Banking and Bank Runs

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Readings

Mishkin Ch. 9

GLS Ch. 33

Diamond (2007): "Banks and Liquidity Creation: A Simple Exposition of the Diamond-Dybvig Model" *Federal Reserve Bank of Richmond Economic Quarterly*, 189-200

Bank

A bank is a financial institution that issues liabilities (e.g., checking accounts) and uses the funds from these liabilities to purchase assets (e.g., loans)

At its core, a bank borrows funds and lends/invests them. Earns returns by earning more on its assets than it pays for its liabilities

We have already encountered two reasons why banking / financial intermediation is important:

- Economies of scale (aggregating small savings to fund large investment projects)
- Mitigating informational asymmetries between savers and borrowers

Third reason for the importance of financial intermediation – liquidity or maturity transformation

Liquidity Transformation

Savers want to invest in high-return investment projects, but they also want to easily access their savings in the event of an unexpected spending need

By aggregating lots of small liabilities, banks can engage in what is known as maturity or liquidity transformation – bank assets are typically long term (maturity) and illiquid (difficult to sell on short notice), but liabilities are short term and liquid (i.e., holder of an account can liquidate his account "on demand")

A bank therefore "borrows short and lends long"

Households indirectly invest in illiquid long term assets but the bank provides them liquidity, which they value

Lots of financial institutions engage in similar behavior, but only some are classified as commercial banks and regulated as such

Beneficial, but prone to the problem of runs

Bank Liabilities

Bank liabilities include the following:

1. Demand deposits: checking accounts that pay “on demand”
2. Non-transaction deposits: deposits on which checks cannot be written (e.g., savings accounts, CDs)
3. Borrowings: banks can borrow funds (from the Fed – e.g., discount loans) or from other financial institutions

Bank Assets

Bank assets include the following:

1. Reserves: cash in the vault or on account with central bank
2. Securities: financial assets owned by banks (for commercial banks, just bonds as they are not allowed to hold equity)
3. Loans: loans issued to households and businesses that entitle the bank to interest plus principal

Bank Equity (Capital)

Bank equity (or capital) is defined as the difference between the value of its assets and its liabilities:

$$\text{Assets} = \text{Liabilities} + \text{Equity}$$

When a bank's assets (e.g., loans) earn more than its liabilities (e.g., checking accounts), the bank can either increase its equity or pay dividends out to shareholders in the bank

If equity is negative (liabilities exceed assets), we say that the bank is <u>insolvent</u>

It is important for monetary policy to distinguish between <u>liquidity issues</u> and <u>insolvency issues</u>

Can summarize the balance sheet of a bank (or the banking system as a whole) with a T-Account, as we have done previously when studying money creation

TABLE 1 Balance Sheet of All Commercial Banks (items as a percentage of the total, June 2014)

Assets (Uses of Funds)*		Liabilities (Sources of Funds)	
Reserves and cash items	19%	Checkable deposits	11%
Securities		Nontransaction deposits	
U.S. government and agency	13	Small-denomination time deposits (<$100,000) + savings deposits	47
State and local government and other securities	6	Large-denomination time deposits	11
Loans		Borrowings	20
Commercial and industrial	12	Bank capital	11
Real estate	25		
Consumer	8		
Interbank	1		
Other	7		
Other assets (for example, physical capital)	9		
Total	100	Total	100

*In order of decreasing liquidity.

Source: http://www.federalreserve.gov/releases/h8/current/.

The Business of Banking

Suppose a Bank has the T-Account

Assets		Liabilities + Equity	
Securities	\$50,000	Demand Deposits	\$100,000
Loans	\$50,000	Borrowings	\$20,000
Reserves	\$30,000		
		Equity	\$10,000

Suppose it earns 5 percent interest on loans, 3 percent on securities, and pays 2 percent interest on deposits and 3 percent interest on borrowings. Then net income or profit is:

$$\begin{aligned} \textit{Profit} &= 0.05 \times 50,000 + 0.03 \times 50,000 \\ &\quad - 0.02 \times 100,000 - 0.03 \times 20,000 = \$1,400 \end{aligned}$$

Bank can either increase reserves and increase equity by same amount, or pay the \$1,400 out to shareholders as dividend

Some Terms

Return on Assets (ROA) (flow divided by stock):

$$ROA = \frac{profit}{assets}$$

Return on Equity (ROE) (flow divided by stock):

$$ROE = \frac{profit}{equity}$$

Financial leverage (or equity multiplier, EM) (stock divided by stock):

$$EM = \frac{assets}{equity}$$

Relationship between the three:

$$ROE = EM \times ROA$$

Ratios in Previous Example

Using the numbers in the previous example, we have:

$$ROA = \frac{1,400}{130,000} = 0.0108$$
$$ROE = \frac{1,400}{10,000} = 0.1400$$
$$EM = \frac{130,000}{10,000} = 13$$

What if we changed previous example with less equity and more borrowings?

Less Equity

Suppose a Bank has the T-Account

Assets		Liabilities + Equity	
Securities	$50,000	Demand Deposits	$100,000
Loans	$50,000	Borrowings	$25,000
Reserves	$30,000		
		Equity	$5,000

Profit is now $1,250, and ROA is 0.0096. But EM is now 26, and the ROE is 25 percent

Bigger EM ⇒ bigger ROE for a given ROA

Business of Banking

When managing the balance sheet, the bank has to take two things into consideration:

1. Credit risk: assets may underperform (say, due to default)

2. Liquidity risk: the bank may face unexpectedly large withdrawals (reduction in liabilities)

Liquidity risk may lead to fire sales: if the bank faces unexpectedly high withdrawals, it may have to sell assets (at a discount, if these are illiquid) to meet withdrawal demands, which could in turn affect other banks and lead to insolvency issues

Lender of last resort: central bank trying to deal with liquidity risk

Credit Risk

Initial balance sheet:

Assets		Liabilities + Equity	
Securities	\$50,000	Demand Deposits	\$100,000
Loans	\$50,000	Borrowings	\$20,000
Reserves	\$30,000		
		Equity	\$10,000

Suppose that an outstanding loan worth \$5,000 goes into default. The new balance sheet is:

Assets		Liabilities + Equity	
Securities	\$50,000	Demand Deposits	\$100,000
Loans	\$45,000	Borrowings	\$20,000
Reserves	\$30,000		
		Equity	\$5,000

Since the decline in asset value is less than existing equity, bank remains solvent

Credit Risk with Less Equity

Same assets, but higher leverage (i.e., less equity):

Assets		Liabilities + Equity	
Securities	\$50,000	Demand Deposits	\$100,000
Loans	\$50,000	Borrowings	\$25,000
Reserves	\$30,000		
		Equity	\$5,000

\$5,000 in loans go bad:

Assets		Liabilities + Equity	
Securities	\$50,000	Demand Deposits	\$100,000
Loans	\$45,000	Borrowings	\$25,000
Reserves	\$30,000		
		Equity	\$0

Now the bank is insolvent

Benefits of Equity

Having more equity (i.e., being "better capitalized") makes it less likely that a bank will become insolvent in the event of assets (e.g., loans) losing value. Gives them a "cushion" or "capital buffer"

On the other hand, banks have an incentive to not have much equity to maximize return on equity

If banks bear the burden of insolvency, this isn't so bad

But if there is anticipation of government bailouts of failing banks, there is a moral hazard problem – banks have incentive to "lever up" to maximize gains if they are insured on the downside

This gives rise to justification for bank regulation

- We have mandated capital ratios (ratio of equity to assets, so the inverse equity multiplier)
- Idea being to force banks to have more skin in the game and to have a bigger cushion to absorb losses

Liquidity Risk

Liquidity risk: banks face potentially unpredictable withdrawals of deposits, have to meet these with reserves or have to sell off assets to raise cash. Initial balance sheet:

Assets		Liabilities + Equity	
Securities	$50,000	Demand Deposits	$100,000
Loans	$50,000	Borrowings	$20,000
Reserves	$30,000		
		Equity	$10,000

Suppose there is a withdrawal of $20,000:

Assets		Liabilities + Equity	
Securities	$50,000	Demand Deposits	$80,000
Loans	$50,000	Borrowings	$20,000
Reserves	$10,000		
		Equity	$10,000

As long as bank has sufficient reserves, withdrawal doesn't affect equity

Liquidity Risk with Different Initial Balance Sheet

Suppose the initial balance sheet is instead:

Assets		Liabilities + Equity	
Securities	$10,000	Demand Deposits	$100,000
Loans	$110,000	Borrowings	$20,000
Reserves	$10,000		
		Equity	$10,000

Suppose securities are perfectly liquid, in that they can be sold instantaneously at no discount. Bank can meet the withdrawal demand by selling securities to raise cash:

Assets		Liabilities + Equity	
Securities	$0	Demand Deposits	$80,000
Loans	$110,000	Borrowings	$20,000
Reserves	$0		
		Equity	$10,000

Withdrawal shock doesn't affect equity, but bank no longer has any reserves

Another Withdrawal Shock

Consider new balance sheet as initial balance sheet:

Assets		Liabilities + Equity	
Securities	$0	Demand Deposits	$80,000
Loans	$110,000	Borrowings	$20,000
Reserves	$0		
		Equity	$10,000

$20,000 withdrawal shock. Bank doesn't have cash. To meet withdrawal, will have to sell loans. Suppose that loans are illiquid in that they can only be sold quickly at a discount. Suppose this discount is 1/2 their balance sheet value. Bank must sell $40,000 in loans to meet withdrawal. New balance sheet:

Assets		Liabilities + Equity	
Securities	$0	Demand Deposits	$60,000
Loans	$70,000	Borrowings	$20,000
Reserves	$0		
		Equity	-$10,000

Liquidity Risk and Insolvency

In the above example, it the bank lacks sufficient reserves and/or sufficient liquid securities, a big enough withdrawal shock could lead it into a “fire sale” situation – selling loans at a discount

This could lead to insolvency

Alternative is for bank to borrow funds (either from the central bank, e.g., discount loans, or from other banks, e.g., the Fed Funds Market). Could handle the withdrawal without affecting equity as follows:

Assets		Liabilities + Equity	
Securities	\$0	Demand Deposits	\$60,000
Loans	\$110,000	Borrowings	\$40,000
Reserves	\$0		
		Equity	\$10,000

This is not ideal – bank has to pay interest on borrowings, so dynamically this costs the bank something. But it's better than insolvency

Balance Sheet Management and Policy

A bank wants to manage its balance sheet to avoid insolvency

Having sufficient equity/capital helps it deal with credit risk, but the downside from the bank's perspective is more equity lowers ROE for a given amount of assets

Having sufficient liquidity (in the form of either reserves or liquid securities) helps it deal with liquidity/withdrawal risk, but the downside is that reserves and liquid securities typically offer lower returns than more illiquid loans

Regulation

Moral hazard problem if there will be bailouts. Commonsense regulations:

1. Mandatory capital ratios (to deal with credit risk)
2. Required reserve ratios (to deal with liquidity risk)
3. Restrictions on which kinds of securities banks can hold (to reduce credit risk and give banks more liquidity)

Lender of last resort: central bank may want to make temporary loans to banks dealing with liquidity risk, but not to banks that are insolvent

Bank Runs

An individual bank never has sufficient liquidity to meet all of its withdrawal demands

Nor does the banking system as a whole

Nor should it: as we will see, a major benefit of banking is to fund illiquid investments while providing liquidity to individuals

But this means that the system is prone to "runs": depositors become afraid that the bank will fail, and try to withdraw

If enough of them do try to withdraw, and the bank doesn't have access to other funding (e.g., loans from central bank), the bank will fail. This is a self-fulfilling prophecy, and it's completely rational

An implication of information asymmetry – depositors don't know whether a particular bank is healthy or not, which exposes system to fear-induced runs

Liquidity

Liquidity refers to the ease with which an asset can be sold quickly without affecting the asset's price

Cash is the most liquid asset – I can "buy" or "sell" cash without affecting its price (the inverse price of goods)

In contrast, a house is not very liquid

Agents value liquidity because they are uncertain of when they will need to purchase things

If I knew I wouldn't have to buy anything for the next six months, I could invest my wealth in a financial asset (e.g., bond) with this maturity

But if there is a chance I might have to buy something before six months is up, I value holding an asset that is more liquid over a less liquid asset

Diamond-Dybvig Model Assumptions

I will follow the setup in Diamond (2007). GLS gets at the same point but uses a slightly different setup and notation

Time lasts for three periods: $T = 0, 1, 2$

Many households (so price-takers). Have 1 unit to invest in period $T = 0$. Will need to consume in *either* $T = 1$ or $T = 2$

At time of investment, household doesn't know if it will be "early/impatient" type (need to consume in $T = 1$) or a "late/patient" type (can wait to consume until $T = 2$)

The investment the household has access to gets a (gross) return of r_1 if sold in $T = 1$. Gets r_2 if not sold until T, where $r_2 \geq r_1$

$\frac{r_1}{r_2}$ is a measure of the liquidity of the investment. The closer the ratio is to 1, the more liquid it is (i.e., you don't take much of a "hit" by selling "early")

Uncertainty over Timing of Expenditure

In period $T = 0$, household doesn't know if it will need to consume early or late

Only knows that it will need to consume in $T = 1$ with probability t and in period $T = 2$ with probability $1 - t$

For simplicity, assume no time discounting (i.e. $\beta = 1$)

Expected utility of investing in the asset:

$$\mathbb{E}[U] = tU(r_1) + (1 - t)U(r_2)$$

Outside option: not investing, storing the 1 unit yields 1 unit of consumption in either $T = 1$ or $T = 2$, so:

$$\mathbb{E}[U] = U(1)$$

Risk-Aversion

Assume that utility function is:

$$U(C) = 1 - \frac{1}{C}$$

Note utility is ordinal – it can be negative! What is key is that utility is concave in C (negative second derivative)

First and second derivatives:

$$U'(C) = \frac{1}{C^2} > 0$$

$$U''(C) = -\frac{2}{C^3} < 0$$

To Invest or Not?

Suppose that the investment opportunity pays $r_1 = 0.5$ if sold in $T = 1$ and $r_2 = 1.5$ if sold in $T = 2$. Suppose $t = 0.4$

Expected utility from investing in the asset:

$$\mathbb{E}[U] = 0.4 \times \left(1 - \frac{1}{0.5}\right) + 0.6 \times \left(1 - \frac{1}{1.5}\right) = -0.2$$

Expected utility from not investing:

$$\mathbb{E}[U] = 0.4 \times \left(1 - \frac{1}{1}\right) + 0.6 \times \left(1 - \frac{1}{1}\right) = 0$$

Household prefers not investing!

Non-Funding of the Illiquid Project

In this particular example, since expected utility from not investing exceeds expected utility from investing, the household won't invest, and the illiquid project won't get funded

This need not necessarily be the case – depends on how risk averse household is, how illiquid project is, and probabilities

Note, in this example, the illiquid project doesn't get funded even though it offers a higher expected return than holding cash (which, by assumption, offers zero net return):

$$\mathbb{E}[R] = 0.4 \times 0.5 + 0.6 \times 1.5 = 1.1 > 1$$

Enter a Bank

Because of its preference for liquidity, the household will not directly fund the project

Without some kind of financial intermediary, the illiquid project won't get funded

Enter a "bank." For purposes of this example, suppose this is a "mutual bank" – effectively a credit union. No equity and not trying to increase equity

By pooling deposits of many households, can bank offer the household an asset it prefers to holding cash while at same time investing in the illiquid project?

In principle, yes. It's playing probabilities – the bank knows only a fraction t of depositors will need their money out in period $T = 1$.

Liquidity Transformation

Suppose there are 100 depositors

Bank offers depositors the following asset: it pays $r_1^d = 1$ if withdrawn in $T = 1$, and r_2^d if withdrawn in $T = 2$

Bank anticipates 40 depositors will want their money back in $T = 1$. So it will store 40 in cash (i.e., reserves)

It will invest the other 60 in the illiquid investment

This will generate $60 \times 1.5 = 90$ in period $T = 2$, which it can distribute to the remaining 60 depositors for a return of $r_2^d = 1.5$

So it can offer the household $r_1^d = 1$ and $r_2^d = 1.5$, which is more liquid than the actual project. Household's expected utility:

$$\mathbb{E}[U] = 0.4 \times \left(1 - \frac{1}{1}\right) + 0.6 \times \left(1 - \frac{1}{1.5}\right) = 0.2$$

Household likes this and prefers it to storage!

Alternative Example

Suppose the illiquid project pays $r_1 = 1$ if sold in $T = 1$ and $r_2 = 2$ if sold in $T = 2$

Probability of $t = 1/4$ that household needs to consume early

Same utility function

Expected utility from household directly financing project:

$$\mathbb{E}[U] = 0.25 \times \left(1 - \frac{1}{1}\right) + 0.75 \times \left(1 - \frac{1}{2}\right) = 0.375$$

This means that the household <u>will</u> directly fund the project since expected utility from doing so exceeds expected utility of storage

Any Role for a Bank?

Is there any role for a bank to make the household better off in this example? Yes!

Suppose bank offers withdrawals in period $T = 1$ $r_1^d = 1.28$. It anticipates 25 withdrawals. Since r_1 on the illiquid project is 1, it will invest all 100 units in this project in $T = 0$, and will sell 32 (25×1.28) to meet withdrawal demands in $T = 1$

The other 68 remains invested, and generates 136 in revenue in $T = 2$, which it distributes to remaining 75 withdrawers for $r_2^d = 1.813$

Liquidity of this asset is 0.7, which is greater than the actual project. Household expected utility from this:

$$\mathbb{E}[U] = 0.25 \times \left(1 - \frac{1}{1.28}\right) + 0.75 \times \left(1 - \frac{1}{1.813}\right) = 0.391 > 0.375$$

Bank Run

Suppose in period $T = 1$ that you learn you don't need to consume until period $T = 2$

Nothing is stopping you from withdrawing in $T = 1$

Would it ever make sense to withdraw in $T = 1$?

Potentially, if you think other late types are also going to withdraw

If bank faces more than the expected number of withdrawals in $T = 1$, it will have to liquidate some of the illiquid asset early at a discount

Which means it won't be able to pay back the r_2^d it promised late withdrawers

To Run or Not?

Go with our earlier example, where the bank promises $r_1^d = 1$ and $r_2^d = 1.5$, while the illiquid project pays the bank $r_1 = \frac{1}{2}$ or $r_2 = 1.5$, where $t = 0.4$

Suppose you are a late type, but think that some fraction $f \geq t$ are going to withdraw

Suppose $f = 0.6$. Bank has stored 40 and invested 60, but will need to sell 40 of the 60 invested to raise the additional 20 it needs to come up with to pay additional withdrawers

This leaves bank with 20 invested in the asset, which will yield 30 in $T = 2$

There would be 40 depositors left over, so bank could only pay them 0.75 each

This is <u>worse</u> than you get by withdrawing in $T = 1$. Conditional on your belief about f, it is optimal for you to withdraw

Cutoff f

Let $N = (f - t) \times 100$ be the number of late types you expect to withdraw in $T = 1$

For each withdrawal, bank needs to sell 2 of the illiquid asset

Remaining illiquid assets: $60 - 2N$

These remaining assets return 1.5, and are distributed among $60 - N$ late withdrawers. The return the bank can offer late withdrawers as a function of N is:

$$\frac{1.5 \times (60 - 2N)}{60 - N}$$

To <u>not</u> withdraw early, this must be greater than or equal to $r_1^d = 1$ (the return on withdrawing early)

This means $N \leq 15$ (equivalently, $f \leq 0.55$)

Multiple Equilibria: Good

In this particular example, as long as $N \leq 15$ (equivalently, $f \leq 0.55$), it is optimal for patient households to not withdraw in period $T = 1$

If it is not optimal for you to withdraw, then it can't be optimal for others to withdraw, and you must expect $N = 0$ (equivalently, $f = t$). This is the "good equilibrium"

Multiple Equilibria: Bad

But if you expect $N > 15$ (equivalently, $f > 0.55$), then it is optimal for you to withdraw in $T = 1$ if you are a patient household. But if it is optimal for you to withdraw, then it is optimal for all patient types to withdraw ($N = 40$, or $f = 1$). This is the "bad equilibrium"

Both of these equilibria (where the initial N is exogenous) are self-fulfilling and hence entirely rational

In the bad equilibrium, bank can't even pay back $r_1^d = 1$ to all early withdrawers, and the bank fails. This is a "bank run" or a "bank panic"

One small piece of bad news could shift you from good to bad equilibrium

Liquidity Transformation: Costs versus Benefits

Liquidity transformation is potentially highly valuable – savers indirectly get access to high return projects but access the liquidity they desire

Arguably, in modern times in developed economies liquidity transformation is an even more important benefit of financial intermediation than is ameliorating informational asymmetries

But the process of liquidity transformation leaves the banking system (or more generally the financial system) inherently susceptible to runs

Liquidity transformation is both a <u>feature</u> and a (potential) <u>bug</u>

Runs can be quite costly and are the defining feature of financial crises

How to Prevent Runs?

In practice, runs are incredibly costly

Possible prevention strategies:

1. High reserve requirements
2. Suspension of convertibility
3. Deposit Insurance
4. Lender of last resort

Reserve Requirements

As we have seen, in practice central banks require banks to keep some fraction of total deposits in the form of reserves

The more you require banks to keep in reserves, the less likely we are to get runs – in the terminology of the previous example, you'd need N (equivalently f) to be bigger to get you into the bad equilibrium

But if you set reserve requirement too high, you defeat the potential benefit of liquidity transformation altogether

It bank can't invest in the illiquid asset, it can't do the liquidity transformation as well, and household is worse off (in the good equilibrium)

Suspension of Convertibility

Banks could just say "We will only meet withdrawal demands for a fraction x of depositors"

If the bank does this at $x = t$ and you are a patient type, then you don't need to worry about your payout in $T = 2$ being diluted by a run in $T = 1$. Hence, we don't have a run.

This is how banking panics were dealt with prior to central banking

Problem: how does bank really know what t is? If it sets $x < t$, there will be some people who need their money out in $T = 1$ who can't get it. If it sets $x > t$, it may not solve the run problem

Deposit Insurance

FDIC

Member banks pay small fee into a pool. If a bank can't meet withdrawal demands, then the FDIC does

Presence of FDIC (if credible) ought to reduce fear-induced runs altogether, and in practice that is more or less what has happened

- Recent Silicon Valley Bank run: depositors had way more than the FDIC cap

Without runs, the FDIC rarely has to pay out, so this isn't expensive for the government

But there is a downside – moral hazard. If banks know that deposits are insured, bank has little incentive to maintain sufficient liquidity, and may take too many risks

Lender of Last Resort

A central bank can also eliminate runs by implicitly serving the role of explicit deposit insurance – the central bank can lend freely to banks in the event of liquidity shortages

Has similar potential adverse moral hazard consequences to deposit insurance

Central bank doesn't want to lend to cover insolvency problems, but rather liquidity problems. May be hard to disentangle

Also, there is a potential <u>fiscal cost</u> to lender of last resort policies – if the central bank loses money on its loans, this costs the taxpayer (because central banks remit operating surpluses to the Treasury)

Debt, Equity, and Runs

The possibility of runs occurs because banks finance their operations with (fixed value) debt

By fixed value I mean they issue \$1 in deposits which are redeemable for \$1

There is a "first come, first served" aspect – if everyone lines up to get their deposits out, the first in line get their money back while those at the end don't

If there is a potential for a run, this "first come, first served" aspect <u>increases incentives to run</u>

100 Percent Equity Banking

Some people, such as John Cochrane, think we should have 100-percent equity banking

Basic idea: you purchase floating value shares with a bank. This is equity/stock, not debt!

The bank invests your money. The value of your shares fluctuate with the value of the bank's assets it has invested

You can sell shares at any time at market prices and use proceeds to conduct transactions

Cochrane argues that there can be no runs in this setup

Why is It Run Proof?

In traditional banking, you redeem liabilities with the issuer for a fixed value (i.e., you withdraw \$1 of deposits and the bank is forced to come up with \$1 cash)

With equity banking, if you wanted to redeem shares for cash, you have to sell them on the open market

You can get cash, but the issuer of the equity shares (i.e., the bank) does not have to come up with the cash

Hence it wouldn't be pressured to sell assets, potentially leading it into insolvency

So we wouldn't have runs

But would this be desirable? You'd be missing out on the liquidity services that deposits and other short term liabilities provide (i.e., you are fairly certain about the value of your account)

100-Percent Reserve Banking

Another run-proof alternative is 100-percent reserve banking, or "narrow banking"

With the Fed now paying interest on reserves, this in principle is feasible – a bank accepts deposits, holds 100 percent reserves, earns interest on reserves, and pays interest on deposits, keeping a small spread

Like equity banking, this is run-proof, but provides liquidity services (i.e., deposits)

This was recently tried, but the Fed nixed the charter of the so-called Narrow Bank