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
- A puzzling observation: despite central bank efforts, significant banking crises continue to occur across the world, including in advanced economies with comprehensive regulatory frameworks

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1. Historical Success of Banks with Unlimited Liability

- White (1995) on the Scottish Free Banking Era (1710-1844):

  Scotland...enjoyed remarkable monetary stability during the 18th and early 19th centuries. During this time Scotland had no monetary policy, no central bank and very few legal restrictions of the banking industry. Entry was open and the right of note issue universal.

  - *By 1844, unlimited liability banks "became the dominant element in the Scottish banking system" (Evans and Quigley, 1995)*

- Prior to the Great Depression, many banks in Europe and US operated well under contingent liability structures: shareholders were responsible for at least a portion of debt after insolvency

- More recently, empirical evidence suggests that contingent convertible bonds can help reduce bank fragility (Valle, 2019; Avdjiev et al., 2020)

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2. The Emergence of Central Banking

- Central banks emerged globally in the 19th and 20th centuries, taking on the role of lender of last resort (LOLR)

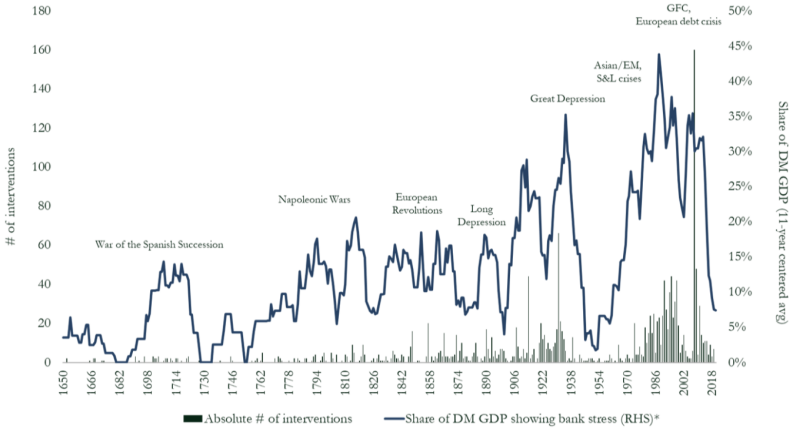
Country	Modern Central Bank was Established in	First LOLR-type Intervention by Central Bank
United Kingdom	1694	1711
Spain	1782	1829
France	1800	1818
Netherland	1814	1924
Germany	1876	1880
Japan	1882	1890
Italy	1893	1906
United States	1913	1916

Source: Bordo and Siklos (2018), Metrick and Schmelzing (2021)

Note: The First and Second Bank of United States were in place between 1791-1836 but not included as a modern central bank. The first lender of last resort-type intervention were based on the chronology provided by Metrick and Schmelzing (2021).

3. The Growing Reach of Public Interventions

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

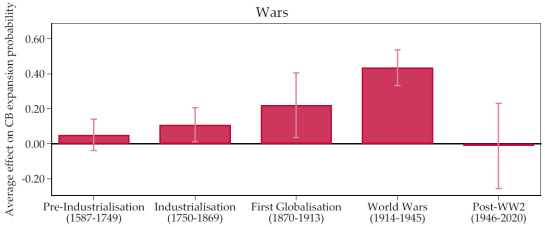


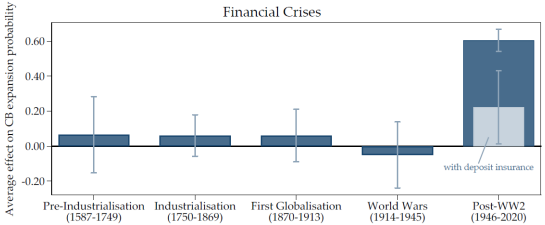
Source: Metrick and Schmelzing (2021). The left axis reports the total number of interventions for their database. The right axis (the line) takes a GDP-weighted view for advanced economies, focused on the subset of eight leading developed economies (Italy, the U.K., Netherlands, France, Germany, Spain,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

4. Financial Crises as Central Bank Balance Sheet Drivers

Time Series

- Post-WW2, central bank policy responses *"has become close to systematic"* amid financial crisis (Ferguson et al., 2023)

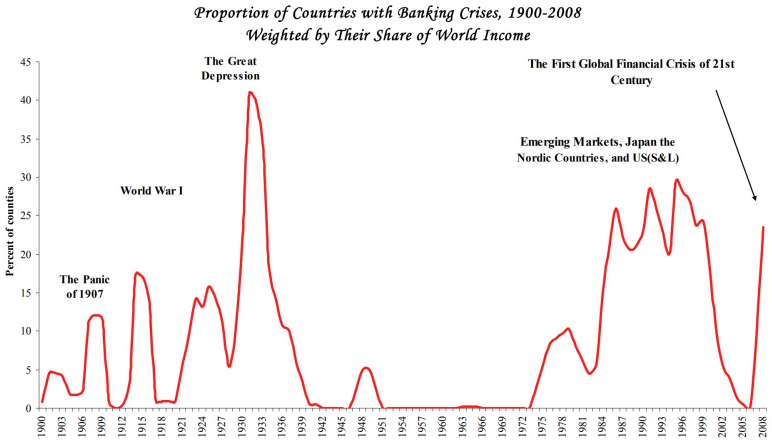




Source: Ferguson et al. (2023). The figure plots average effects on the probability of a central bank balance sheet expansion of +15% or more during the current or the next year.

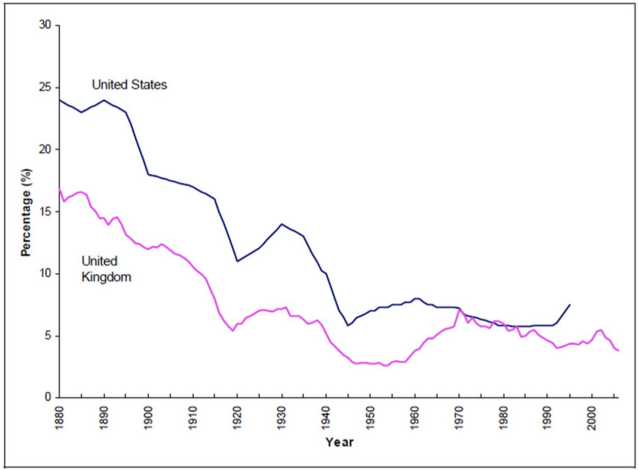
5. The Recurrence of Banking Crises Continues

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



Source: Reinhart and Rogoff (2013)

6. 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 the private provision of contingent liquidity?

Starting Point: A Model with Fire-Sale Externality

- Banks borrow short to lend / invest long $\implies$ liquidity crises in some states
- Stein (2012): banking sector raises funds from households via ST liabilities (money / deposits) and LT bonds to invest in long-term projects
  - Money: cheaper than bond funding due to a liquidity premium, but depositors may run in a crisis state
  - The amount of money issued is constrained by the need to have enough saleable assets in the crisis state
  - If collateral constrained: banks overinvest to overcreate money, neglecting their effects on the fire-sale price

This Paper

1. Private provision of contingent liquidity $\Longrightarrow$ restores efficient outcomes
   - Historical evidence of banks having calls on shareholders in bad times
2. Public provision of contingent liquidity $\Longrightarrow$ crowds out private insurance due to moral hazard
   - Money issuance can be supported privately by real investment and private insurance
   - If **central bank support** is not priced right, **its perception** can distort this mix
   - In general, actuarially fair central bank support is underpriced – should charge a higher rate to account for incentives and restore efficient outcomes
3. Central bank intervention can also fuel financial speculation, raising liquidity demand during crises even as it crowds out money held by households

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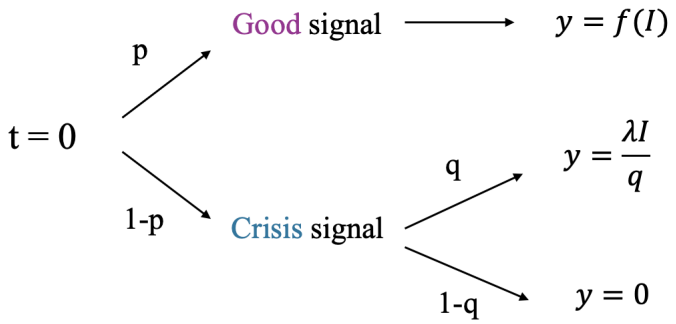
Households

- Representative households with unit measure, endowment Y
- Choose between current consumption C_0 and late consumption C_2 that is financed by either liquid money / deposits M or risky, illiquid 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: $R^M = \frac{1}{\beta+\gamma}$
  - γ : convenience on money
  - Fixed money-bond spread

Timing and Real Investment



Banks

Assets

- Real investment I:
  - Output $= f(I)$ in good state
  - Expected Output $= \lambda I$ in crisis state
- Illiquid storage technology that pays R^B at $t = 2$ ($m > 1$)

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 $k\lambda I$
  - Purchase private insurance $E = \chi I$ at time 0, pay $r^E E$ in good state to receive E in crisis state

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

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 constraint
- MC of insurance = Savings from fire sale + MB of relaxing constraint
- Expected MB of insurance = MC of financing - MB of relaxing constraint

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Private Investor's Problem

- Private investors (PIs) invest in late-arriving opportunity $g(\cdot)$ and fire-sales, and provide private insurance to banks

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

FOCs: PI FOCs

- At time 1 in the crisis state: MB of g investment = MB of fire-sale purchases
- At time 0: PI's expected gains from insurance premium = Expected forgone gains from fire-sale / g investment in the crisis state

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Private Equilibrium

Definition

A private equilibrium is a set of prices and allocations such that

- Taking the prices k, r^E as given, banks and PIs optimize,
- The markets for private insurance and fire sale of real investments clear.

Theorem

The private equilibrium outcome in the baseline model with private contingent liquidity and no friction in its commitment or provision is efficient.

- Consistent with Krishnamurthy (2003), Asriyan (2020)

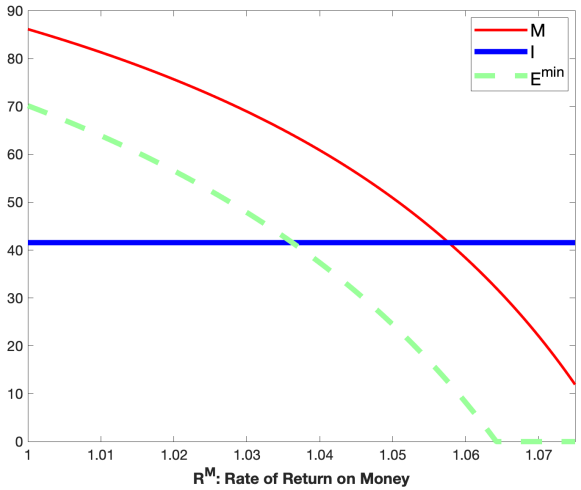
Equilibrium Characterization

Full Details I | Full Details II

- The money creation constraint never binds
  - Insurance premium = Bank's fire sale savings + shadow cost of constraint = PI's forgone fire-sale gains $\implies$ shadow cost of constraint = 0
- Real investment I:
  - Expected MB of investment = Expected MC of financing
- Other FOCs pin down money and therefore private insurance Details

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.

Central Bank as a Lender of Last Resort

- Central Bank provides liquidty $L = \phi I$ 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
- Different types of central bank
  - Planner: can choose I, M, E at time 0 along with $L = \phi I$ altogether
  - Bailout: take levels of I,m as given, choose L during crises ex post
  - Pre-committed liquidity: take the optimizing behavior of I, m as given, at time 0, commit to provide L during the crisis and charge L back after the crisis

Moral Hazard Problem with a Bailout Central Bank

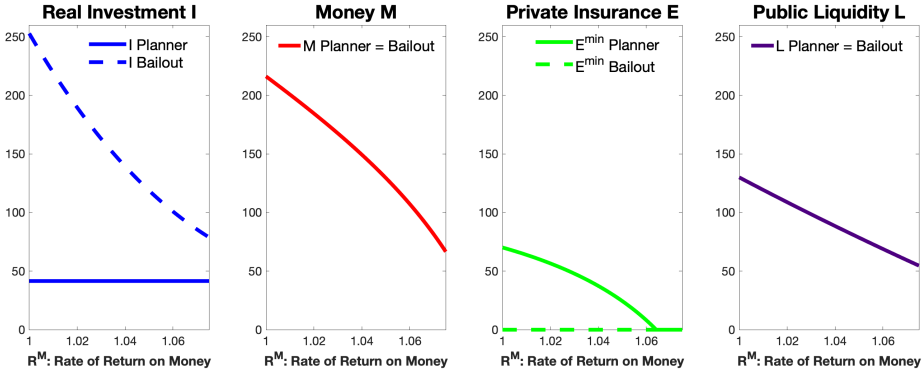
- Moral hazard: at time 0, banks perceive that the central bank provides liquidity $L = \phi I$ in the crisis state in proportion of real investment I

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

- Banks now have additional incentive to scale up real investment at time 0
  - More money created via real investments rather than private insurance $\implies$ could lead to an "endogenous missing market" for private insurance

Model with a Bailout Central Bank

- M and L at efficient levels, but overinvestment due to $L \implies$ endogenously missing market for private insurance
  - When the money-bond spread is large, the addition of 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 in the 19th and 20th century and expanding liquidity interventions amid 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: similar distortion to a less extent
  - At time 0, commit to L in the crisis state and charge L back after the crisis, taking into account of how private agents optimize AFPL
  - The actuarially fair rate is not enough to restore planner's choice: banks save $(1 +$ fire-sale costs$)$ 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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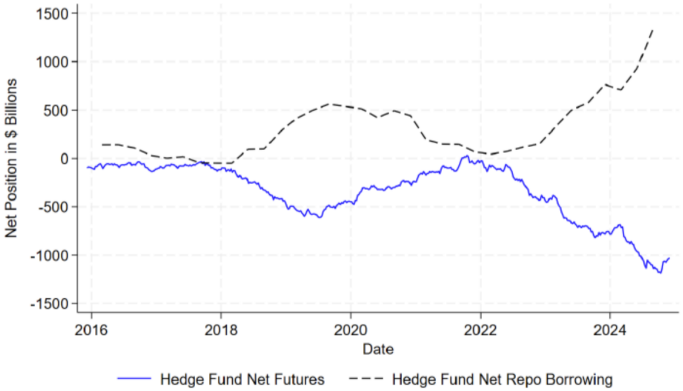
Modern Motivation: Rising Financial Speculation

- The recent bond market disruption in April 2025 was also at least partly attributed to the unwinding of the basis trade (Liang, 2025)
  - The size of the bond basis trade is estimated to be $800B to $1T USD (Kashyap et al, 2025; Slok, 2025)



Source: Kashyap et al (2025). This figure shows hedge fund net repo borrowing and net Treasury futures positions.

Financial Speculation

Assets

- Real investments I
- Speculation: pays $1 + ls$ per dollar invested, for a level of leverage l chosen
  - At time 1 in crisis state: margin calls $v(l)$ per dollar invested
  - Must be financed by at least a fraction $\bar{m}$ in money

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 R^B storage, even after accounting for margin calls
- Total liquidity demand during crises = money liabilities + margin calls
  - Financed by fire sale of real investments and private insurance (and possibly public liquidity)

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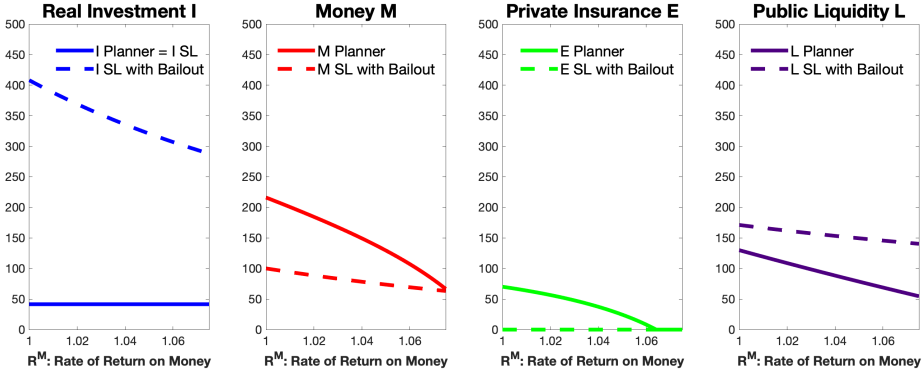
Model with Bailout Central Bank and Financial Speculation

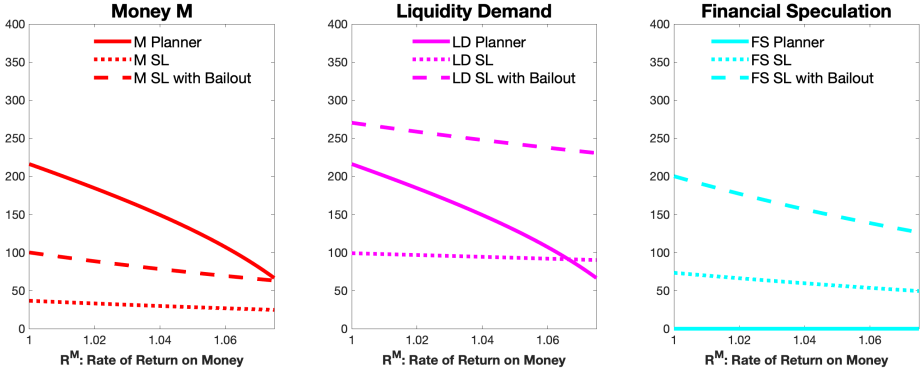
- With a bailout central bank: overinvestment and underprovision of private insurance continues to prevail
  - Excessive Intervention L , but less M — why?



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)
  - LOLR also induces more financial speculation than the private outcome
  - Consistent with rising financial speculations post-QE



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Conclusion

- There are straightforward private-sector remedies to the age-old problem of banks overissuing money-like liabilities
- 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
- Post WWII: mounting evidence that central banks have become more willing to intervene, and expectations of future intervention grow with intervention
  - Schularick and Taylor (2012): crises remain severe and at least as frequent post WWII, possibly because the banking system leverages and takes risk in anticipation
  - Ferguson et al. (2023): central bank liquidity support has reduced the severity of crises, but also raises the probability of future boom-bust episodes Boom-Bust
- Finding the right mix of private contracting and public support remains an important topic for future research

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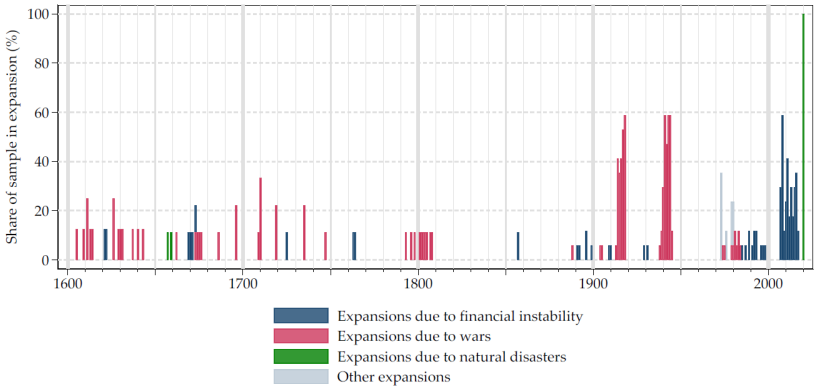
4A. Drivers of Central Bank Balance Sheet Expansions

Back

- Shift from wars pre-1870 to **financial crises** post-WWII (more than 40% of post-WWII expansions were linked to financial crises, vs $< 15\%$ pre-1870)

Figure 5: Major balance sheet expansion events, by type, 1600-2020



Source: Ferguson et al. (2023). Balance sheets expansion events are defined as +15% year-on-year total nominal asset growth.

5A. 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)

5B. 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 (source: Bouis et al., 2025):

- 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

Bank's FOCs

Back

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

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

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

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

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

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

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

Full Details I | Full Details II | Back

- The money creation constraint never binds
  - Insurance premium = Bank's fire sale savings + shadow cost of constraint = PI's forgone fire-sale gains $\implies$ shadow cost of constraint = 0
- Fire-sale price k:
  - Money spread $(R^B - R^M)$ = Expected fire-sale cost
- Real investment I:
  - Expected MB of investment = Expected MC of financing
- Other FOCs pin down money and therefore private insurance:
  - Take costs arising from insurance friction $\to 0$ $\implies$ frictionless benchmark
  - Private insurance E = Money liability M − Real investments I at fire-sold price

Equilibrium Characterization I

Back

- Private insurance 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:

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

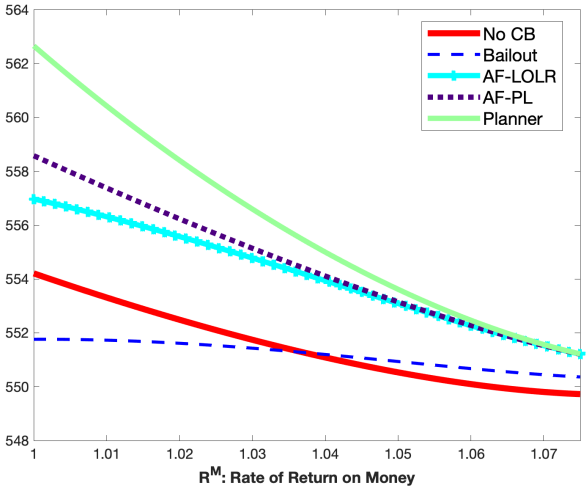
- Take costs arising from insurance friction $\to 0 \implies$ frictionless benchmark

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

  - 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

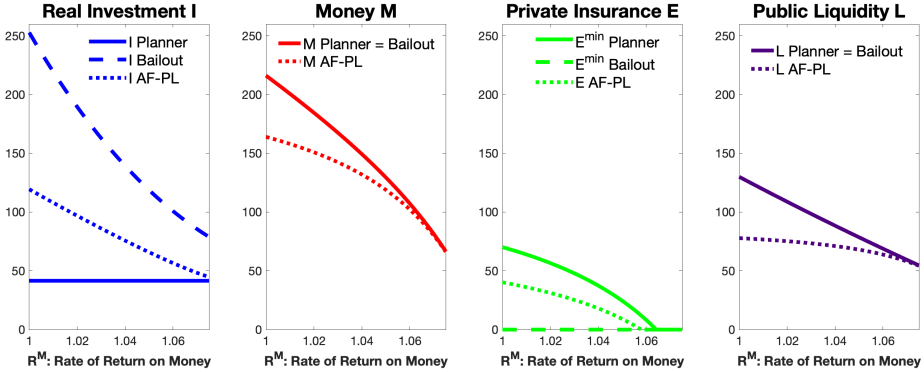


Parameters: $p = 0.95$, $\lambda = 1$, $W = 140$, $R^B = 1.08$, R^M between 1 and 1.075; $f(I) = a\log(I) + I$ with $a = 3.5$, $g(K) = \theta\log(K)$ with $\theta = 140$. These parameters are used throughout the slides, with $C(L) = 0.5cL^2$, $c = 0.02$.

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

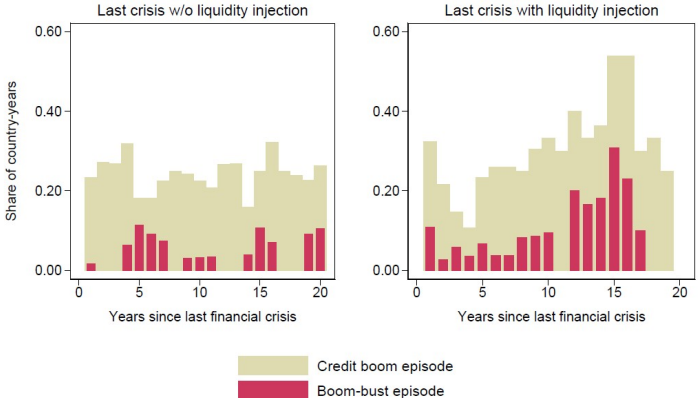


Note: Same parameters as the baseline model without central banks, with $C(L) = 0.5cL^2$, $c = 0.02$.

Credit Boom-Bust Episodes Following Interventions

Back

- Following a crisis, the probability of credit boom-bust episodes increase substantially with public liquidity injection



Source: Ferguson et al. (2023). This figure plots the share of country-years experiencing a credit boom episode, binned by the number of years since last financial crisis and respective central bank liquidity support. A country-year is defined to belong to a credit boom episode if the credit-to-GDP ratio increased beyond +0.10 over the past three years. A country-year is labeled as a part of a boom-bust episode if in addition a financial crisis ensues during any of the three subsequent years.