When is Less More?
Bank Arrangements for Liquidity vs Central Bank Support

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Motivation

- Over the past century: considerable increase in the size and scope of central bank interventions in response to banking crises
- Significant banking crises continue to occur across the world
  - despite central bank intervention, made easier in the fiat money era
  - including in advanced economies with comprehensive regulatory frameworks

Crises from Schularick-Taylor | US Crises post-FDIC | Worldwide Crises from Reinhart-Rogoff

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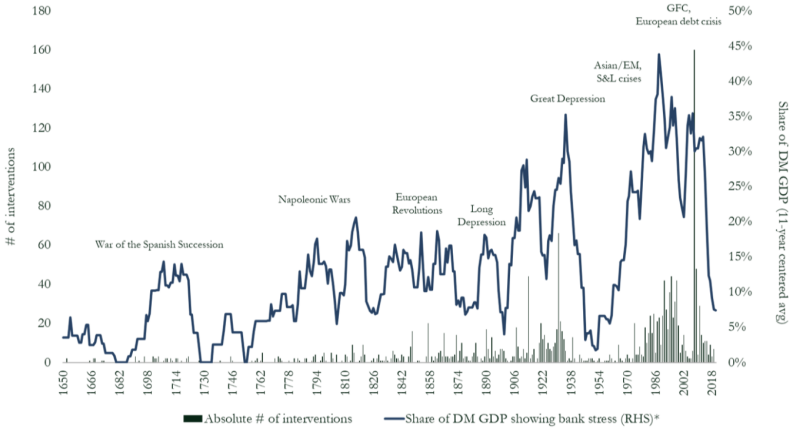
Schularick and Taylor (2012)

- No collapse of money or bank loans post crisis post WWII, unlike pre WWII
- Central bank action through Lender of Last Resort, monetary policy?
  - Role of deposit insurance?
- Inflation does not collapse into deflation, unlike pre-war: no debt deflation
- Real output and investment fall more in post WWII crisis (Table 2 of their paper)
  - Larger size of financial sector?
- Why despite central bank activism?

The Growing Reach of Public Interventions

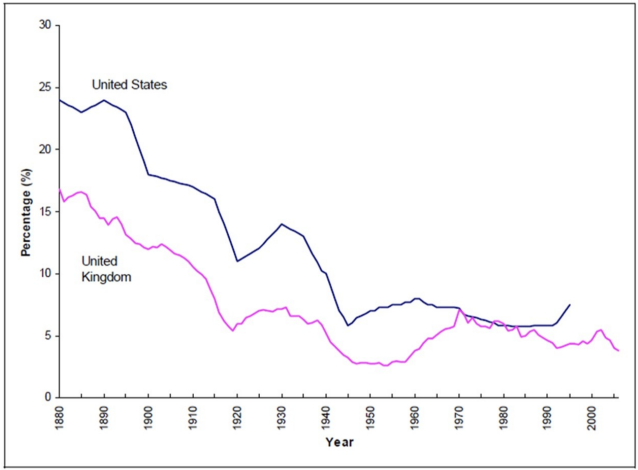
CB Balance Sheet

- Banking crisis interventions expanded significantly in size and scale in the 20th century



Source: Metrick and Schmelzing (2021). The left axis reports the total number of interventions for their database. The right axis (the line) takes a GDP-weighted view for advanced economies, focused on the subset of eight leading developed economies (Italy, the U.K., Netherlands, France, Germany, Spain, the U.S., and Japan).

Secular Decline in Banks' Capital Ratios



Source: US: Berger, A, Herring, R and Szegö, G (1995). UK: Sheppard, D.K (1971), BBA, published accounts and Bank of England calculations.

Source: Alessandri and Haldane (2009)

How does public intervention alter private arrangements and outcomes?

Starting Point – Stein (2012): Model with Fire-Sale Externalities

- Stein (2012): banking sector raises funds from households via ST liabilities (money-like deposits) and LT bonds to invest in long-term projects
  - Money-like deposits: cheaper than bond funding due to a premium attributed to riskless liquid assets, but depositors run in a crisis state
    - Also see Diamond and Dybvig (1983), Diamond and Rajan (2001), Dang, Gorton, Holmstrom and Ordonez (2017)
  - Bank cannot borrow in crisis state
  - The amount of money-like deposits issued is constrained by the need to have enough saleable assets in the crisis state so that deposits are risk free
  - If money funding cheap and constrained by assets, banks overinvest to overcreate money funding, neglecting effects on the fire-sale price

This Paper

1. Private provision of contingent capital $\Longrightarrow$ restores efficient outcomes in Stein (2012)
   - Historical evidence of banks having claims on shareholders in bad times (double/unlimited liability)
   - Contingent convertible bonds
2. More generally: money issuance can be supported by real investment, private contingent capital, but also public provision of contingent liquidity
   - Public provision of liquidity $\Longrightarrow$ crowds out private contingent capital **if underpriced**
   - In general, actuarially fair central bank support is underpriced – should charge a higher rate to account for incentives and restore efficient outcomes

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Other effects of public provision of liquidity

3. Central bank intervention can exacerbate the financing of financial speculation

- Financing speculation: returns increase in leveraging (and thus liquidity dependence)
  - Can crowd out money financing because financing speculation offers higher returns to available liquidity than money financing of real investment
  - Another way investments can be distorted

Related Literature

1. Banking Theory
   - Bank Runs: Diamond and Dybvig (1983), Diamond and Rajan (2001), Dang et al. (2017)
   - Fire-sale externality: Krishnamurthy (2003), Davila and Korinek (2017), Asriyan (2020)
2. Private Arrangements of Contingent Bank Capital
   - Unlimited and Contingent Liability: Macey and Miller (1992), White (1995, 2014), Grossman and Imai (2013), Kenny and Ogren (2021), etc.
   - Contingent Convertible Bonds: Flannery (2005), Kashyap, Rajan, and Stein (2008), French et al. (2010), Flannery (2014), Vallee (2019), Avdjiev et al. (2020)
3. Monetary Policy and Financial Stability
   - Theory: Bagehot (1873), Holmstrom and Tirole (1998), Stein (2012)
   - Empirics and History: Schularick and Taylor (2012), Reinhart and Rogoff (2013), Metrick and Schmelzing (2021), Ferguson et al. (2023)
4. Pre-committed Liquidity
   - Tuckman (2012), King (2016), Nelson (2023), Hanson et al. (2024)
5. The Rise of Financial Speculation
   - Duffie (2020), Barth and Kahn (2021), Schrimpft et al. (2020), Vissing-Jorgensen (2021), Kashyap et al. (2025), etc.

Households

- Representative households with unit measure, endowment Y
- Choose between current consumption C_0 and late consumption C_2
- Households can invest in either liquid money-like deposits M or risky, illiquid long term bonds B
- Linear preferences $U = C_0 + \beta \mathbb{E}[C_2] + \gamma M$
  - Expected gross return on bonds: $R^B = \frac{1}{\beta}$
  - Gross return on money: $R^M = \frac{1}{\beta+\gamma}$ where is the convenience yield on money
  - Fixed money-bond spread $= R^B - R^M$

Banks

Assets

- Real investment I:
  - Output $= f(I)$ in good state
  - Expected Output $= \lambda I$ in crisis state

Liabilities

- mI financed by money: pay $M = mIR^M$
  - At $t = 2$ in good state
  - At $t = 1$ in bad state
- $(1 - m)I$ financed by illiquid bonds that pay R^B at $t = 2$

- Crisis state: must meet money demand by depositors $M = mIR^M$
  - Sell real assets at fire-sale cost up to $k\lambda I$
  - Arrange for contingent capital $E = \psi I$ at time 0, pay $r^E E$ in good state to receive E in crisis state

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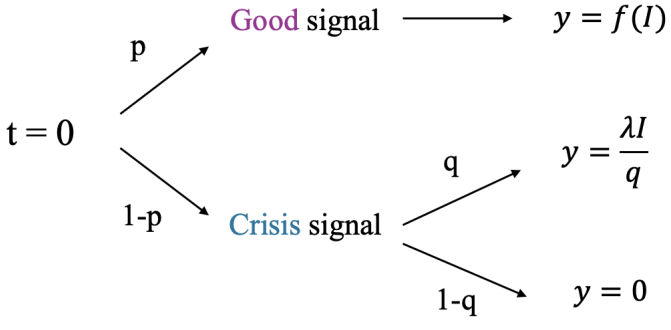
Timing and Real Investment



Bank's Problem

$$\max_{m,\psi,I} \underbrace{pf(I) + (1-p)\lambda I - R^B I}_{\text{real investment}} + \underbrace{mI(R^B - R^M)}_{\text{money spread}}$$

$$- \underbrace{pr^E \psi I}_{\text{insurance premium}} + \underbrace{(1-p)\psi I}_{\text{insurance payout}} - \underbrace{(1-p)(\frac{1}{k} - 1)[mIR^M - \psi I]}_{\text{loss on fire sale}}$$

s.t.

$$\underbrace{mIR^M}_{\text{Money Liability}} \leq \underbrace{k\lambda I}_{\text{Fire Sale}} + \underbrace{\psi I}_{\text{Private Insurance}} \iff m \leq \frac{k\lambda + \psi}{R^M}$$

FOCs: Bank FOCs

- Money-bond spread = Fire-sale cost + Shadow cost of money constraint
- MC of insurance for bank = Savings from fire sale + MB of relaxing money constraint
- MB of bank investment = MC of bank financing - MB of relaxing money constraint

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Private Investor's Problem

- Private investors (PIs) invest in late-arriving opportunity $g(\cdot)$, in purchasing firesold assets, and in providing contingent capital to banks

$$\max_{M,E} p\left[g(W) + \underbrace{r^E E}_{\text{insurance premium}}\right] + (1-p)\left[g(W-M) + \underbrace{\frac{1}{k}(M-E)}_{\text{Fire-sale purchases}}\right]$$

FOCs: PI FOCs

- At time 1 in the crisis state: MB of g investment = MB of fire-sale purchases
- At time 0: PI sets: Expected premium paid for contingent capital = Expected forgone gains from fire-sale purchases / g investment in the crisis state

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Equilibrium Characterization

Full Details I | Full Details II

- The money creation constraint never binds:

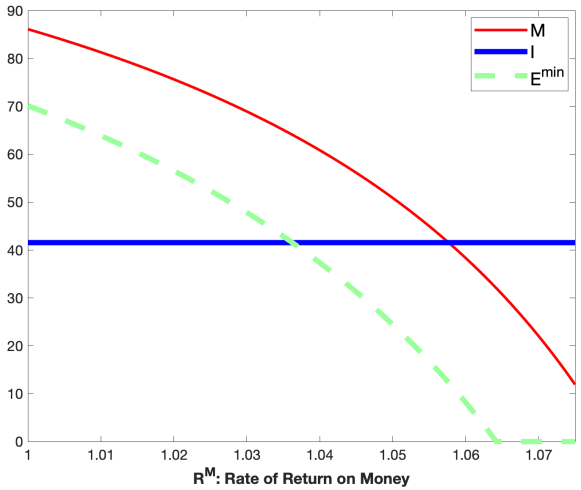
$$\begin{aligned}\text{Premium for CC} &= \text{Bank's fire-sale savings} + \text{Shadow cost of constraint} \\ &= \text{PI's forgone fire-sale gains}\end{aligned}$$

  - $\Longrightarrow$ Shadow cost of constraint $= 0$
  - Price of contingent capital at date 0 ensures no incentive to enhance money issuance by investing more

- Real investment I:
  - Since the money creation constraint does not bind, no incentive to overinvest

Baseline Model: Numerical Illustration

- Consistent with historical evidence on unlimited / contingent liability



Parameters: $p = 0.95$, $\lambda = 1$, $W = 140$, $R^B = 1.08$, R^M between 1 and 1.075; $f(I) = a\log(I) + I$ with $a = 3.5$, $g(K) = \theta\log(K)$ with $\theta = 140$. These parameters are used throughout the slides.

Intervention

- Seeing fire sales, might a central bank want to intervene?
- The 1907 Knickerbocker Crisis, JP Morgan and fire sales, and the setting up of the Federal Reserve

Central Bank as a Lender of Last Resort

- Central Bank provides liquidity $L = \phi I$ to cover a fraction of fire sales during crises:

$$\max_{m,\psi,\phi,I} \underbrace{pf(I) + (1-p)\lambda I - R^B I}_{\text{time-0 real investment}} + \underbrace{mI(R^B - R^M)}_{\text{money spread}} + pg(W)$$
$$+ \underbrace{(1-p)\left[g(W - M + L) + M\right]}_{\text{time-1 investment and transfers}} - \underbrace{(1-p)C(L)}_{\text{LOLR Cost}}$$

- At time 1 in the crisis state: $g'(W - M + L) = C'(L)$, where $C(L)$ captures the central bank's perceived distortionary fiscal / inflation cost or its political sensitivity

Varieties of central banks

- Different types of central bank
  - Planner: can choose I, M, E at time 0 along with $L = \phi I$ altogether
  - Bailout: takes levels of I,M as given, chooses L during crisis state ex post
  - Pre-committed liquidity: takes the optimizing behavior of I, M as given, at time 0, commits to provide L in the crisis state and charges τL in the good state

Moral Hazard Problem with a Bailout Central Bank

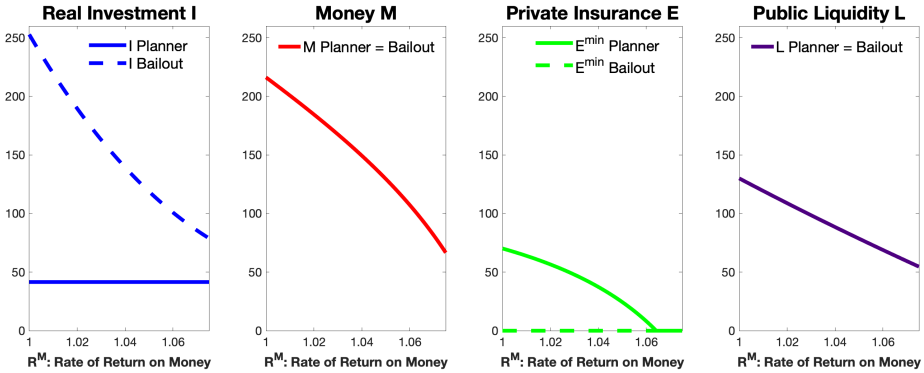
- Moral hazard: at time 0, banks perceive that the central bank provides liquidity $L = \phi I$ in the crisis state in proportion to real investment I:

$$\max_{m,\psi,\phi,I} \text{ Bank's Old Objective} + \underbrace{(1-p)\phi I}_{\text{LOLR payout}} + \underbrace{(1-p)(\frac{1}{k}-1)\phi I}_{\text{savings on fire sales due to LOLR}}$$

- Banks now have additional incentive to scale up real investment at time 0
  - More money-issuance made possible by real investment rather than private contingent capital $\implies$ could lead to an "endogenous missing market" for private contingent capital

Model with a Bailout Central Bank

- M and L at efficient levels, but overinvestment in I due to L
  - endogenously missing market for private contingent capital
  - When the money-bond spread is large, a bailout central bank can lead to lower welfare Welfare



Note: Same parameters as the baseline model without central banks, with $C(L) = 0.5cL^2$, $c = 0.02$.

Effects of Central Bank Intervention

- The "endogenous missing private insurance market" result under a bailout central bank is consistent with
  - The establishment of central banks and expanding liquidity interventions in banking crises

  in conjunction with
  - The disappearance of private contingent capital (in the form of unlimited or contingent liability), and the secular decline in bank capital
- Actuarially fair pre-committed liquidity: continues crowding out private contingent capital, though to a lesser extent
  - At time 0, commit to L in the crisis state taking into account how private agents optimize and charge $(1-p)L$ back in expectation AFPL
  - The actuarially fair rate is not enough to restore planner's choice: banks save (1 + fire-sale returns) from public liquidity intervention
- Correcting the moral hazard distortion is particularly difficult!

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Modern Motivation: Rising Financial Speculation

- How do the model's insights on the distortive effects of public intervention on money creation inform our understanding of the modern financial system?
  - Not only overinvestment in real technology, but also financial speculation
- The bond basis trade (long Treasuries with leverage, short futures) has raised major financial stability concerns
  - A key factor in the bond market turmoil in March 2020 (Duffie, 2020; Barth and Kahn, 2021; Schrimpft et al, 2020; etc.), followed by Fed's $1T intervention in Treasuries (Vissing-Jorgensen, 2021)
  - Kashyap et al. (2025) advocate for a more targeted policy response by the Fed

According to the Composite Index for the Euro Area, several other recent episodes of financial speculation have also raised financial stability concerns due to fire sales triggered by margin calls. Notable examples include the €100M trading losses from Einar Aas borne by Nasdaq and its clearing house members in September 2018, the collapse of Archegos Capital Management in April 2021, and the liability-driven investment (LDI) crisis involving UK pension funds in September 2022.

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Model Motivation

- Returns to taking on illiquidity/fire sale risk limited by $R^B - R^M$
- What if returns could be higher – financing financial speculation such as the bond-basis trade
- Greater returns for greater leveraging, but greater need for liquidity in the crisis state

Financial Speculation

Assets

- Real investments I
- Speculation: pays $1 + ls$ per dollar invested (leverage l chosen)
  - At time 1 in crisis state: margin calls $v(l)$ per dollar invested

Liabilities

- Money M (gross rate R^M)
  - Can be issued to finance either real investment or financial speculation
  - At $t = 1$ in crisis state: must repay depositors
- Illiquid bonds (pay R^B at $t = 2$)

- Consider the case where speculation is more profitable than an R^B storage technology, even after accounting for margin calls
- Total liquidity demand during crises = money liabilities + margin calls
  - Financed by fire sale of real investments and private contingent capital (and possibly public liquidity)

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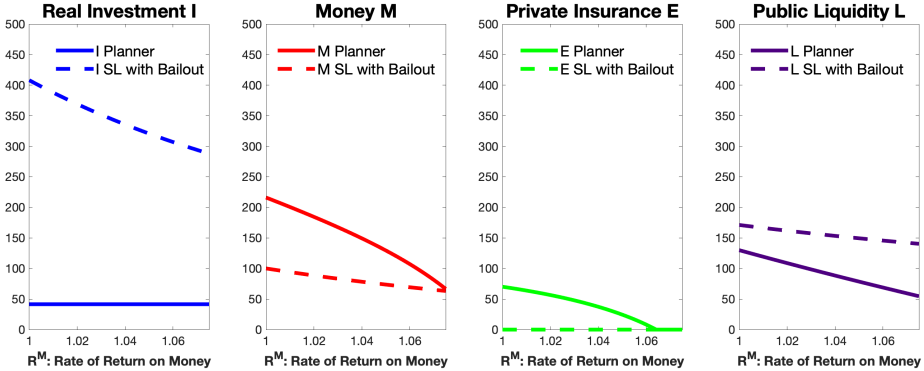
Model with Bailout Central Bank and Financial Speculation

- Financial speculation + bailout central bank: excessive real investment and underprovision of private insurance continues to prevail
  - Excessive intervention L , but less M relative to planner's choice — why?



Note: Same parameters as the baseline model, and we choose $s = 0.01$, $\bar{m} = 0.5$, $v(I) = 0.002I^2 + 0.001I$. These parameter choices give reasonable levels of speculation returns (net return of 0.1-0.13) and leverage (I is around 20-26; the size of the margin call, $v(I)$, is around 0.8-1.3.

Model with Bailout Central Bank and Financial Speculation

- Institutional liquidity demand through financial speculation (margin calls) crowds out individual deposit demand (with a convenience yield) Full Results
  - LOLR also induces more financial speculation than the private outcome
  - Consistent with rising financial speculations post-Q

Conclusion

- Straightforward private-sector remedies to problem of banks overissuing money-like liabilities
- Leaves possibility of public intervention – fire sale prices
- Public intervention is invariably underpriced and distortionary
  - Politically difficult to charge an adequate fee that is higher than actual public costs to restore the right private incentives
- Can incentivize liquidity dependence in investment allocation (financing speculation) as well as overinvestment
- Finding the right mix of private contracting and public support remains an important topic for future research

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The Recurrence of Banking Crises Persists

Back

- List of Banking Crises from Schularick and Taylor (2012)

Country	ISO	Financial crisis (first year)
Australia	AUS	1893, 1989
Canada	CAN	1873, 1906, 1923, 1983
Denmark	DNK	1877, 1885, 1902, 1907, 1921, 1931, 1987
France	FRA	1882, 1889, 1904, 1930, 2008
Germany	DEU	1880, 1891, 1901, 1931, 2008
Italy	ITA	1887, 1891, 1907, 1931, 1930, 1935, 1990, 2008
Japan	JPN	1882, 1907, 1927, 1992
Netherlands	NLD	1897, 1921, 1939, 2008
Norway	NOR	1899, 1921, 1931, 1988
Spain	ESP	1920, 1924, 1931, 1978, 2008
Sweden	SWE	1876, 1897, 1907, 1922, 1931, 1991, 2008
Switzerland	CHE	1870, 1910, 1931, 2008
United Kingdom	GBR	1890, 1974, 1984, 1991, 2007
United States	USA	1873, 1884, 1893, 1907, 1929, 1984, 2007

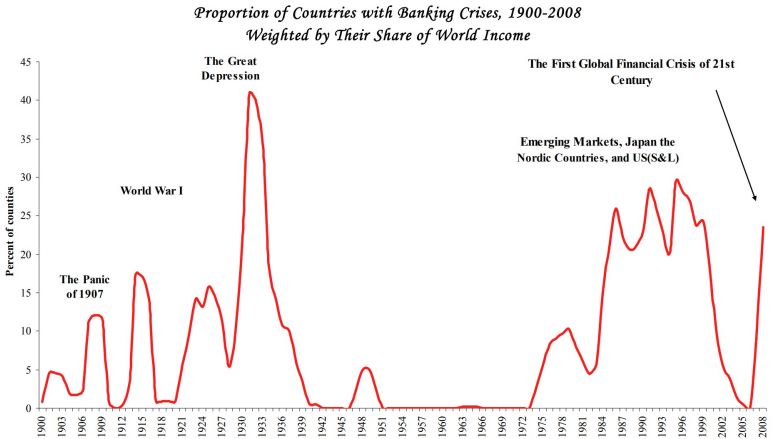
Notes: As described in the text, our crisis coding follows previous work, notably Reinhart and Rogoff (2009, RR), and Bordo, Eichengreen, Klingebiel, and Martinez-Peria (2001, BEKM). We corroborated the coding with Laeven and Valencia (2008) as well as Cechetti et al. (2009). There are only three major cases where these sources differ and which we need to discuss briefly:

Source: Schularick and Taylor (2012)

The Recurrence of Banking Crises Persists

Back

- Despite central bank efforts, severe banking crises remain a recurring phenomenon, even in advanced economies



Source: Reinhart and Rogoff (2013)

US Crises Post FDIC

Back

List of U.S. banking crises and financial crises involving financial stability concerns since the establishment of central banking and deposit insurance:

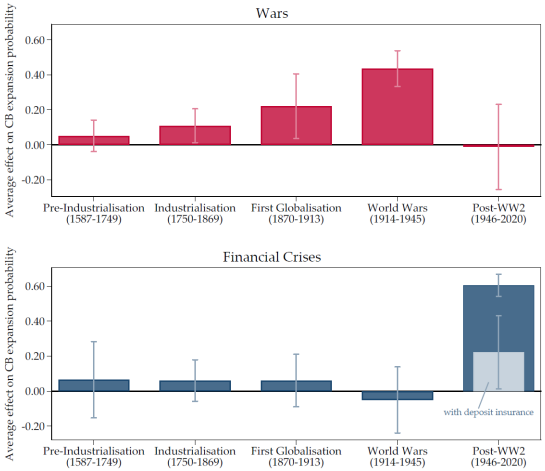
- 1970: Penn Central bankruptcy
- 1980s: Savings and Loans (S&L) crisis
- 1983 – 1984: Bailout of Continental Illinois National Bank and Trust Company
- 1998: Failure of Long-Term Capital Management
- 2007 – 2009: Great Financial Crisis
- 2023: US regional bank crisis

Source: Bouis, Romain, Damien Capelle, Giovanni Dell'Ariccia, Christopher Erceg, Maria Martinez Peria, Mouhamadou Sy, Ken Teoh, and Jerome Vandenbussche, 2025, Navigating trade-offs between price and financial stability in times of high inflation, IMF Staff Discussion Notes 2025

Financial Crises as Central Bank Balance Sheet Drivers

Back

- Post-WW2, central bank policy responses have become *"close to systematic"* amid financial crisis (Ferguson, Kornejew, Schmelzing, and Schularick, 2023)



Source: Ferguson et al. (2023). The figure plots average effects on the probability of a central bank balance sheet expansion of +15% or more during the current or the next year.

Bank's FOCs

Back

- w.r.t. bank's fraction of real investment financed by deposits, m:

$$\underbrace{R^B - R^M}_{\text{money-bond spread}} \underbrace{-(1-p)zR^M}_{\text{fire sale cost}} = \underbrace{\frac{\eta}{I}}_{\text{shadow cost of constraint}}$$

- w.r.t. bank's fraction of real investment covered by private contingent capital ψ:

$$\underbrace{pr^E}_{\text{MC of insurance}} = \underbrace{\frac{\eta}{IR^M}}_{\text{MB of relaxing constraint}} + \underbrace{(1-p)(1+z)}_{\text{Fire sale savings}}$$

- w.r.t. bank's real investment I:

$$\underbrace{pf'(I) + (1-p)\lambda}_{\text{expected MB of investment}} = \underbrace{R^B}_{\text{MC of financing}} - \underbrace{\frac{\eta}{I}\left[m - \frac{\psi}{R^M}\right]}_{\text{MB of relaxing money constraint}}$$

Private Investor's FOCs

Back

- At time 1 in the crisis state:

$$\underbrace{g'(W-M)}_{\text{MB of g investment}} = \underbrace{\frac{1}{k}}_{\text{MB of fire-sale purchases}}$$

- At time 0:

$$\underbrace{pr^E}_{\text{Expected insurance premium}} = \underbrace{(1-p)\frac{1}{k}}_{\text{Expected forgone gains from fire-sale / g inv in crises}}$$

Equilibrium Characterization I

Back

- private contingent capital markets FOCs $\implies$ money creation constraint never binds:

$$\underbrace{(1-p)(1+z)}_{\text{PI's MC of Insurance}} = \underbrace{pr^E}_{\text{Insurance Premium}} = \frac{\eta}{IR^M} + \underbrace{(1-p)(1+z)}_{\text{Bank's Fire Sale Savings}} \implies \eta = 0$$

- Fire sale price k pinned down by bank's FOC w.r.t. m:

$$\underbrace{\frac{R^B - R^M}{R^M}}_{\text{Money spread}} = \underbrace{(1-p)(\frac{1}{k} - 1)}_{\text{Expected Fire Sale Cost}}$$

  - In expectation, the overall financing cost is the same via money vs bonds

Equilibrium Characterization II

Back

- Real investment I is pinned down by the bank's FOC w.r.t I:

$$\underbrace{pf'(I) + (1-p)\lambda}_{\text{Expected MB of investment}} = \underbrace{R^B}_{\text{MC of Financing}}$$

- Total amount of money $M = mIR^M$: from PI's FOC at time 1:

$$\underbrace{g'(W-M)}_{\text{PI's MB of } g \text{ investment}} = \underbrace{\frac{1}{k}}_{\text{PI's MB of fire-sale purchases}}$$

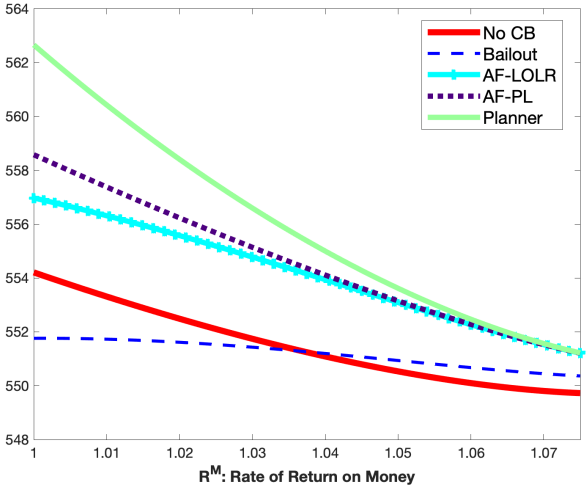
- Take costs arising from insurance friction $\to 0 \implies$ frictionless benchmark

$$\underbrace{E}_{\text{Private contingent capital}} = \underbrace{M}_{\text{Money Liability}} - \underbrace{k\lambda I}_{\text{Fire-sold real investment}}$$

  - More generally, any E s.t.$M - k\lambda I \leq E \leq M$ is an equilibrium outcome (only in the frictionless model).

Baseline Model: Welfare

Back

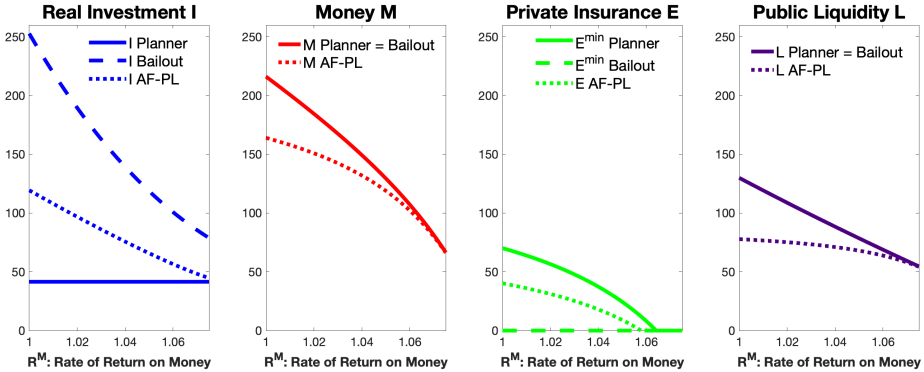


Parameters: $p = 0.95$, $\lambda = 1$, $W = 140$, $R^B = 1.08$, R^M between 1 and 1.075; $f(I) = a\log(I) + I$ with $a = 3.5$, $g(K) = \theta\log(K)$ with $\theta = 140$. These parameters are used throughout the slides, with $C(L) = 0.5cL^2$, $c = 0.02$.

Model with Actuarially Fair Pre-committed Liquidity

Back

- At time 0, less public intervention L and therefore money M to alleviate the distortion on money creation via I vs E, charge L back at $t = 2$
  - Banks save (1 + fire-sale costs) from public liquidity intervention $\implies$ a central bank that breaks even is not enough to restore efficient outcomes

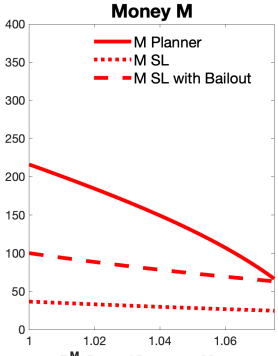


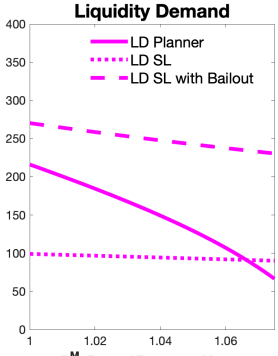
Note: Same parameters as the baseline model without central banks, with $C(L) = 0.5cL^2$, $c = 0.02$.

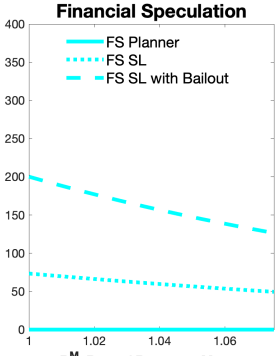
Model with Bailout Central Bank and Financial Speculation

Back

- Institutional liquidity demand through financial speculation (margin calls) crowds out individual deposit demand (with a convenience yield)
  - LOLR also induces more financial speculation than the private outcome
  - Consistent with rising financial speculations post-QE







Note: Same parameters as the baseline model, and we choose $\varepsilon = 0.01$, $\bar{m} = 0.5$, $\psi(l) = 0.002l^2 + 0.001l$. These parameter choices give