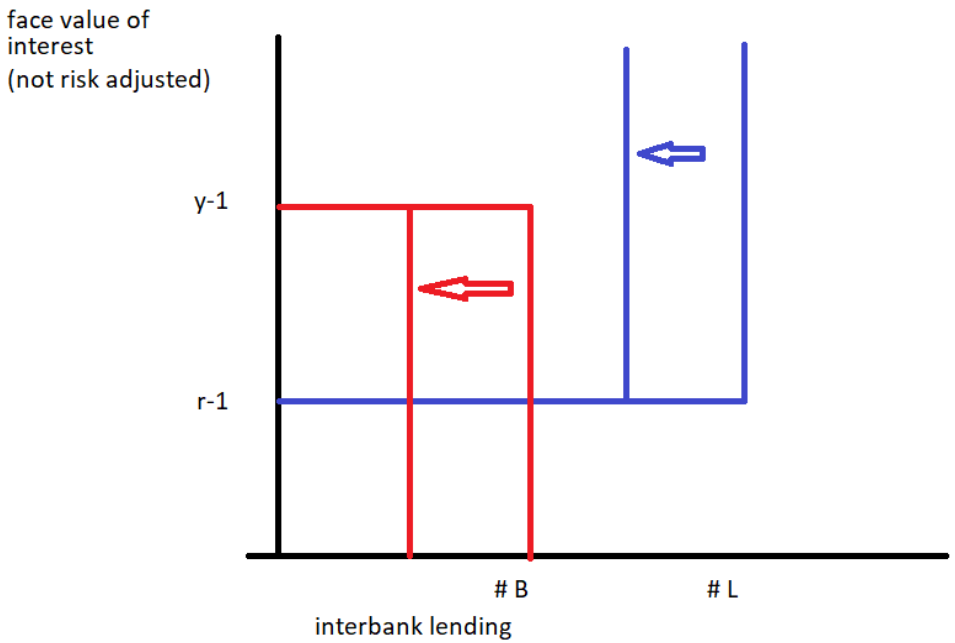
With this modification, lending banks supply liquidity with a smooth response to interest rate changes. Their decision involves the following tradeoff:

- On the one hand, increases in interest rates cause the bank to obtain more profits inducing it to lend more.
- On the other hand lending more means it is more likely that the remaining funds plus the expected value of assets in place will be inadequate to convince the depositors to rollover the bank's obligations, with resultant loss in profits.

The moral hazard problem comes into the story because it creates a wedge between bank and depositor payoffs. In the state where depositors are on the margin between rollover and shutdown, the bank is not indifferent: it wants to continue and thereby reap the unpledgeable gains.

Further extension:

The authors also briefly consider incorporating a risk shifting problem on the borrowing bank's side
In the simple diagram this would induce a reduction on the liquidity demand side as well:



Extension:

In general feedbacks between the two incentive problems can lead to further decline in the amount borrowed.
Again the authors draw a contrast with a model based solely on borrower risk:

- Precautionary demand increases the spread above that attributable to borrower risk
- Leads to reduced interbank borrowing, because of rollover risk on both borrower and lender banks.
- Banks “hoard” liquidity because of precautionary demand. The borrower bank "hoards" liquidity by *not* taking on loans today that put him in an illiquid position (in the future).