

Lecture 5: The Global Financial Crisis

Rhys Bidder

University of Oxford - MFE - International Finance

Trinity, 2019

Disclaimer

The views expressed in this presentation, and all errors and omissions, should be regarded as those solely of the authors, and are not necessarily those of the Federal Reserve Bank of San Francisco, the Federal Reserve Board of Governors or the Federal Reserve System.

The Importance of Capital

Firm balance sheet

- A firm's balance sheet has two sides
 - Assets: Cash, intellectual property, inventory, receivables, machinery, trucks, real estate...
 - Liabilities: Bank loans, commercial paper, trade credit, long term debt/bonds, capital
- If a firm's assets exceed its liabilities *excluding its capital* then we say it is 'solvent'
- Capital is the buffer of the asset value over obligations to external creditors
 - Simplifying somewhat, it comprises equity and retained earnings
 - Natural to think of it as liabilities to the bank's owners (shareholders)

Bank balance sheet

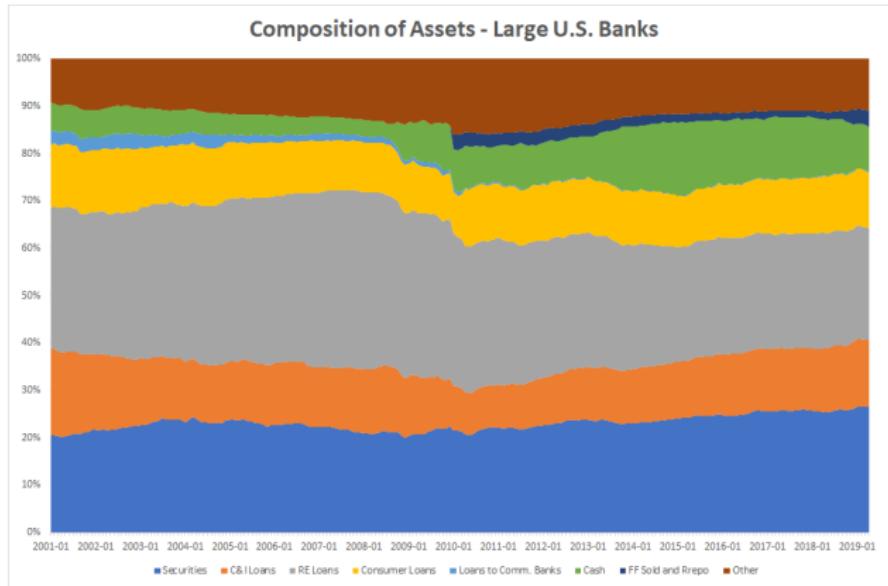
- A bank balance sheet also has two sides
 - Assets: Traditionally predominantly loans, but also securities, cash etc.
 - Liabilities: Deposits, wholesale funding, long term debt/bonds, **capital**
- Other than the composition of the balance sheet, the essential logic of a bank balance sheet is the same as in the firm case
 - The 'other than' is obviously very important!
- Confusing terminology: People (and I will) often refer to the bank's liabilities as excluding equity
 - Under this relabeling, solvency \Leftrightarrow assets \geq liabilities \Leftrightarrow capital > 0

Bank balance sheet



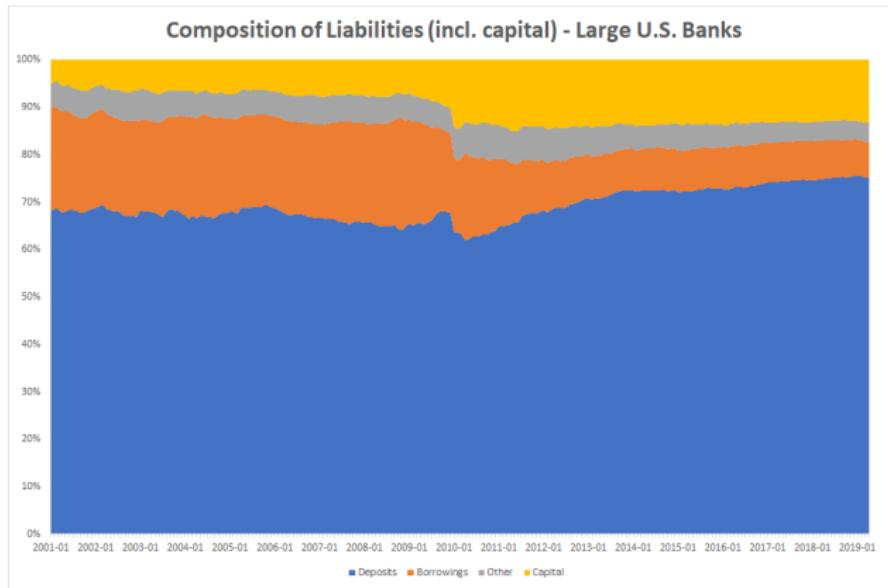
Simplified bank balance sheet. Source: Bank of England - Farag (2013)

Composition of assets



Asset composition of large U.S. banks (percent). Source: Federal Reserve table H.8

Composition of liabilities



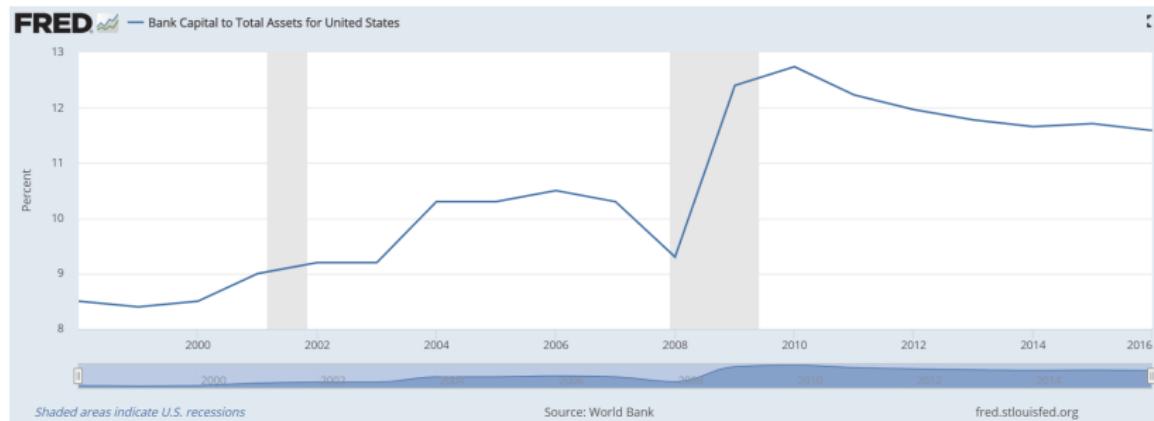
Liability (including capital) composition of large U.S. banks (percent).
Source: Federal Reserve table H.8

Loans vs. deposits

| (in \$ billions) | Avg. Loans Outstanding | Avg. Deposits | Loan-to-Deposit Ratio |
|-------------------------|------------------------|---------------|-----------------------|
| U.S. Bancorp | 273 | 328 | 83% |
| Wells Fargo | 964 | 1,299 | 74% |
| Bank of America | 914 | 1,257 | 73% |
| Citigroup | 623 | 941 | 66% |
| JPMorgan Chase | 892 | 1,392 | 64% |
| Top 5 U.S. Banks | 3,666 | 5,217 | 70% |
| All U.S. Banks | 9,139 | 12,990 | 70% |

Loan to deposit ratios (2017Q1). Source: Forbes (2017)

Bank capitalization (inverse of leverage)

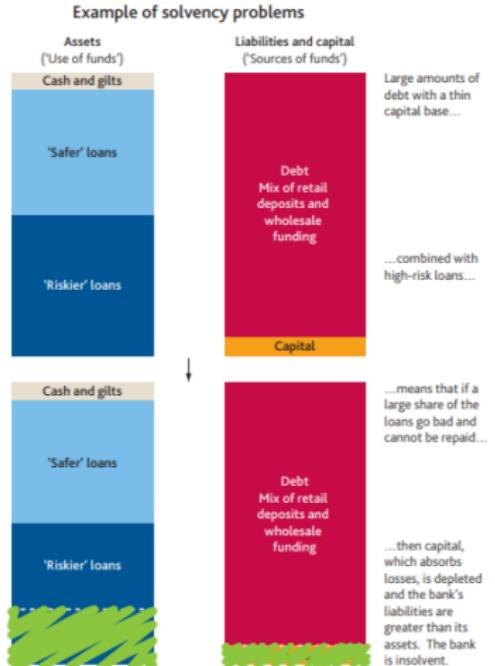


Ratio of bank capital and reserves to total assets. Capital and reserves include funds contributed by owners, retained earnings, general and special reserves, provisions, and valuation adjustments. Capital includes tier 1 capital (paid-up shares and common stock), and total regulatory capital, which includes several specified types of subordinated debt instruments which need not be repaid if the funds are required to maintain minimum capital levels (these comprise tier 2 and tier 3 capital). Total assets include all nonfinancial and financial assets. Source: St Louis Fed. FRED database

Bank balance sheet - solvency after losses

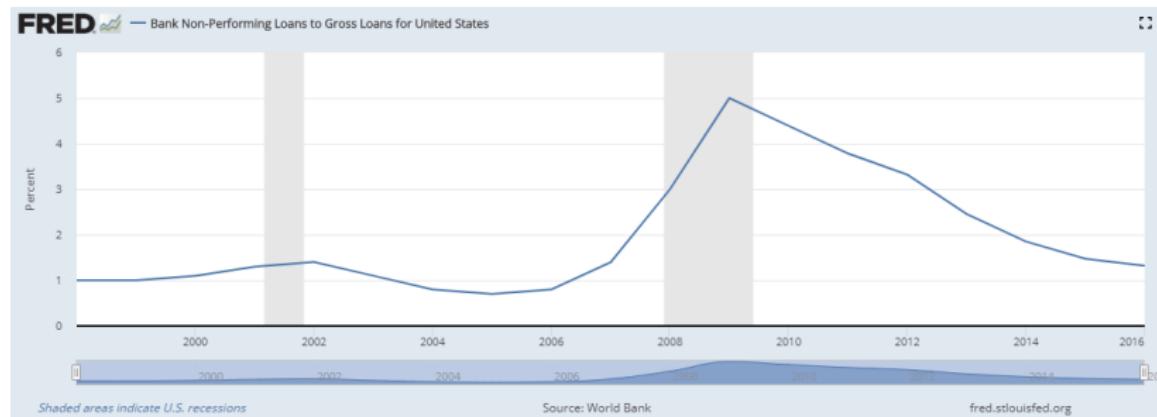
- Suppose a bank initially has a balance sheet of size \$100
 - Assets:
 - \$20 of risky loans
 - \$70 of safe loans
 - \$10 of cash
 - Liabilities:
 - $\$x$ of capital
 - $\$100 - \x of deposits/wholesale funding/bonds
- Suppose it is discovered that the risky loans were originated under very low standards and half are certain to default
 - Risky loans revalued to \$10
- If, initially, $x = 20$ then bank is still solvent as capital absorbs the loss (reduced to \$10)
- But if $x = 5$ then bank is now insolvent as capital is exhausted, leaving assets = $\$90 < \95

Bank balance sheet - solvency problem



Simplified bank balance sheet - example of solvency problem. Source:
Bank of England - Farag (2013)

Bank balance sheet - bad loans



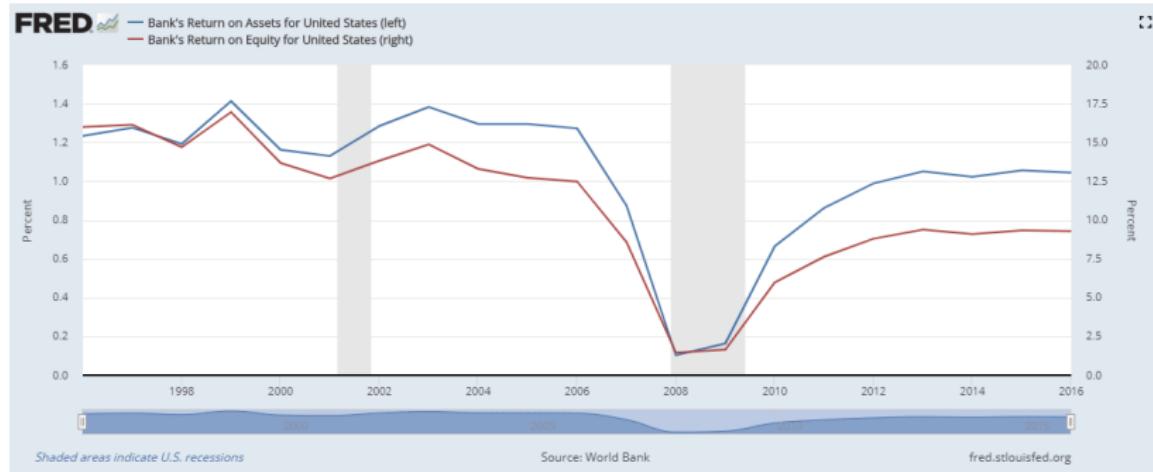
Ratio of defaulting loans (payments of interest and principal past due by 90 days or more) to total gross loans (total value of loan portfolio).

Source: St Louis Fed. FRED database

Amplification through leverage

- Why lever up so much?
 - Consider simple example
 - \$A of assets
 - \$x of capital (or 'equity')
 - \Rightarrow 'leverage ratio' of $\mathcal{L} = A/x$
 - Suppose change in value of assets of δ
 - Shareholders only put up x
 - Return on their equity is $\frac{\delta}{x} = \frac{A}{x} \frac{\delta}{A} = \mathcal{L} \frac{\delta}{A}$
 - Leverage blows up gains (but also amplifies losses)

Bank RoA and RoE



Return on assets (percent, left scale) vs. return on equity (percent, right scale) Source: St Louis Fed. FRED database

Models of the importance of capital

- People often use the term ‘capital structure’ to refer to the split between ‘debt’ and ‘equity’ in funding a firm
- In a perfect world the value of a firm should be invariant to capital structure
 - This is the punchline of the (in)famous ‘Modigliani-Miller’ result
 - Reallocating payoffs to debt, equity shouldn’t, *per se*, create value
 - Only overall payoff stream from a firm’s activity should influence value
 - Δ Leverage \Rightarrow Δ riskiness of debt vs. equity \Rightarrow Δ prices of claims
- This result holds only in the simplest models and anecdotally there is strong disagreement with it
 - Disagreement may be self-serving (short termist bank managers may want to boost their pay in the short term)
 - Also, strong empirical evidence that erosion of capital affects cost of finance
 - Taxes and various other (typically information) frictions can break the result

Models of the importance of capital

- Naive view of credit: If savers have funds to lend, what matters is the entrepreneur's idea and nothing else
 - Either it's a good project or it's not
 - How it's funded (bank credit, bonds, equity - some weird type of structured finance) doesn't matter (Modigliani-Miller again)
- Empirical evidence and theoretical work questioned this
 - Financial accelerator models focused on non-financial firms
 - Bernanke, Gertler and Gilchrist (1999) - lenders must pay a fixed 'auditing cost' in order to observe an individual borrower's realized return
 - Kiyotaki and Moore (1997) - borrowers cannot be forced to repay debts
 - Asset price variation induces fluctuations in firms' net worth
 - Credit tightens as net worth declines and this can further suppress asset prices
 - Vicious circle...

Models of the importance of capital

... when borrowers have little wealth to contribute to project financing, the potential divergence of interests between the borrower and the suppliers of external funds is greater, implying increased agency costs; in equilibrium, lenders must be compensated for higher agency costs by a larger premium [in the lending rate]. To the extent that borrowers' net worth is procyclical (because of the procyclicality of profits and asset prices, for example), the external finance premium will be countercyclical, enhancing the swings in borrowing and thus in investment, spending, and production.

- Bernanke, Gertler and Gilchrist (1999)

Models of the importance of bank capital

Traditionally, most economists have regarded the fact that banks hold capital as at best a macroeconomic irrelevance and at worst a pedagogical inconvenience.

- Ben Friedman (1991)

The current generation of workhorse models used for monetary policy analysis typically abstract from imperfections in financial markets. Firms and households can borrow freely at riskless interest rates. And financial intermediaries, if they are explicitly modeled, are nothing more than a veil.

- Aikman and Paustian (2006)

Models of the importance of bank capital

- Pre-crisis treatment of ‘banks’ in most macro models
 - Simply a conduit for funds to flow from investors to firms
 - State of investors and firms might matter but bank health not separately influential
- Similar intuitions as for firms apply to banks
 - To the extent that monitoring of firms by banks is costly and unobservable, the bank might want to shirk
 - Knowing this, bank investors (e.g. depositors) would like the bank to have ‘skin in the game’
 - By funding their activities with some of their own money (net worth) banks retain an interest in the good performance of the loans they fund
 - Aligns incentives for monitoring with the interests of bank investors

Liquidity Crisis - Theory

Liquidity Crisis

- The crisis saw dramatic disruption to, and loss of, liquidity
 - Many ways to define liquidity
 - Ability to sell/liquidate asset rapidly at a reasonable price
 - Ability to borrow on reasonable terms easily / quickly
 - With collateralization, the two definitions are closely related
- Liquidity problems interacted with, but to an important degree, are distinct from solvency problems
 - Liquidity: Can I borrow quickly?
 - Solvency: 'Appropriately valued' assets > liabilities
- Common models of liquidity risk to banks build on the Diamond-Dybvig model
 - Explains how depositors may 'run' on 'maturity mismatched' banks
 - Banks 'borrow short and lend long'
 - Runs affected banks and shadow banks in the crisis
 - Not by people queuing outside banks but also in debt markets

Diamond Dybvig (1983)

- Seminal paper that offers insights into
 - Why maturity transformation by banks might be efficient
 - Why this phenomenon also renders them vulnerable to runs
 - Why a solvent institution might fail regardless, due to a lack of liquidity
 - The concept of liquidity - formulated precisely
 - Possible policy responses
- The original *1983 paper* is readable (one of the great papers)
- A later summary paper, *Diamond (2007)*, is an easier read

Diamond Dybvig (1983)

- Banks borrow to fund investments in long(er) term projects
 - Think of ‘borrowing’ as providing demand deposits to hholds
 - But also can apply to short term borrowing in money markets
 - Deposits: provide ‘liquidity’ (can withdraw at any time at face value)
 - Long-term projects: ‘illiquid’ assets (early liquidation may reduce value)
- A principle function of banks is to create liquidity
 - Deposits more liquid than assets
 - Investors who want liquidity will prefer to hold illiquid assets *indirectly* - through the bank
 - This is great - when it works - but there is a nasty sting in the tail!
- We will briefly discuss the version of the model in Ch. 7 Freixas and Rochet (2008)
 - Also draws on Bryant (1980, 1981)

Diamond Dybvig (1983) - Setup

- One good
- Three dates: $t = 0, 1, 2$
- Continuum (infinitely many, infinitesimally small) of agents
- Each agent endowed with a unit of the good at $t = 0$
- *Ex ante* the agents are identical (at $t = 0$)
- But face idiosyncratic shock at $t = 1$
 - With (independent) probability π they need to consume at period 1
 - So with probability $1 - \pi$ they need to consume at period 2
 - Think of first ('type 1') as impatient and second ('type 2') as 'patient'
 - Perhaps better to imagine type 1 getting an unexpected cashflow need
- As of period 0 they have utility given by

$$U = \pi u(C_1) + (1 - \pi)u(C_2)$$

- Continuum of agents, independence and LOLN \Rightarrow realized fraction of type 1 at $t = 1$ is given by π

Diamond Dybvig (1983) - Alternative 'investments'

- Agents can store good from one period to the next without any cost
 - Think of this like sticking money under the mattress
- **Alternatively** they have access to a constant returns to scale (CRS) technology
 - One unit invested at $t = 0 \Rightarrow$ return $R > 1$ at $t = 2$
 - Technology implies an 'illiquid asset' in that investment only yields return $s < 1$ if it is liquidated at $t = 1$
 - Think of this as trying to quickly wind up a business or interrupt the building of a factory prematurely

Diamond Dybvig (1983) - Autarky

- Consider an agent (who does not yet know her type) choosing the scale of investment, I , in the CRS technology
- Remainder, $1-I$, will be stored
- There is no trade with the other agent by assumption (autarky) so it is a standalone problem

Diamond Dybvig (1983) - Autarky

- They look forward in time...
 - If they turn out to be type 1 they will liquidate (only care about C_1)

$$C_1 = sl + 1 - I$$

- If they turn out to be type 2 they will continue project (only care about C_2)

$$C_2 = RI + 1 - I$$

- Anticipating this, they choose I to maximize

$$\pi_1 u(sl + 1 - I) + (1 - \pi_2) u(RI + 1 - I)$$

- The FOC implies

$$-\frac{1 - \pi_1}{\pi_1} \frac{R - 1}{s - 1} = \frac{u'(C_1)}{u'(C_2)}$$

Diamond Dybvig (1983) - Autarky

- We can partially characterize the solution (even without specifying further utility function details)
 - Suppose $I = 0$, then $C_1 = C_2 = 1$
 - Suppose $I = 1$, then $C_1 = s$ and $C_2 = R$
 - Suppose $I \in (0, 1)$ then...
 - $C_1 = (s - 1)I + 1 < 1$ (since $s < 1$)
 - $C_2 = (R - 1)I + 1 < R - 1 + 1 = R$ (since $R > 1$)
- Note that $C_1 \leq 1$ and $C_2 \leq R$ with at least one strict equality
 - The chosen I is *ex post* inefficient with probability > 0
 - Type 1: Wish had set $I = 0$ as sticking it under the mattress for return of 1 is better than s from premature liquidation
 - Type 2: Wish had set $I = 0$ since all savings would have earned R , rather than 1 under the bed
 - They do this because they don't want to risk a complete mismatch of payoffs and their liquidity demands

Diamond Dybvig (1983) - Opening a financial market

- Is the problem solvable simply by opening a bond market?
 - Price in period 1 of a unit of good in period 2 is given by p
 - Allows type 1 to have $C_1 = pRI + 1 - I$
 - From selling RI bonds (instead of liquidating long term investment)
 - The long term investment allows her to fulfill her commitment
 - Allows type 2 to have $C_2 = RI + \frac{1-I}{p}$
 - From buying $\frac{1-I}{p}$ bonds (instead of storing the good for another period)
 - $C_1 = pC_2$ and thus utility is $\uparrow (\downarrow)$ in I if $pR > 1 (< 1)$
 - Linearity in I implies that an interior solution can only exist if $pR = 1$
 - Using feasibility $(1 - \pi_1)C_2 = RI \Rightarrow I = 1 - \pi_1$
 - Then $(C_1, C_2) = (1, R)$ which is Pareto superior to the autarkic case (where $C_1 \leq 1$ and $C_2 \leq 1$ with at least one - and typically both - strict inequality)
- So opening a bond market has improved the situation, but is it 'ideal'?

Diamond Dybvig (1983) - Optimal (symmetric) allocation

- Suppose we simply ask what the ‘planning’ optimum would be
- We simply maximize $\pi_1 u(C_1) + (1 - \pi_2)u(C_2)$, subject to
 - Feasibility in period 1: $\pi_1 C_1 = 1 - I$
 - Feasibility in period 2: $(1 - \pi_1)C_2 = RI$
- This is equivalent to choosing I to maximize

$$\pi u\left(\frac{1-I}{\pi_1}\right) + (1-\pi_1)u\left(\frac{RI}{1-\pi_1}\right)$$

- This yields the FOC that optimal allocation (C_1^*, C_2^*) must satisfy
$$-u'(C_1^*) + Ru'(C_2^*) = 0$$
- Generically the market allocation will not satisfy this condition
 - Would need a fluke utility function for it to hold with $(C_1, C_2) = (1, R)$ and $I = 1 - \pi_1$.

Diamond Dybvig (1983) - Banking equilibria

- It turns out that the presence of banks can implement the optimum, as **an** equilibrium
- Suppose we have a fractional reserve system
 - Not all deposits are backed by short term assets
- The bank...
 - Collects agents' endowments in time 0 (deposits)
 - Offers the depositors the right to withdraw at any time
 - Invests a fraction in the long-term project
 - Proposes a deposit contract that allocates (C_1^*, C_2^*) in periods 1 and 2, respectively, given a unit deposit in period 0
- Is this contract feasible in equilibrium?

- Good equilibrium
 - Suppose type 2 agent (whose beliefs matter) believes bank will satisfy its obligations in period 2
 - The FOC from the planning problem $\Rightarrow C_1^* < C_2*$ so sticking with the contract is preferable to withdrawing and storing
 - All type 1 agents will withdraw - so the bank must have $\pi_1 C_1^*$ on hand
 - So the bank must invest only $1 - \pi_1 C_1^*$ in project at $t = 0$
 - Then the bank is solvent in this equilibrium with probability 1

Diamond Dybvig (1983) - Banking equilibria

- Bad equilibrium (bank run)
 - Suppose the bank has adopted the approach above but...
 - Suppose a type 2 agent believes that all other type 2 agents will withdraw at $t = 1$
 - Then bank will need to liquidate all its assets at $t = 1$ yielding total value $\pi_1 C_1^* + (1 - \pi_1 C_1^*)s < 1 < C_1^*$ where C_1^* is the value of its liabilities
 - Thus the bank is insolvent and nothing will remain to pay out in period 2
 - So optimal for type 2 agent to withdraw in 1
 - This behavior confirms the belief that induced it and thus this is also an equilibrium
- Deposit insurance or a willingness to bail banks out can prevent this
 - But dulls depositors' incentive to monitor banks and - unless properly priced - is a subsidy to risky investments
 - Huge problems with moral hazard if banks know they will be bailed out

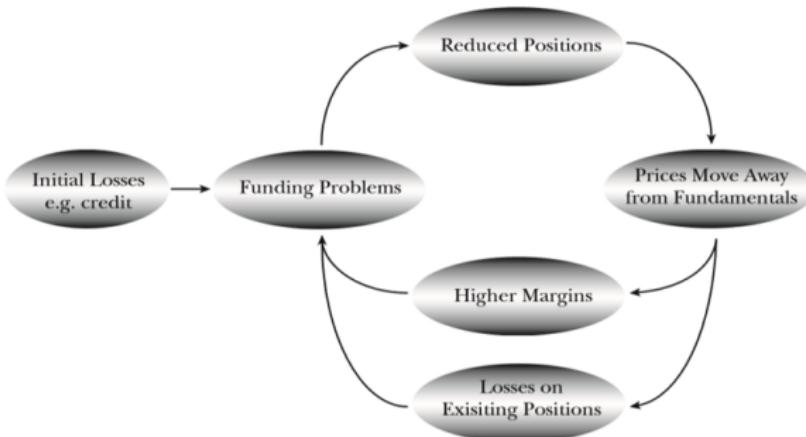
Other models of liquidity crises and runs

- There are various ways of modeling runs and liquidity crunches
- But the Diamond-Dybvig setup captures many of the main elements
- Other frameworks relevant to the recent crisis are those that emphasize fire-sales
- There can be important feedbacks from fire-sales, depressing asset prices, to weakening of banks, requiring further sales and difficulty in obtaining funding with collateralized borrowing...

Vicious circles in funding and asset prices

Figure 4

The Two Liquidity Spirals: Loss Spiral and Margin Spiral



Source: Brunnermeier and Pedersen (forthcoming).

Note: Funding problems force leveraged investors to unwind their positions causing 1) more losses and 2) higher margins and haircuts, which in turn exacerbate the funding problems and so on.

Liquidity spirals feeding back into fire sales and asset price declines, feeding back into liquidity spirals. . . . Source: Brunnermeier (2009); Bloomberg

Pre-crisis Vulnerabilities

Pre-crisis vulnerabilities

Table 1
Size and Structure of the Leveraged Financial System

| | 2001:Q4 | | | | 2007:Q4 | | | |
|-------------------------------------|------------------|-------------|------------------|-----------------------|------------------|-------------|------------------|-----------------------|
| | Assets (\$bn) | Leverage | Liquid assets | Short-term funding | Assets (\$bn) | Leverage | Liquid assets | Short-term funding |
| Commercial banks | 6,552 | 11.0 | 6.6% | 26.5% | 11,182 | 9.8 | 4.6% | 33.2% |
| <i>of which: large institutions</i> | <i>2,291</i> | <i>12.2</i> | <i>6.7%</i> | <i>32.9%</i> | <i>5,422</i> | <i>11.8</i> | <i>4.6%</i> | <i>37.5%</i> |
| Savings institutions | 1,317 | 11.6 | 3.0% | 18.2% | 1,852 | 9.1 | 2.3% | 22.6% |
| Broker-dealers | 2,376 | 28 | 2.4% | 57.3% | 4,686 | 45 | 0.4% | 63.4% |
| Government-sponsored enterprises | 1,417 | 42.3 | 0.2% | | 1,677 | 23.7 | 0.7% | |
| Total | 11,662 | | | | 19,397 | | | |

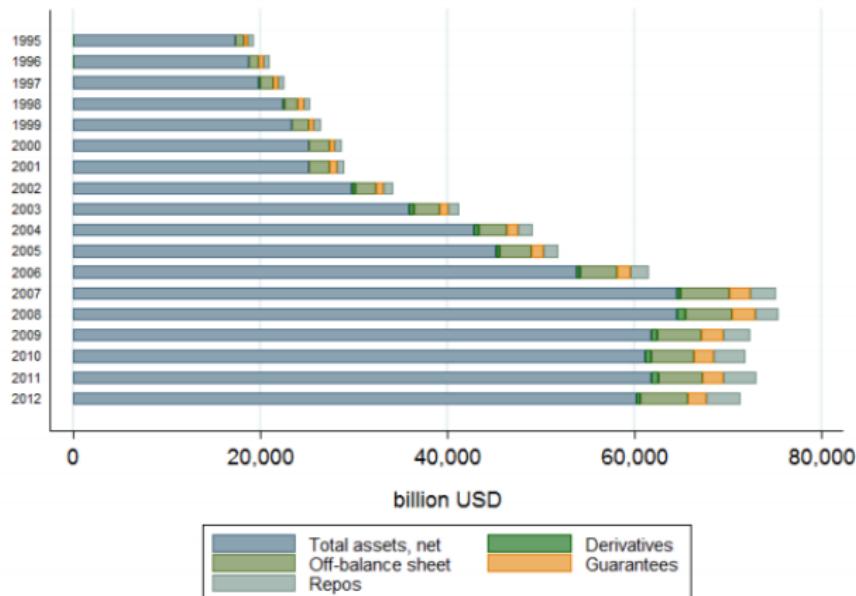
Source: Financial Accounts of the United States; Call Reports; FDIC; Adrian, Fleming, Shachar, and Vogt (2017); and Annual Reports of Fannie Mae and Freddie Mac.

Note: "Leverage" is defined as total assets divided by (book) equity. "Liquid assets" refers to the ratio of cash and Treasury securities to total assets. For brokers, "short-term funding" refers to repo funding relative to total assets. For deposit-takers, it refers to (estimated) uninsured domestic deposits and foreign deposits relative to total assets. While deposits are typically short-term liabilities, many types of deposits, including insured deposits in particular, are "behaviorally stable" and were not withdrawn during the crisis (Martin, Puri, and Ufier 2018). "Large commercial banks" are defined as banks with at least \$150 billion in total assets. For 2007, this is adjusted using the Consumer Price Index (\$180 billion). Government-sponsored enterprises include Fannie Mae and Freddie Mac.

Buildup of vulnerabilities from 2001 to 2007 - solvency, liquidity and funding. Source: Aikman *et al* (2019)

Off balance sheet exposures

Figure A1: Total exposure decomposition, all banks

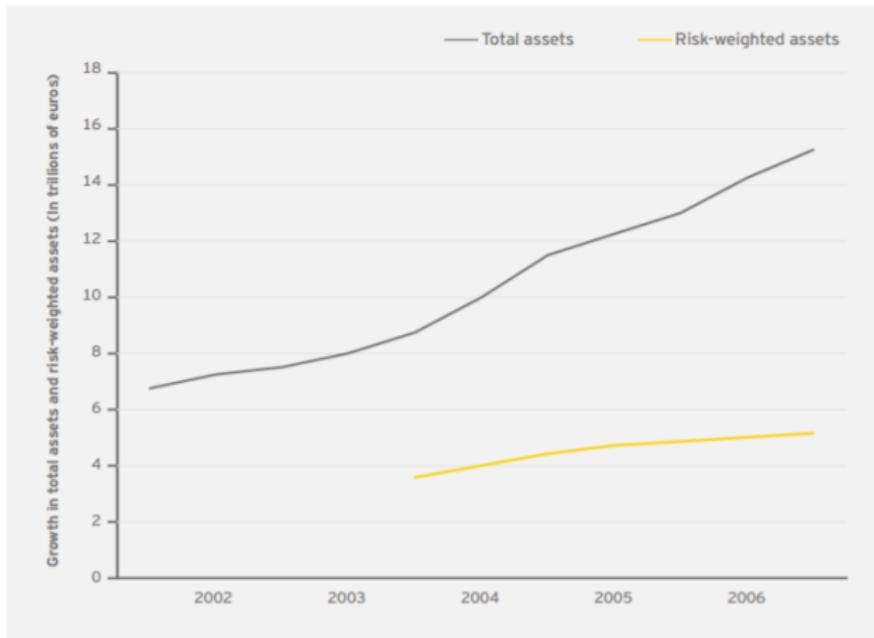


Note: Total assets, net = Total assets – Goodwill – Intangibles.

Adjusting total exposure for derivatives and off-balance-sheet positions.
Source: Brei and Gambacorta (2014)

Risk weight 'optimization' (regulatory arbitrage)

Figure 2: Balance sheet profiles for the 10 largest publicly listed banks 2002-07



Approximate constancy of capital ratios with respect to risk weighted assets vs. buildup of leverage. Source: EY, Avgouleas and Cullen (2015); IMF

Enormous expansion of leverage

- Banks (and other financial intermediaries) were highly levered
 - Especially if one looks at raw (not risk-weighted) assets
- Plentiful supply of funds
 - Partly a search for yield
 - Developing countries - esp. oil producers - looking to invest using their 'savings glut'
- Misspricing and unawareness of risks of innovative, opaque and poorly understood asset classes which often collateralized debt
 - Regulators, risk weights
 - Ratings agencies
 - market participants
- Also reflected highly profitable (for a time) 'originate and distribute' model...

Originate and distribute

- Traditionally banks originated loans and then held them on their balance sheet
- Incentive to keep monitoring them and to make good loans in the first place
- Arguably the 'market' can improve on this as banks may not be the natural holders of the various types of risks involved - even if they are good at originating loans (vetting borrowers etc.)
- Securitization (supposedly) allowed banks to 'distribute' the loans
 - Shift a pool of loans to special purpose vehicles (SPVs)
 - SPVs issue asset backed commercial paper (or MBS if they were pools of mortgages)
 - This CP allows the loans to be funded 'off balance sheet' of the bank (with perhaps an explicit or implicit back-up line of credit)

Originate and distribute

- Why might OaD promote lending? Optimistic answer...
 - Improves liquidity (lowers borrowing rates)
 - Might allow banks to de-risk or raise funds more quickly under stress
 - See Loutschina (2011) and Bidder *et al* (2018)
 - Reduces risk through diversification and a broader investor base
 - Tranching of asset pools allowed creation of derivative assets with different risk classes
 - Some investors (e.g. money market funds) can only invest in AAA
 - AAA can be synthesized by the 'last loss' of 'super senior' tranche of CDOs
 - Interesting literature on the shortage of public provision of 'riskless assets' (see Krishnamurthy and Caballero's work) inducing private sector to fill the void
 - **But banks were buying a lot of the derivatives - so risk was staying within the system!**

Originate and distribute

- Why might OaD promote lending? More cynical (realistic) answer...
 - Preferential regulatory treatment of off-balance sheet item
 - Less capital required despite risk the same (possibly endogenously worse)
 - Capital held against loans > capital held against backup lines of credit
 - Private securitization (esp. of subprime mortgages and ABCP) helped artificially stimulate credit - Keys *et al* (2010).
 - Eventually seemed to induce declines in lending standards
 - Low-documentation, NINJA and ARMs became prevalent
 - Senior Loan Office Surveys also indicated excessive loosening
 - Homeowners encouraged to extract equity (aggregate LTV \approx flat despite price rises)
- Research by Mian and Sufi (2013) \Rightarrow debt was an important transmission mechanism to the broader economy
 - Fine until **aggregate** U.S. house prices slowed/turned
 - Overleveraged households (or states where they were prevalent) suffered the most when the cycle turned

Mortgage debt and house price growth (and collapse)

Figure 2

Mortgage Debt and House Prices (annual percentage change)



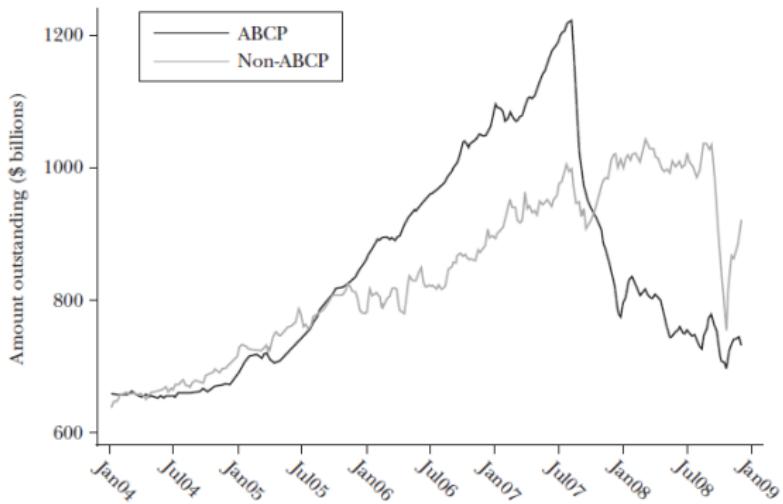
Source: Financial Accounts of the United States and S&P Case-Shiller US National Home Price Index.

Rapid run-up (and then crash) in mortgage debt growth and U.S. house prices. Source: Aikman *et al* (2019)

Commercial paper buildup - especially asset-backed

Figure 2

Outstanding Asset-Backed Commercial Paper (ABCP) and Unsecured Commercial Paper



Source: Federal Reserve Board.

Buildup and then collapse in ABCP (eventually followed by non-asset backed paper). Source: Brunnermeier (2009); Bloomberg

Additional vulnerabilities

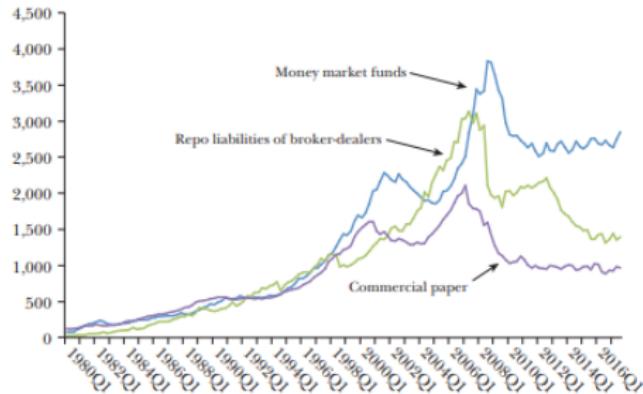
- Increased opacity of assets and counterparty interlinkages
 - Companies (e.g. AIG) that weren't on the radar, become enormously interlinked through insuring CDOs etc.
 - Fine while agents are looking for 'informationally insensitive' assets, but disastrous when people were trying to reassess
 - In the absence of liquid markets the assets are very difficult to price / learn about - so arbitrary beliefs can be held...
- Shortened maturity of debt
 - Recall Diamond-Dybvig
 - Large banks using short maturity repo to frequently roll over large amounts of debt
 - 3 – mo repo fairly constant but overnight increased substantially
 - Tapping money market funds on the basis of (implausible) AAA ratings
 - Off-balance sheet lines of credit for SPV were a time bomb

- Repo (or a 'repurchase agreement')
 - A form of collateralized borrowing
 - Borrower sells an asset to the lender at a 'haircut'
 - Promises to buy it back at maturity plus interest

Additional vulnerabilities

Figure 1

Reliance on Short-Term Funding
(\$ billions)



Source: March 2018 release of the Financial Accounts of the United States, based on Adrian, de Fontnouvelle, Yang, and Zlate (2017). The size of money-market funds is measured as outstanding money market fund shares (liabilities) in table L.121. Commercial paper refers to commercial paper (liabilities) issued by any sector (table L.2019), which includes asset-backed commercial paper. Repo liabilities of broker-dealers are based on security repurchase agreements (liabilities) in table L.130.

Buildup of vulnerabilities from 2001 to 2007 - increased use of repo and other short term funding and the absorption of this debt by money market funds. Source: Aikman *et al* (2019)

Still dancing...

When the music stops, in terms of liquidity, things will be complicated. But as long as the music is playing, you've got to get up and dance. We're still dancing.

- Chuck Prince, Citi CEO, July 10, 2007

The Crisis

Housing market and mortgage debt

Figure 2

Mortgage Debt and House Prices (annual percentage change)

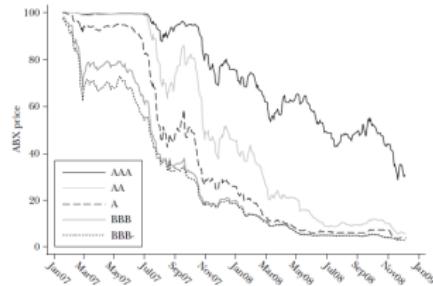


Source: Financial Accounts of the United States and S&P Case-Shiller US National Home Price Index.

House prices and mortgage debt. Source: Aikman *et al* (2019)

Rapid deterioration of MBS market

Figure 1
Decline in Mortgage Credit Default Swap ABX Indices
(the ABX 7-1 series initiated in January 1, 2007)



Source: LehmanLive.

Note: Each ABX index is based on a basket of 20 credit default swaps referencing asset-backed securities underlying pools of different ratings. An investor seeking to insure against the defaults of the underlying securities pays a periodic fee (spread) which—at initiation of the series—is set to guarantee an index price of 100. This is the reason why the ABX 7-1 series, initiated in January 2007, starts at a price of 100. In addition, when purchasing the default insurance after initiation, the protection buyer has to pay an upfront fee of $(100 - \text{ABX price})$. As the price of the ABX drops, the upfront fee rises and previous sellers of credit default swaps suffer losses.

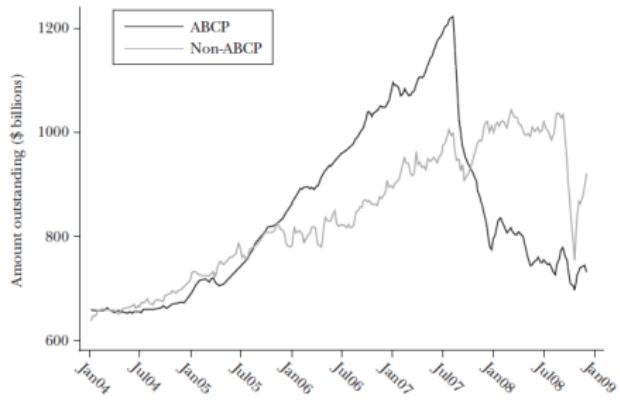
Source: Brunnermeier (2009); Bloomberg

- Sudden deterioration in sentiment in MBS markets
- Reflects higher (perceived) probabilities of systematic defaults in pools
- House-price slowdown and some funds needing parent support

Shutdown of asset backed commercial paper markets

Figure 2

Outstanding Asset-Backed Commercial Paper (ABCP) and Unsecured Commercial Paper



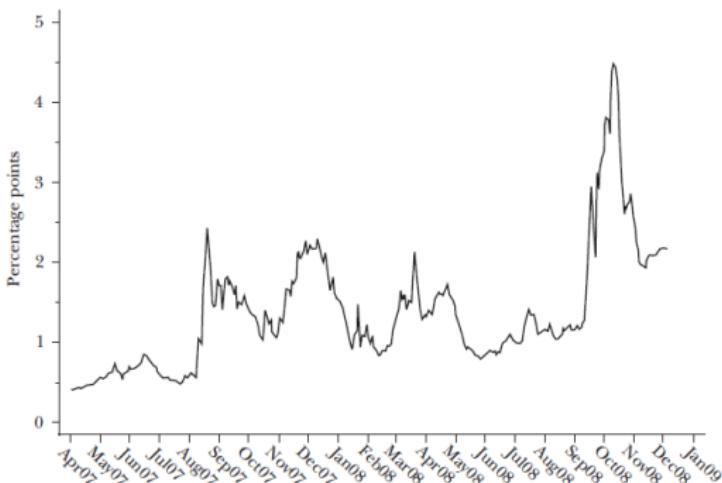
Source: Federal Reserve Board.

Collapse in ABCP (eventually followed by non-asset backed paper).
Source: Brunnermeier (2009); Bloomberg

- Note the initial impact is in the *asset backed* segment

Fear in the interbank markets

Figure 3
The TED Spread



Source: Bloomberg.

Note: The line reflects the TED spread, the interest rate difference between the LIBOR and the Treasury bill rate.

House prices and mortgage debt. Source: Brunnermeier (2009)

Fear in the interbank markets

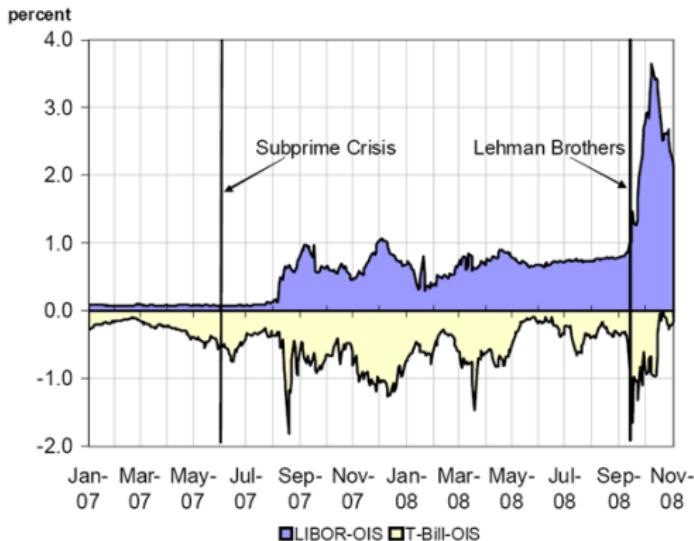
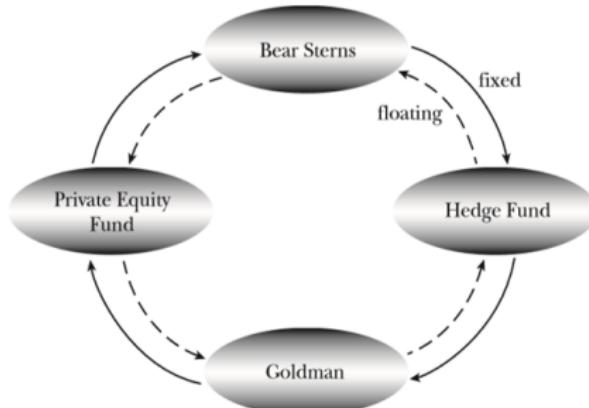


Figure 6: U.S. Treasury and LIBOR-OIS Spread. Jan-2007 to Oct-2008. Data Sources: Morgan-Market; Authors' calculations.

Decomposing Ted-spread into 'risk' and 'liquidity'. Source: Caballero, Fahri and Gourinchas (2008)

Fear in the interbank markets

Figure 5
A Network of Interest Rate Swap Arrangements



Note: Figure 5 shows a network of interest rate swap arrangements in which, theoretically, all positions could be fully netted out in a multilateral netting agreement. However, in over-the-counter markets each party only knows its own contractual obligations, and fear of counterparty credit risk might prevent netting.

Complexity and opacity of interbank and financial intermediary networks implies netting of positions subject to ambiguity. Source: Brunnermeier (2009); Bloomberg

Run on repo

- Remember Diamond-Dybvig model of bank runs and the famous movie, '*It's a wonderful life*'...

Run on repo



Run on repo

- or '*Mary Poppins*'...

Run on repo



Run on repo



Run on repo

- Similar though no one is physically ‘running’
- Silent runs - executed in money market over computer screens
- Gorton and Metrick (2009, 2017) provide an analysis

What happened is analogous to the banking panics of the 19th century in which depositors en masse went to their banks seeking to withdraw cash in exchange of demand and savings deposits. The banking system could not honor these demands because the cash had been lent out and the loans were illiquid, so instead they suspended convertibility and relied on clearinghouses to issue certificates as makeshift currency. Evidence of the insolvency of the banking system in these earlier episodes is the discount on these certificates. We argue that the current crisis is similar in that contagion led to ‘withdrawals’ in the form of unprecedented high repo haircuts and even the cessation of repo lending on many forms of collateral.

- Gorton and Metrick (2009)

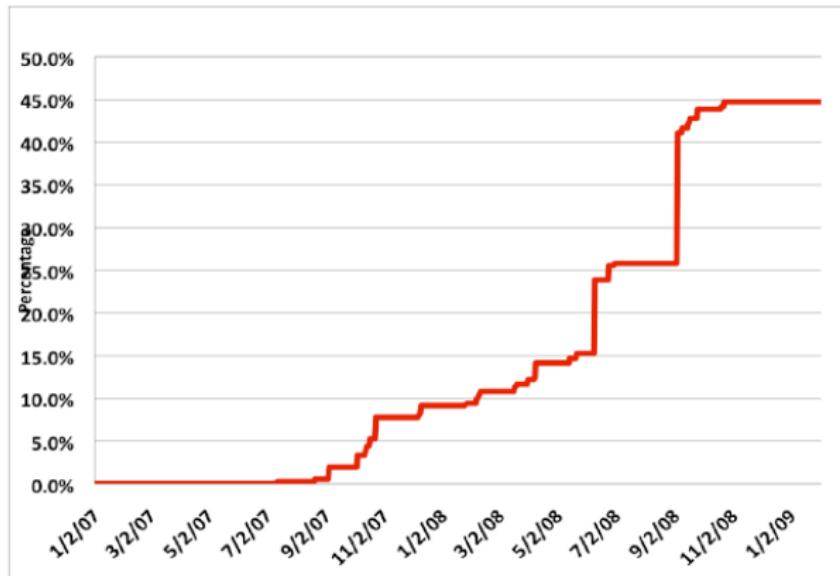
Run on repo

- Investor buys some asset (acts as collateral) from the bank for X
- Bank agrees to repurchase the same asset some time later (perhaps the next day) for Y
- The percentage $(Y-X)/X$ is the “repo rate” (\approx interest rate on a bank deposit)
- Typically, the total amount of the deposit will be some amount less than the value of the underlying asset (the difference is the ‘haircut’).
- Numerical example...
 - An asset has a market value of 100
 - Bank sells it for 80 with an agreement to repurchase it for 88
 - Repo rate is 10% ($\frac{88-80}{80}$)
 - Haircut is 20% ($\frac{100-80}{100}$)
 - If the bank defaults on the promise to repurchase, the investor keeps collateral

- Pools of mortgages are used as collateral by SPVs when they borrow
- Also, the outputs of securitization (MBS etc.) are themselves often used as collateral
- Haircut plays the role of reserves (covering a fraction of deposits) in the traditional model of banking - forces bank to keep some fraction of their assets in reserve
 - Note this captures a form of 'solvency' protection and worries about this might induce people to run
- Collateral plays the role of (govt-provided) deposit insurance in traditional model of banking - maintains faith of lender

Run on repo

Figure 4: The Repo-Haircut Index



Notes: The repo-haircut index is the equally-weighted average haircut for all nine asset classes included in Table I, Panel D.

Repo haircut - averaged over asset classes. Source: Gorton and Metrick (2009)

Run on repo

- Numerical example of effects of haircut ↑
 - Suppose repo market size = 10
 - Haircut of 0% ⇒ banks can raise financing of 10
 - Suppose haircut rises to 20% on average
 - Then banks can only raise 8 in financing
 - Need to find other ways - new securities? Difficult.
 - May need to sell assets - but this might drive prices down and will typically be the assets used as collateral!
 - This hampers them further as raises more concern about solvency - leading to higher haircuts. . .
- Additionally, the size of the potential market might shrink (money market funds leaving the market)

Crisis timeline

- There are some useful timelines of the crisis online, which I here summarize
 - St louis fed - hyperlink
 - 2007, 2008 and 2009 from 'The Balance' website
- See also, the timeline provided in Brunnermeier (2009)

Crisis timeline - 2007

- Early 2007
 - Home sales/prices peak and troubles emerge in MBS and funds invested in them
 - New Century Financial 'death spiral' (subprime lender), Bear Stearns suspended redemptions from a prominent fund, ratings downgrades on swathes of MBS
- Summer
 - Housing market numbers continued to worsen and, in late Summer, interbank lending was stressed (recall Ted spread discussion)
 - Fed cuts rate by 50bp in August to 4.75 (would be 4.25 by end of year)
 - American Home Mortgage Investment Corporation goes bankrupt
 - BNP Paribas halts redemptions on mortgage/MBS related funds
- Fall
 - Housing market continues to weaken
 - Northern Rock (old-skool) run in the UK

Crisis timeline - 2007

- December
 - Transmission of monetary policy (rate cuts) was not freeing up bank lending as spreads over safe rates were widening
 - To avoid stigma of discount window lending, Fed creates Term Auction Facility
 - Provides collateralized (even with various MBS) funding to banks with sub-prime exposures
 - Trying to follow Bagehot approach
 - Like an anonymous discount window
 - Intended to give breathing room - avoid firesale into closed/dislocated markets
 - Foreclosures pick up speed - but problems still largely restricted to financial markets, banking system and housing market (not broader economy, yet)

Crisis timeline - 2007

Under the Term Auction Facility (TAF) program, the Federal Reserve will auction term funds to depository institutions against the wide variety of collateral that can be used to secure loans at the discount window. All depository institutions that are judged to be in generally sound financial condition by their local Reserve Bank and that are eligible to borrow under the primary credit discount window program will be eligible to participate in TAF auctions. All advances must be fully collateralized. By allowing the Federal Reserve to inject term funds through a broader range of counterparties and against a broader range of collateral than open market operations, this facility could help promote the efficient dissemination of liquidity when the unsecured interbank markets are under stress.

Crisis timeline - 2008

- Early 2008
 - Fed continues cutting
 - Tax rebates announced (though not to be paid until summer)
 - But housing market and foreclosures keep worsening
 - BoA buys Countrywide (aggressive subprime lender) and Ambac Financial Group downgraded (important guarantor / monoline insurer)
- March
 - Fed extends TAF and other lending facilities
 - Provide banks with MBS and CDOs with 'good' assets collateral they could then use for funding
 - Note these are liquidity policies
 - Bear 'failure' - acquisition by J. P. Morgan Chase
 - JPMC agreed to pay \$2 a share (< 7% of price two days earlier)
 - Partly backed by Fed but JPMC had a first loss position (junior loan)
 - Loosening by Fed and opened discount window to investment banks via 'Primary Dealer Credit Facility'
 - Overnight funding to investment banks
 - Helped Lehman, for now...

Crisis timeline - 2008

- Spring-Summer
 - Further emergency lending by Fed
 - Indymac failure
 - Housing and Economic Recovery Act allowed Treasury to guarantee some loans backed by Fannie and Freddie (GSEs that securitized huge fraction of U.S. mortgages)
 - Discussions about possible future support for the GSEs
- September
 - Fannie and Freddie put into conservatorship
 - Made explicit and formalized government backing of the GSEs that had previously been assumed
 - This had arguably allowed them to be so aggressive in their expansion
 - Note: similarity to deposit insurance and other moral hazard examples
 - Lehman Brothers failure
 - Had been an attempt to form a private sector buyout
 - But Korean SWF, Barclays and BoA backed off (BoA buys Merrill)
 - A lot of debate over why Fed 'allowed' Lehman to fail...

Crisis timeline - 2008

- Brief aside on Lehman failure
 - Highly levered (less restricted by reg since not depository institution)
 - Short term funding
 - Highly exposed to housing market directly and through complex derivatives/MBS
 - Had to take big write-downs - especially in subprime (weakening capital position)
 - Tried to delever and raise funding but opacity of assets and suspicion in market hindered this
 - Once private sector bailout failed and (according to the Fed) it was decided that Lehman had inadequate collateral to secure a loan from the Fed with sufficient certainty that the Fed would not take a loss

Crisis timeline - 2008

- Ball (2018) argues that the Fed's claim that they could not legally provide a loan, was false and not the real reason
 - Implies it was a political decision to avoid moral hazard (driven by Paulson)
 - Claims there were plenty of assets that, even conservatively valued, could have secured a loan to allow at least an orderly wind-down (avoiding value destruction that certainly did occur in the chaos)
 - Should have helped as they helped Bear and, soon after, helped AIG
 - Hadn't realized that the effects would be so disruptive (Bernanke strongly disagrees)

Crisis timeline - 2008

- Great reference to understand 'How big banks fail' is Duffie's book of that title
- Here I quickly summarize his description of the stages of a 'typical' failure (of a big dealer bank - see Bear, Lehman)
- This and the (more difficult) Ball book are very useful for getting a grip on the nuts and bolts of how these banks functioned before the crisis (without endorsing Ball's take on why Lehman was 'allowed' to fail) - this is more for your general knowledge - not for detailed testing!

How a big bank fails

Dealer banks are financial institutions that intermediate the ‘back-bone’ markets for securities and over-the-counter (OTC) derivatives. These activities tend to be bundled with other wholesale financial market services, such as prime brokerage and underwriting. Because of their size and their central position in the plumbing of the financial system, the failure of a dealer bank could place significant stress on its counterparties and clients, and also on the prices of assets or derivatives that it holds. The collapse of a major dealer bank also reduces the ability of the financial system to absorb further losses and to provide credit and liquidity to major market participants. Thus, the potential failure of a major dealer bank is a systemic risk.

- Duffie, *How big banks fail - and what to do about it*, 2011

How big banks fail

BNP Paribas
Banc of America
Barclays Capital
Citigroup
Commerzbank AG
Credit Suisse
Deutsche Bank AG
Goldman, Sachs & Co.
HSBC Group
J. P. Morgan Chase
Morgan Stanley
The Royal Bank of Scotland Group
Société Générale
UBS AG
Well Fargo

Table 2.1: Major dealers participating at the New York Federal Reserve Bank meeting on over-the-counter derivatives market infrastructure held on January 14, 2010. Source: New York Federal Reserve Bank.

How a big bank fails

- Suppose something (MBS?) has happened to cause substantial losses or drains on liquidity for bank, 'Beta'
 - Hasn't devastated the bank but has weakened its position notably
- Bank tries to signal strength and protect franchise value by not scaling back, but 'putting on a brave face'
 - To prevent loss of counterparties and clients they bail out clients on investments arranged by Beta and continue to offer them good terms (e.g. implicit backing for off balance sheet SPVs)
 - But this drains funds (which in the future will be a problem)

How a big bank fails

- Confidence is dented and Beta perceives that counterparties are avoiding it or reducing positions
 - Might need to top up their collateral / satisfy margin calls
 - Other dealers may be asked to step in between Beta and its counterparties (novations)
 - Rumours spread as dealers become wary of increasing *their* positions
- Beta also has a prime-brokerage business for hedge fund clients, say
 - Provides IT, trade execution, accounting reports
 - Vitally, also custodian services - keeps the HF's cash and securities
 - HF start to ask for them back to shift them to other dealers
 - Can't really say no or rumours become a clamour
 - Damages franchise value (this was profitable) eroding attractiveness for investors further
 - Note the vicious circle
 - Note also, the HF securities were frequently used by Beta *on its own behalf* in repo borrowing as collateral - so double/triple whammy

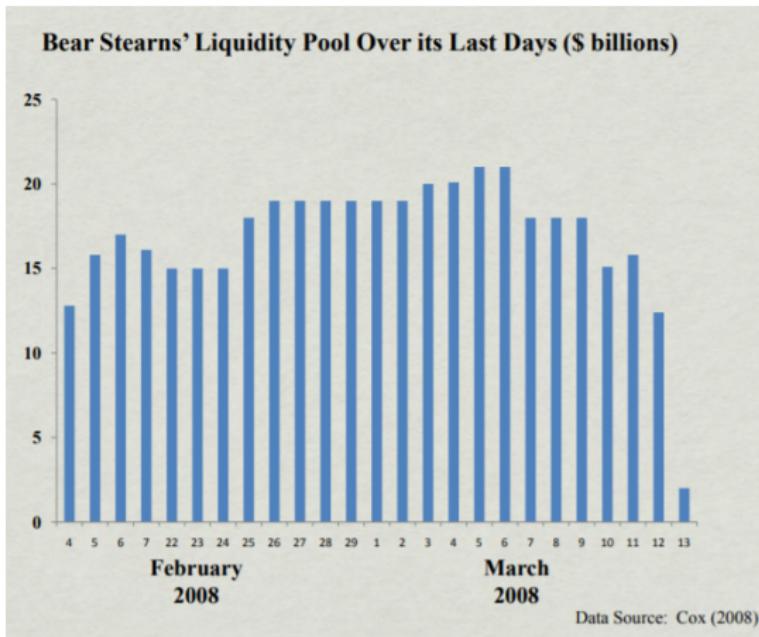
How a big bank fails

- Even secured creditors start backing away
 - Even if collateral is thought solid, why bother getting involved in admin around default?
 - They themselves may need funds and collateral back quickly
 - Haircuts also might no longer be though adequate (will they be able to sell collateral for enough even if they get it back?)
- A lot of these loans are repo (recall Gorton) and **a lot** is rolled over every night
 - If reluctance to lend occurs, the impacts are rapid (recall our discussion last week of shortening of maturity of debt, pre-crisis)
 - Must find a lot more funding - especially as haircuts are rising
 - Or start selling - but assets are opaque and possibly already underpriced!

How a big bank fails

- Banks need to hold enough cash/securities in clearing accounts
 - Usually only need to average out over the day - intraday credit from clearing banks
 - But clearing banks don't want to be left holding the can either
 - Removal of intraday credit is the endgame
 - Can't execute trades - dead...
 - Declare bankruptcy

How big banks fail



Crisis timeline - 2008

- Back to September 2008
 - Fed buys AIG
 - Had used their profitable *core* insurance business to fund a business insuring mortgage/mortgage derivative positions - including insuring securities
 - Was hugely interconnected via this insurance
 - If they failed, the insurance would vanish, causing huge losses across swathes of investors and further asset price declines
 - AIG avoided a disruptive bankruptcy but shareholders were wiped out and replaced with Treasury preferred shares etc. after Fed initially made loans (contrast with Lehman)

Crisis timeline - 2008

- Still September 2008 - not a good month
 - Reserve Primary Fund broke the buck and broader MMF problems
 - Partly from direct exposure to Lehman (RPF) - also from general contagion and concern at their holdings
 - Any sniff of risk in these funds and depositors would pull out (they had previously been thought to be riskless - like money)
 - MMF unable to finance themselves would pull back on CP holdings which is lifeblood of corp America for working capital
 - Fed insurance of MMF via 'Asset-backed CP MMF Liquidity Facility'
 - Goldman and MS become commercial banks
 - Can access discount window
 - No more investment banks!
 - WaMu bankrupt after 'silent' run
 - Handled by FDIC and sold to JPMC
 - Also, Wachovia bought by Wells
 - Treasury requests \$700bn fund from Congress
 - Defeated despite protections for taxpayer and restrictions on banks
 - DJ plunges 770 points

Crisis timeline - 2008

- Autumn

- Bill eventually passed on second attempt
 - Emergency Economic Stabilization Act
 - Funded 'Troubled Asset Relief Program' (TARP)...
 - Helped with Capital Purchase Program (injecting funds into banks with stock purchases - i.e. 'bailouts' though doesn't imply a loss for taxpayer)
 - Additionally - used for AIG, auto companies, 'Term Asset-Backed Securities Loan Facility (TALF) and some homeowner refi programs
 - Bill also increased salary oversight (surprisingly effective), FDIC insurance limit and suspended some mark to market accounting requirements (response to firesales)
- Wheels started to come off stock markets around the world
 - Coordinated rate cuts by central banks in response (rapidly approaching ZLB)
- Fed started 'Commerical Paper Funding Facility'
 - Buying commerical paper from highly rated firms (even they couldn't access CP markets)

Crisis timeline - 2008

- Autumn
 - Fed set up Money Market Investor Funding Facility
 - To take assets off money market funds and lend them sums to deal with redemptions
 - Citi receives funding injections
 - Fed cuts rates to zero
 - TALF bought debt of non-mortgage securitizers
 - Credit cards, autos, student loans...
 - Fear of anything securitized had spread!

Crisis timeline - 2009

- February
 - \$787bn economic stimulus package under Obama (American Recovery and Reinvestment Act)
 - Homeowner Stability Initiative also launched to help prevent foreclosure
 - Revealed that GDP growth was -6.3% at end of 2008
- April
 - Homeowner Affordable Mortgage Program (HARP)
 - To promote financing for underwater borrowers
 - Rates had fallen but negative equity prevented taking out new mortgages / refi to access them
 - Very low takeup - and then by people only slightly underwater - and foreclosures continued
- October
 - Unemployment rate reaches 10%
 - Lending down - loan performance also
 - Banks trying to rebuild balance sheets - cuts off credit
 - Households trying to rebuild balance sheets - demand declines

Broader effects of the crisis

- So far we've mainly focused on the financial aspects
- Ultimately, the effect on the broader economy is the most important motivation for reform
- We cannot give a complete analysis here
- Some of the main channels discussed are...
 - Traditional accelerationist channels through bank weakness and financial market panic
 - Emphasized in Bernanke (2018) in reading list
 - Household leverage/debt channel
 - Emphasized by Mian and Sufi (various papers and book)
 - Fiscal damage
 - See recent work by Jorda *et al* (economic letters in reading list)

Economic impacts - Housing market

Figure 2

Mortgage Debt and House Prices
(annual percentage change)

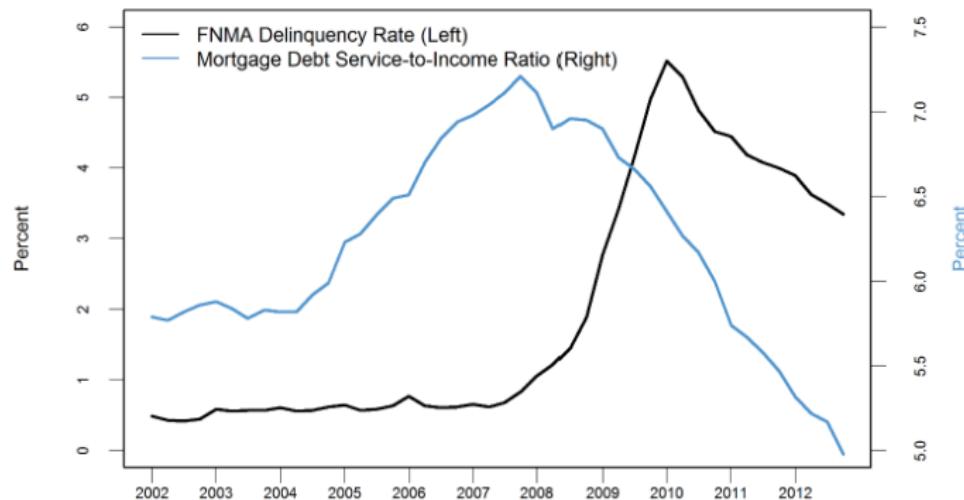


Source: Financial Accounts of the United States and S&P Case-Shiller US National Home Price Index.

House prices and mortgage debt. Source: Aikman et al (2019)

Economic impacts - Household credit problems

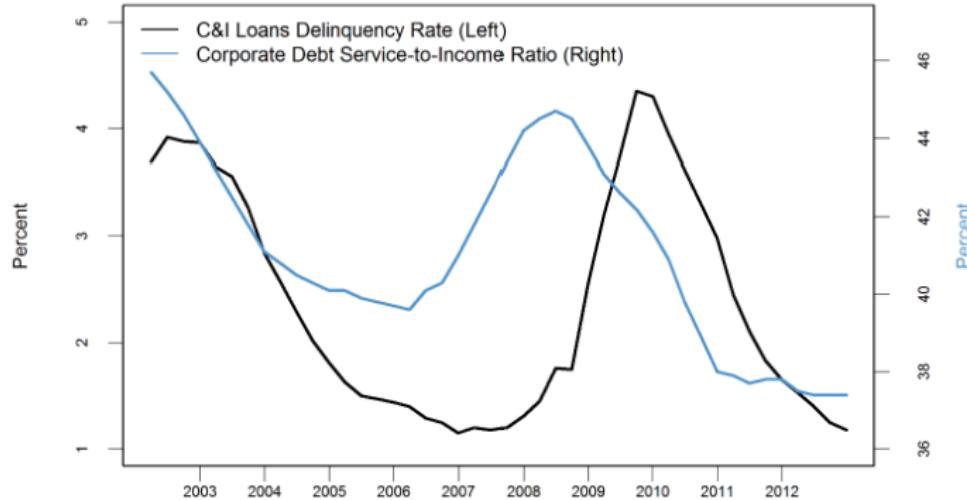
Figure 2. Household Debt Service and Delinquencies, 2002-2012⁹



Household debt to income and delinquencies. Source: Bernanke (2018)

Economic impacts - Corporate credit problems

Figure 3. Corporate Debt Service and Delinquency, 2002-2012¹⁰



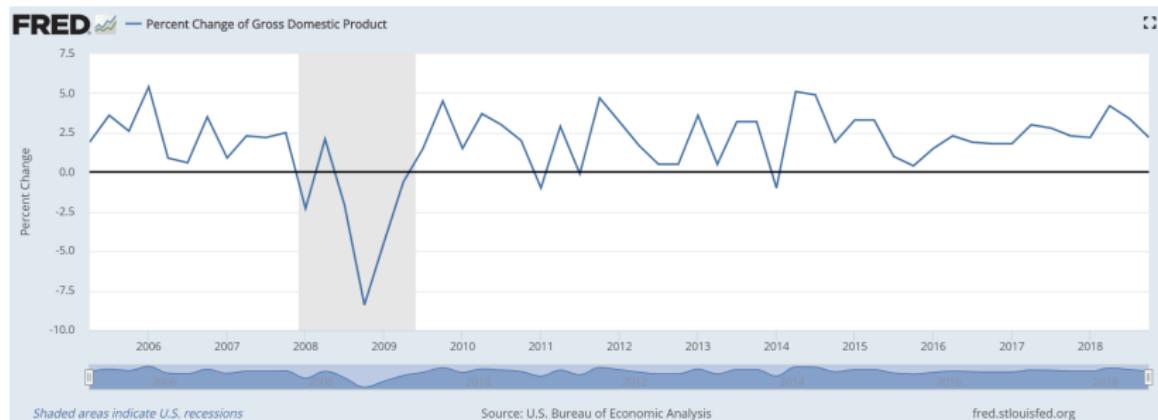
Corporate debt servicing and delinquencies. Source: Bernanke (2018)

Economic impacts - Labor market problems



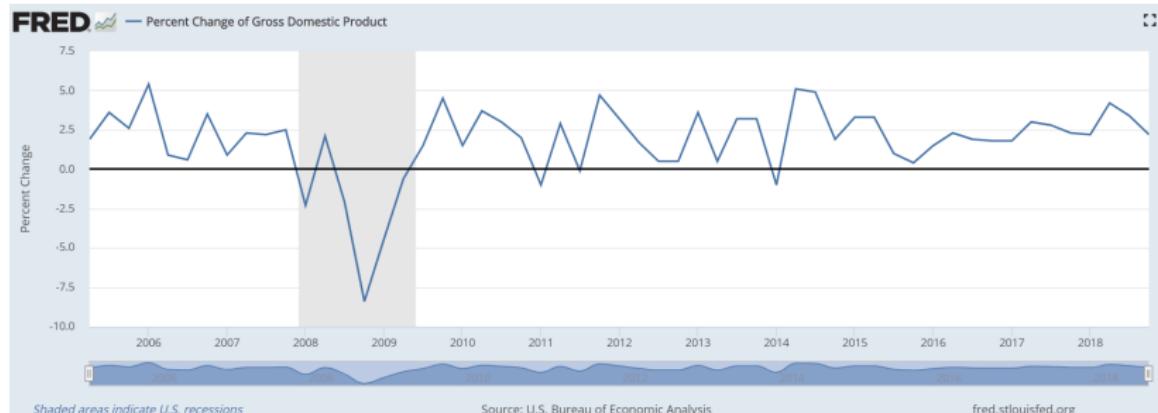
Unemployment rate. Source: FRED

Economic impacts - Deep recession



Percentage growth in GDP. Source: FRED

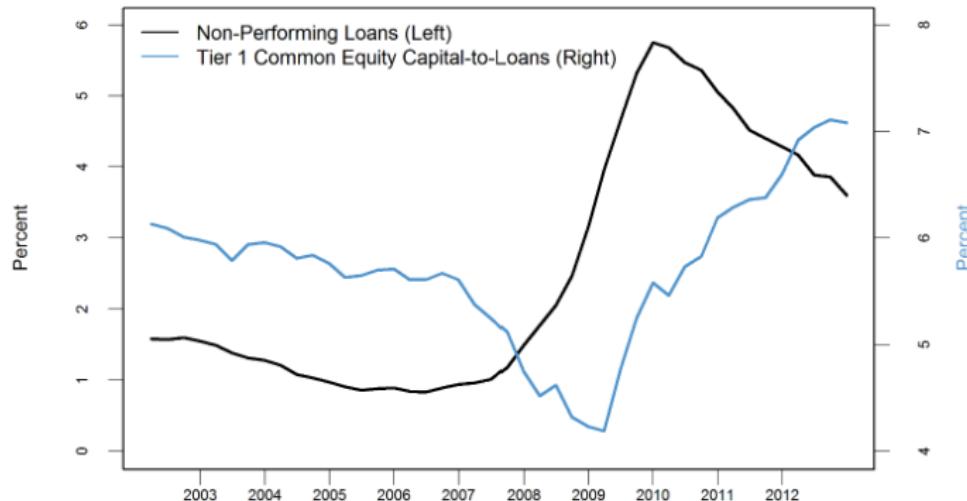
Economic impacts - Investment off a cliff



Percentage growth YoY in Gross Private Domestic Investment. Source: FRED

Economic impacts - Some feedbacks to banks

Figure 4. Capital and Non-performing Loans at Commercial Banks, 2002-2012¹¹



Bad loans grind down bank equity. Source: Bernanke (2018)

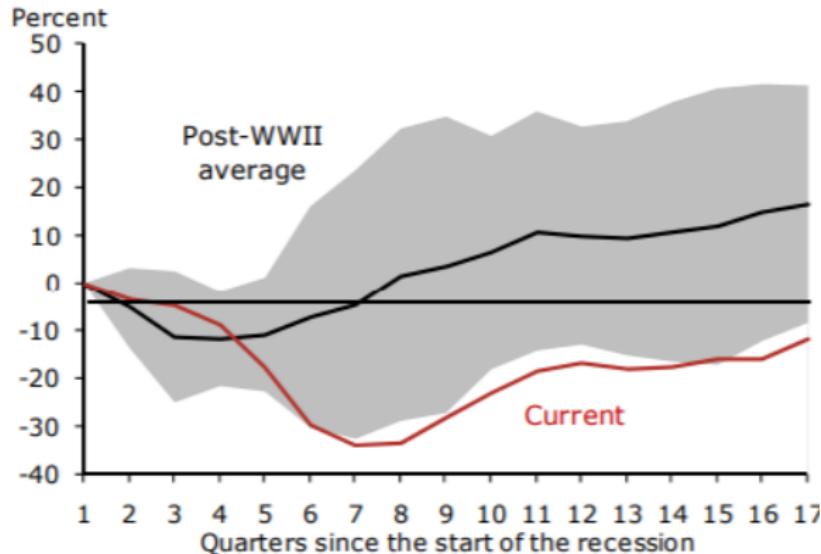
Broader effects of the crisis

- In the work of Jorda *et al* (various papers) they emphasize that
 - Recessions after financial crises are often more prolonged and severe
 - A preceding credit bubble is particularly damaging
 - Pre-crisis fiscal strength can help mitigate the effects

Slow recovery from Great Recession

Figure 2

Percent change in private investment from cycle peaks



Source: Bureau of Economic Analysis.

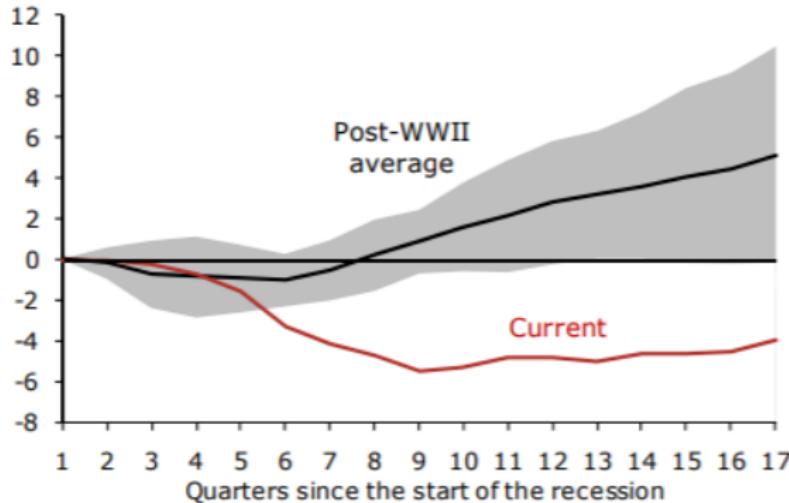
Comparing recent and average recovery in investment. Source: Jorda (2012)

Slow recovery from Great Recession

Figure 1

Percent change in civilian employment from cycle peaks

Percent



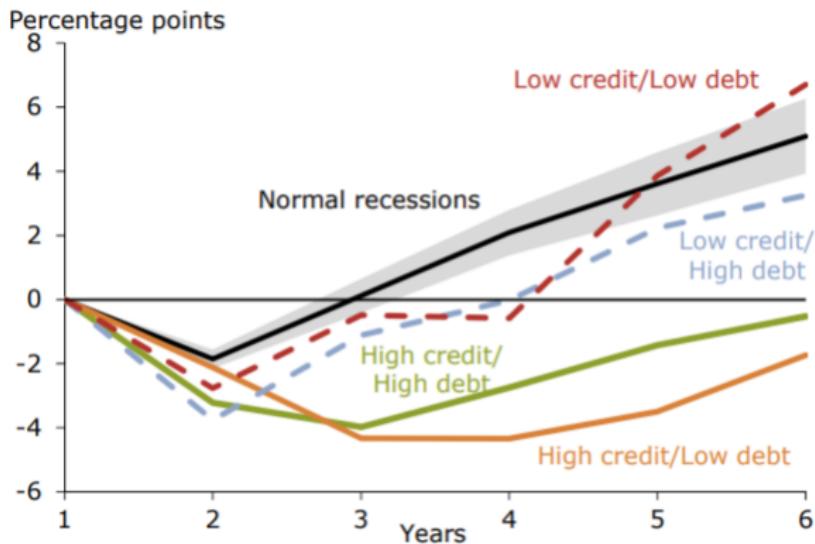
Source: Bureau of Labor Statistics.

Comparing recent and average recovery in unemployment. Source: Jorda (2012)

Fits pattern of recoveries from 'financial' recessions

Figure 2

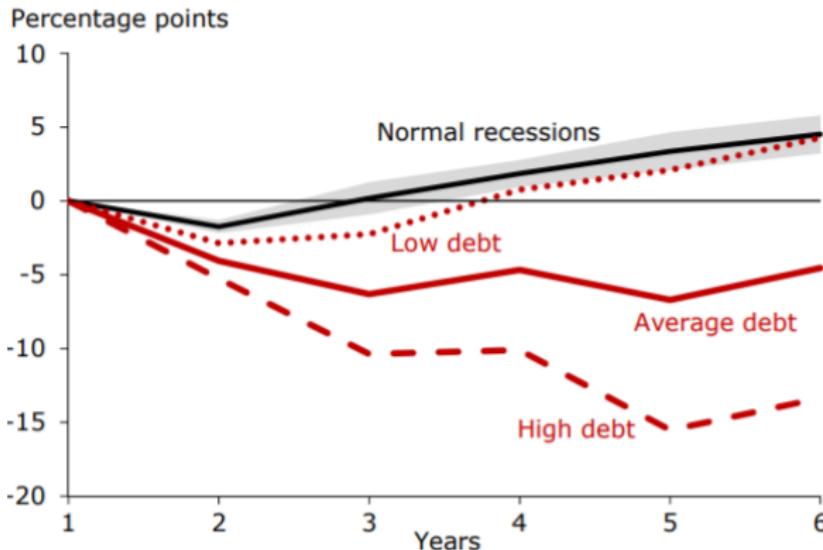
Recoveries from normal recessions vs. financial crises



Comparing recoveries after 'normal' and 'financial' recessions. Source: Jorda (2012)

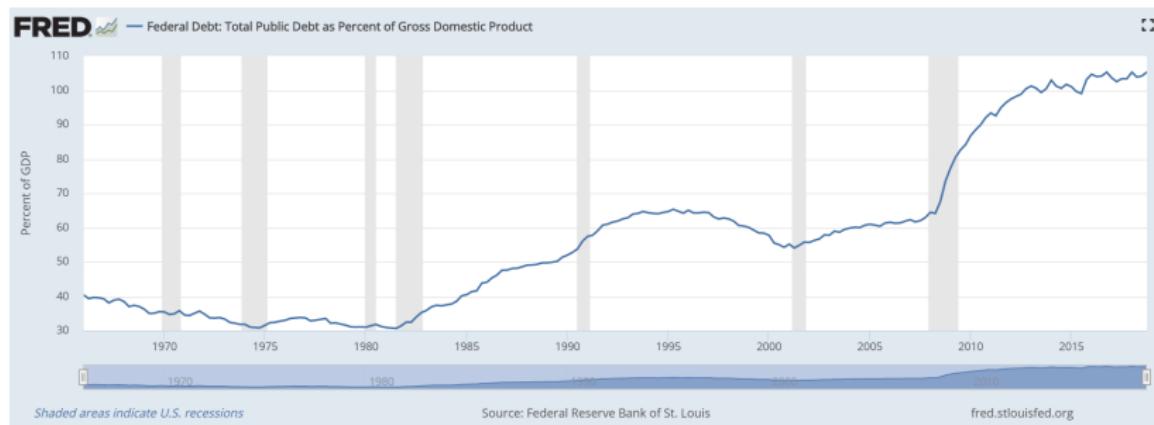
Importance of public debt

Figure 3
GDP in recessions according to public debt levels



Comparing recoveries based on initial public debt. Source: Jorda (2012)

Economic impacts - GFC damaged fiscal positions



Dramatic effect on debt levels. Source: FRED

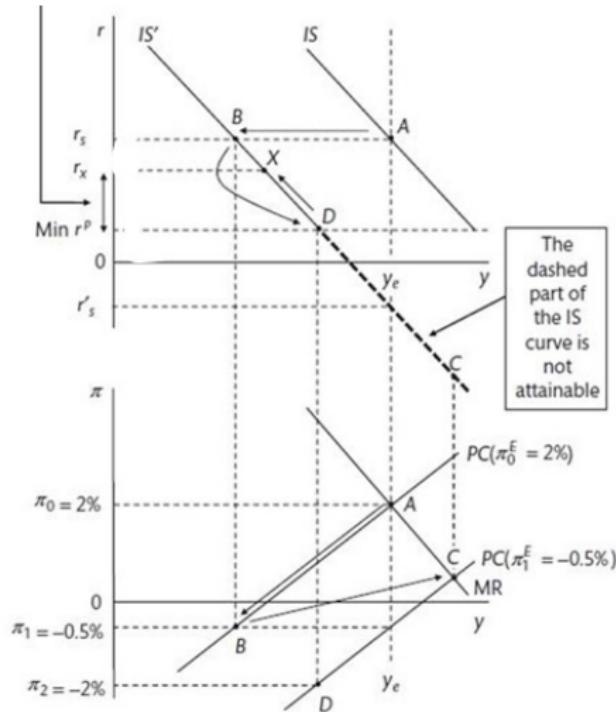
Some implications of fiscal damage

- We have concentrated on the US in this section
- But the Global Financial Crisis was... global
- Fiscal damage was widespread, putting, in some cases, immediate restrictions on countercyclical policy or bailouts
 - In some countries banks were both 'too big to fail' **and** too big to save
 - Inadequate borrowing ability of governments necessitated austerity
 - Even in the U.S. many would argue the large stimulus bill under Obama should have been larger/continued longer
- Longer term, it may also imply important reductions in policy flexibility in the 'next recession'...

Low rates, the new normal and the ZLB

- As discussed in previous classes, the long run level of the real rate seems to have declined substantially
 - Secular stagnation?
 - Aging?
 - Savings glut and regulation-induced demand for safe assets?
 - Lower growth (due to population and technology growth rates \downarrow)?
- Inflation is also low
 - Inflation targeting of $\approx 2\%$ in many countries
 - Has been persistently lower in various countries (e.g. in US)
 - Concerns that expected inflation is de-anchoring downwards
 - Go back to early lecture and see current debates in press/policy circles
- Recalling the Fisher equation (check you know this), this means that it is hard for monetary policy to set low enough real rates
 - Nominal rate constrained by ZLB
 - If rate negative, people simply hold cash ('liquidity trap')

Can't rely on standard monetary policy in ZLB



But fiscal policy may not be available. . .

- Note that essentially the same analysis applies for explicitly open economy (what would the IS curve be replaced by there?)
- Ideally, a fiscal expansion (think of 'G' in the derivation of the IS curve) can shift the IS curve back to offset the 'confidence' (negative demand shock)
- Given the damage to fiscal position from GFC - and ongoing issues with funding other excessively generous entitlements - will policymakers have enough firepower in the future?
- Might need to rely on unconventional monetary policy again
 - But still controversial and poorly understood

Stress testing

Stress testing - post crisis

- The Federal reserve conducts two stress tests
 - Dodd-Frank Stress Tests (DFAST)
 - Comprehensive Capital Analysis and Review (CCAR)
- They essentially differ on capital plan assumptions
 - DFAST: Same 'baseline' capital assumptions across all scenarios
 - CCAR: Capital assumptions based on banks' plans
- 'Banks' bigger than \$100bn in total assets must submit
 - Recently rules have been somewhat relaxed if < \$250bn
- Assessment under three scenarios
 - Baseline, Adverse and Severely Adverse
 - Larger/more complex banks also are subject to 'global market shock' and 'counterparty default'
 - Banks also supply their own scenarios ('reverse' stress testing)

Stress testing - documentation

- The guides/websites are surprisingly user friendly
 - *DFAST website*
 - *CCAR website*
 - *Guide to scenarios (2019)*
- The data dictionaries (in the instructions) at the following webpages are also very accessible
 - FR Y14-M website (monthly data on retail loan portfolios)
 - FR Y14-Q website (quarterly data on various asset classes, capital components, and categories of pre-provision net revenue (PPNR) on a quarterly basis)
 - FR Y14-A website (annual collection of banks' own stress test result projections)
- These, together with the *NY Fed's CLASS model and associated working paper* will give you a concrete sense of what it means to stress test a bank and what bank performance entails

Stress testing - aims

- To some extent the establishment of these tests reflects the consensus that SCAP was successful
 - SCAP was about minimizing repercussions and encouraging quick recovery
 - CCAR/DFAST adds prevention to those aims
- Intent: detect and prevent excessive *systemic* risks
 - Contrast with 'micro-prudential' approach prior to GFC
 - Forward looking rather than 'point in time' capital ratios
 - Emphasizes severe but plausible events
 - Response to model misspecification
 - Requires plausible capital actions
 - Banks must be able to organize their books across whole institution and 'consider' rare events ('soft benefits' of stress testing)
- Note that it (like other regulation) also is a response to moral hazard, which arguably increased after crisis (despite Lehman) due to bailouts

Sidenote on SCAP

I believe that stress testing and the CCAR program were the most significant and impactful regulatory and supervisory changes coming out of the global financial crisis.

- Hirtle (2018)

Sidenote on SCAP

- Helped offset the enormous uncertainty about the evolution of banks' capital going forwards
 - Excellent insight to focus results on capital ratio
- Helped allow banks a 'safe space' to raise extra capital without stigma
 - Solved 'first mover' problem
- Tests were regarded as credible
 - Very granular analysis
 - Publication of a lot of assumptions - showed they were truly severe but plausible
 - Contrast with some other countries. . .
- Not only credible conclusions but the recommended capital raising was feasible
 - Showed things were bad, could get even worse, but not existential threat
 - Some banks already had raised recommended amounts by the time of the announced results

Stress testing - aims

- To some extent the establishment of these tests reflects the consensus that SCAP was successful
 - SCAP was about minimizing repercussions and encouraging quick recovery
 - CCAR/DFAST adds prevention to those aims
- Intent: detect and prevent excessive *systemic* risks
 - Contrast with 'micro-prudential' approach prior to GFC
 - Forward looking rather than 'point in time' capital ratios
 - Emphasizes severe but plausible events
 - Response to model misspecification
 - Requires plausible capital actions
 - Banks must be able to organize their books across whole institution and 'consider' rare events ('soft benefits' of stress testing)
- Note that it (like other regulation) also is a response to moral hazard, which arguably increased after crisis (despite Lehman) due to bailouts

Stress testing - aims

- To some extent the establishment of these tests reflects the consensus that SCAP was successful
 - SCAP was about minimizing repercussions and encouraging quick recovery
 - CCAR/DFAST adds prevention to those aims
- Intent: detect and prevent excessive *systemic* risks
 - Contrast with 'micro-prudential' approach prior to GFC
 - Forward looking rather than 'point in time' capital ratios
 - Emphasizes severe but plausible events
 - Response to model misspecification
 - Requires plausible capital actions
 - Banks must be able to organize their books across whole institution and 'consider' rare events ('soft benefits' of stress testing)
- Note that it (like other regulation) also is a response to moral hazard, which arguably increased after crisis (despite Lehman) due to bailouts

Stress testing - scenarios

- We will focus on the 'supervisory scenarios' (those provided by the Fed)
 - Baseline (B) - Comparable to the central case of private sector forecasters
 - Adverse (A) - Bad stuff happens
 - Severely adverse (SA) - Very bad stuff happens
- Note that SA typically is not simply a 'scaled up' version of A

Stress testing - scenarios

- Six measures of economic activity and prices
 - Real and nominal GDP growth
 - Unemployment rate
 - Real and nominal disposable personal income
 - CPI inflation
- Four measures of asset prices / financial conditions
 - Residential and commercial real estate prices
 - Equity prices and their volatility (VIX)
- Size measures of interest rates
 - 3-m T-bill, 5-y and 10-y Treasury notes (yield curve)
 - 10-y BBB corporate securities yield (corporate credit)
 - Mortgage rate (conforming, 30-y fixed)
 - Prime rate (bank lending)
- GDP growth, CPI inflation and exchange rate
 - Eurozone, UK, Developing Asia and Japan

Stress testing - scenarios

- The scenarios are expressed both qualitatively (as narratives) and quantitatively
 - Narrative reflects the desire for the scenarios to be 'plausible'
 - May focus on topics that have been publicly raised as being of concern
 - They are hypotheticals and **not the forecasts of the Federal Reserve**

Stress testing - narratives

- From baseline (2019)

The baseline scenario for the United States is a moderate economic expansion through the scenario period. Real GDP growth averages 2.25 percent in 2019, drops slightly to 1.5 percent in 2020, and then rises to 2 percent in 2021. The unemployment rate falls to about 3.5 percent during 2019, and then increases to about 4 percent by the first half of 2021. CPI inflation averages about 2.25 percent each year.

Accompanying the moderate economic expansion, Treasury yields are assumed to rise modestly across the maturity spectrum. Short-term Treasury rates increase from about 2.5 percent in the first half 2019 to about 2.75 percent in the second half of 2019 and level off thereafter; yields on 10-year Treasury securities rise from 3 percent at the beginning of 2019 to about 3.25 percent at the beginning of 2020 and continue rising gradually to about 3.5 percent by the end of the scenario period.

Stress testing - narratives

- From severely adverse (2019)

As a result of the severe decline in real activity, the interest rate for 3-month Treasury bills falls 2.25 percentage points and remains near zero through the end of the scenario. The 10-year Treasury yield falls by a somewhat smaller amount, resulting in a mildly steeper yield curve. The 10-year Treasury yield reaches a trough of about 0.75 percent in the first quarter of 2019 and rises gradually thereafter to 1.5 percent by the first quarter of 2021 and 1.75 percent by the first quarter of 2022. Financial conditions in corporate and real estate lending markets are stressed severely. The spread between yields on investment-grade corporate bonds and yields on long-term Treasury securities widens to 5.5 percent by the third quarter of 2019, an increase of 3.5 percentage points relative to the fourth quarter of 2018. The spread between mortgage rates and 10-year Treasury yields widens to 3.5 percentage points over the same time period.

Stress testing - data

Table 2.A. Supervisory baseline scenario: Domestic variables, Q1:2019–Q1:2022

Percent, unless otherwise indicated.

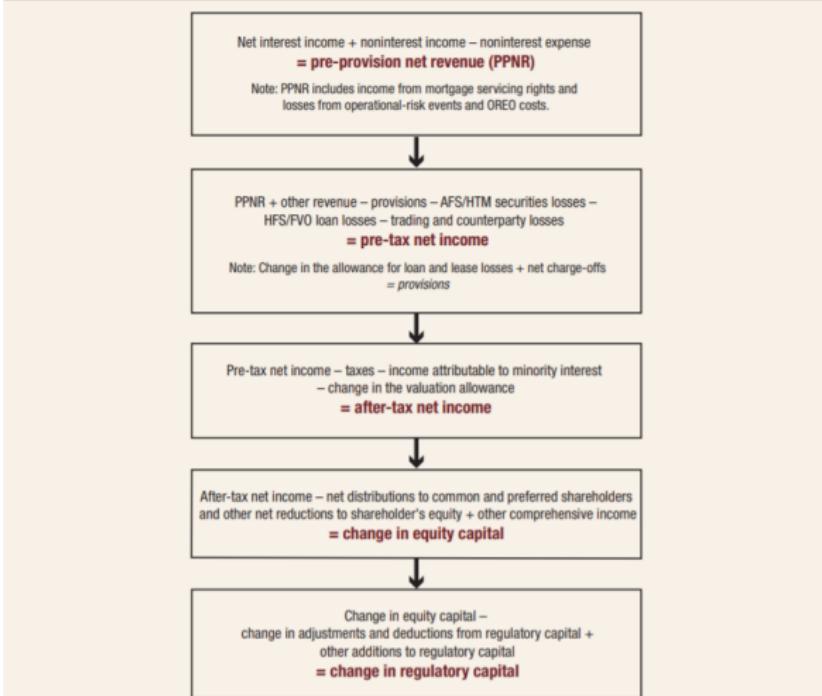
| Date | Real GDP growth | Nominal GDP growth | Real disposable income growth | Nominal disposable income growth | Unemployment rate | CPI inflation rate | 3-month Treasury rate | 5-year Treasury yield | 10-year Treasury yield | BBB corporate yield | Mortgage rate | Prime rate | Level | | | |
|---------|-----------------|--------------------|-------------------------------|----------------------------------|-------------------|--------------------|-----------------------|-----------------------|------------------------|---------------------|---------------|------------|------------------------------------|-------------------|------------------------------------|-------------------------|
| | | | | | | | | | | | | | Dow Jones Total Stock Market Index | House Price Index | Commercial Real Estate Price Index | Market Volatility Index |
| Q1 2019 | 2.2 | 4.2 | 2.8 | 4.2 | 3.7 | 1.5 | 2.5 | 2.8 | 2.9 | 4.6 | 4.5 | 5.5 | 26,026 | 207 | 293 | 28.3 |
| Q2 2019 | 2.5 | 4.8 | 2.3 | 4.5 | 3.6 | 2.3 | 2.6 | 2.9 | 3.0 | 4.8 | 4.6 | 5.6 | 26,367 | 208 | 296 | 27.0 |
| Q3 2019 | 2.2 | 4.4 | 2.3 | 4.4 | 3.6 | 2.3 | 2.7 | 3.0 | 3.1 | 4.9 | 4.6 | 5.7 | 26,687 | 209 | 300 | 25.3 |
| Q4 2019 | 2.0 | 4.2 | 2.2 | 4.3 | 3.6 | 2.3 | 2.8 | 3.0 | 3.2 | 4.9 | 4.7 | 5.8 | 26,998 | 210 | 304 | 24.5 |
| Q1 2020 | 1.7 | 4.0 | 2.1 | 4.3 | 3.6 | 2.4 | 2.8 | 3.0 | 3.2 | 4.9 | 4.7 | 5.8 | 27,299 | 212 | 308 | 23.9 |
| Q2 2020 | 1.6 | 4.0 | 2.1 | 4.0 | 3.6 | 2.1 | 2.8 | 3.0 | 3.2 | 4.9 | 4.7 | 5.8 | 27,603 | 213 | 312 | 23.5 |
| Q3 2020 | 1.5 | 3.7 | 1.9 | 4.0 | 3.7 | 2.2 | 2.8 | 3.0 | 3.2 | 4.9 | 4.7 | 5.8 | 27,894 | 214 | 316 | 23.7 |
| Q4 2020 | 1.6 | 3.8 | 1.9 | 3.8 | 3.8 | 2.1 | 2.8 | 3.1 | 3.2 | 4.9 | 4.7 | 5.8 | 28,193 | 216 | 320 | 23.9 |
| Q1 2021 | 2.2 | 4.3 | 2.3 | 4.4 | 3.9 | 2.2 | 2.8 | 3.3 | 3.4 | 5.2 | 4.9 | 5.8 | 28,529 | 217 | 322 | 24.6 |
| Q2 2021 | 2.0 | 4.1 | 2.2 | 4.2 | 4.0 | 2.2 | 2.8 | 3.3 | 3.5 | 5.1 | 5.0 | 5.8 | 28,858 | 219 | 324 | 23.8 |
| Q3 2021 | 2.0 | 4.1 | 2.2 | 4.2 | 4.0 | 2.2 | 2.8 | 3.4 | 3.5 | 5.2 | 5.0 | 5.8 | 29,191 | 221 | 327 | 23.7 |
| Q4 2021 | 2.0 | 4.1 | 2.2 | 4.2 | 4.0 | 2.2 | 2.8 | 3.4 | 3.5 | 5.2 | 5.0 | 5.8 | 29,527 | 222 | 329 | 23.6 |
| Q1 2022 | 2.0 | 4.1 | 2.2 | 4.2 | 4.1 | 2.2 | 2.8 | 3.4 | 3.6 | 5.2 | 5.1 | 5.8 | 29,868 | 224 | 332 | 23.6 |

Note: Refer to [Notes Regarding Scenario Variables](#) for more information on the definitions and sources of historical observations of the variables in the table.

Table of hypothetical realizations of domestic variables under baseline (2019). Source: Federal Reserve - Guide to the Scenarios (2019)

Stress testing - simplified process

Figure 1. Projecting net income and regulatory capital



Projecting net income and regulatory capital. Source: Board of Governors 2019

Stress testing - not the only regulatory reform

- Stress tests useful in crisis but many other things went wrong and needed fixing
 - It's not just stress tests!
- Liquidity reforms/regulation
 - Comprehensive Liquidity Analysis and Review (CLAR)
 - Net Stable Funding Requirement
 - Liquidity Coverage Ratio and High Quality Liquid Assets
- Bank resolution (avoid chaos and value destruction when wound down)
 - Living wills (U.K.)
 - Penalties (implicit or explicit) for complexity

Stress testing - not the only regulatory reform

- Central party clearing
 - Greater transparency
 - Netting of positions - greater efficiency and clarity in collateral chains
 - Maybe creates more systemic institutions - dangers in the future?
- Reform of capital concepts and leverage ratio backstop
 - 'Bad' (not very loss absorbing/stabilizing) capital eliminated
 - Risk weights can be gamed to there non-risk adjusted leverage ratios also used
 - GSIB surcharges and additional phenomena like 'Countercyclical Capital Buffers'
- Great oversight of lending and products
 - Establishment of CFPB
 - Simplified mortgages
 - Private label MBS haven't returned

Concerns for the future

- This time is different
 - Many centuries of financial crises despite repeated reforms
- Lessons learned but lessons forgotten?
 - Leveraged loans recently seemed to display some of the old 'covenant-lite' frothy lending tendencies
 - Institutions are still enormous / have grown further in many respects - so too big to fail may still apply
- Stress tests are not a panacea
 - Very difficult to anticipate or envisage a sufficiently damaging scenario
 - Do not (yet) adequately allow for feedback effects
 - Liquidity and capital regulation not yet integrated despite important interactions between these concepts

Concerns for the future

- Regulatory pushback
 - See recent relaxing of stress test coverage (for smaller, less complicated firms)
 - CFPB restricted under current administration
 - Heavy lobbying against CCAR even if ostensibly only 'improvements' (publishing models used, for example)
- False sense of security and 'model monoculture'
 - Passing stress test does not guarantee safety
 - A concern that they are inducing banks to become more correlated in their positions
 - With greater model transparency there is a risk of banks being resilient 'only' to the stress scenarios