

How Central Banks Should Use Their Balance Sheets to Control Flight-to-Safety

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- ▶ Large shifts in *asset demand* during financial crises (historically, regulated banking sector)

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(BIS and Financial Stability Board: e.g., money market funds, hedge funds)
 - Held \$63 trillion in 2020, representing 79% of global GDP (S&P Global)

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 - Held \$63 trillion in 2020, representing 79% of global GDP (S&P Global)
- ▶ Wholesale Banking Panics: several flight-to-safety events in the last decades
 - September 2008: \$400B withdrawal (2% of U.S. GDP); March 2020: \$100B withdrawal

This Paper

Implications of wholesale banking panics for *central bank balance sheet policies*

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- ▶ Expansions through open market operations involve purchasing Treasury bills
 - Lower T-bill returns → reduce investors' flight-to-safety incentive/mitigate panics
 - **General asset returns reduction** through **endogenous shifts in asset demand**
 - Mitigate flight-to-safety → increase demand for bank liabilities, bidding down returns

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Endogenous shifts in asset demand can lead to unintended policy implications!

- ▶ Decreased asset returns hinder transactions, e.g., repo transactions involving T-bills

Model

Three-period, Two-Sector Banking Model

- ▶ Three sets of private agents: convert labor (h) to goods (c) one-for-one

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$$- \underbrace{h_1}_{\text{work and deposit}} + \underbrace{u(c_2)}_{\text{consume}} - \underbrace{h_3}_{\text{work to pay taxes}} \quad \text{where} \quad -c \frac{u''(c)}{u'(c)} < 1; \quad u(0) = 0$$

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work in $t = 1$ to raise (sweat) equity and in $t = 3$ to pay debts; consume profits

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- ▶ Government: fiscal authority and central bank

Trading Frictions Give Rise to Demand for Assets

- ▶ Exchanges are essential because goods are **perishable**
 - Depositors trade *bilaterally* with producers in period 2 (take-it-or-leave-it offer)
- ▶ **Limited commitment** → no unsecured IOU → exchanges are supported by assets
 - Depositors and banks trade goods and assets in a *Walrasian market* in period 1

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Underlying assets

- ▶ **Government bonds** (\hat{b}): everyone can hold them
- ▶ **Central bank reserves** (\bar{m}): restricted to retail banks only ▶ details
 - Central bank purchase $\hat{b} - \bar{b}$ government bonds (assets) with \bar{m} reserves (liabilities)
 - The rest of the bonds circulate in the private sector

Banking & Risk of Wholesale Banking Failure

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 - Failed banks default on their liabilities and abscond with assets

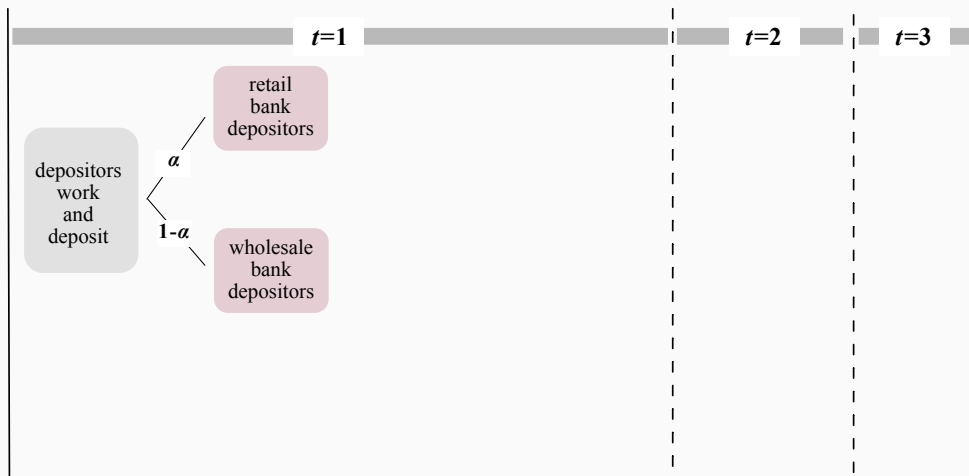
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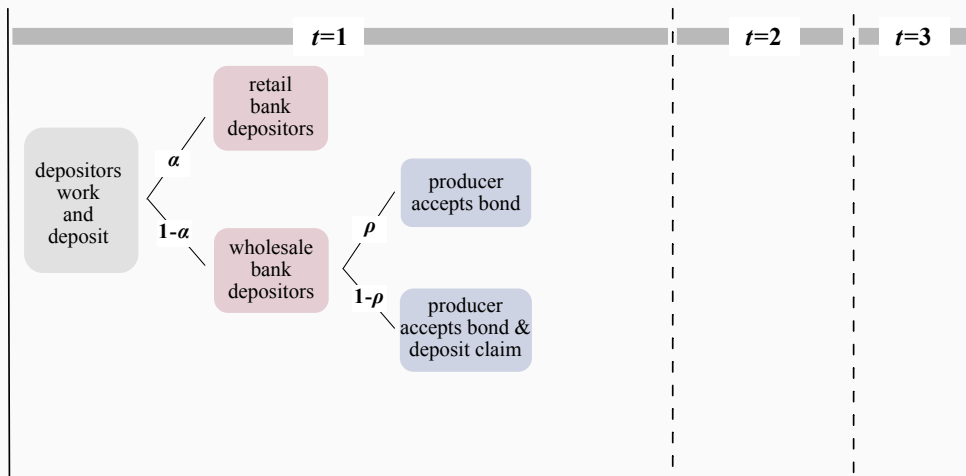
Risk of Banking Failure Sparks Wholesale Banking Panics (Gertler and Kiyotaki, 2015)

- ▶ Depositors decide whether to withdraw in period 1 under imperfect information
 - Withdraw with exogenous prob. ρ to meet liquidity needs
 - Withdraw with **endogenous** prob. η due to safety concerns (**panicking depositors**)
 - Panicking depositors flee to bonds, capturing the severity of panics

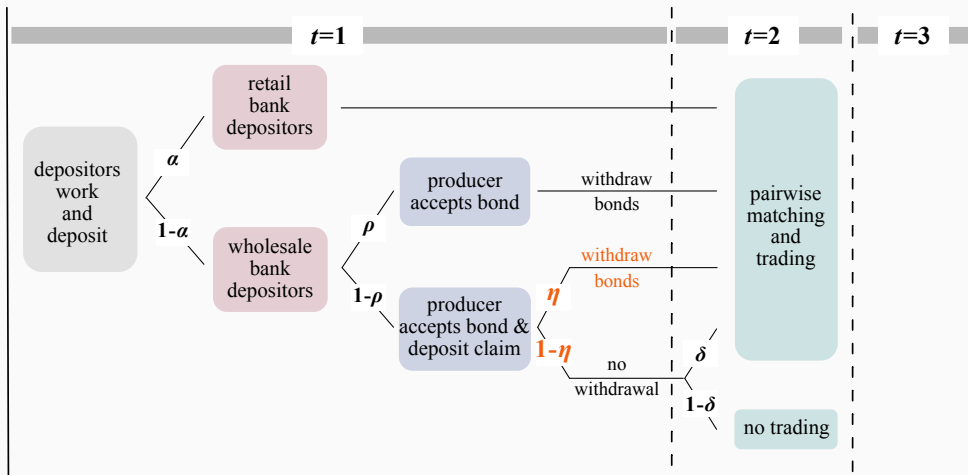
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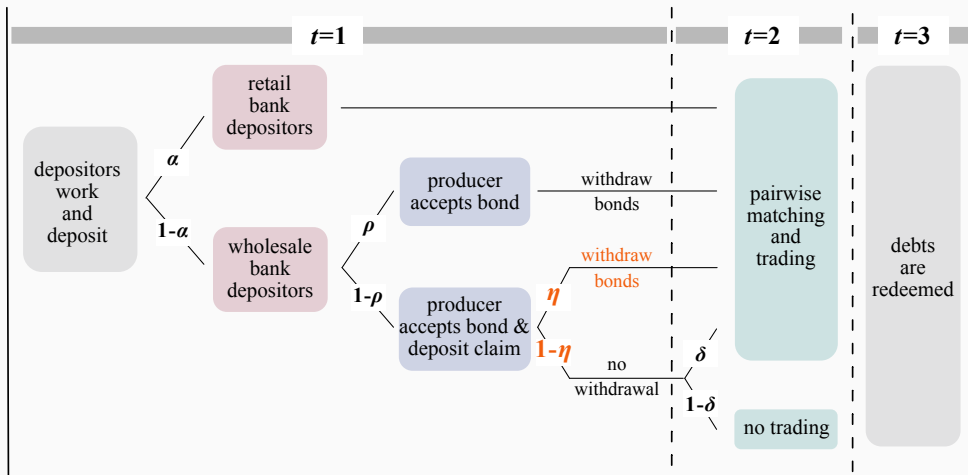
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Retail Bank

1. Deposit contract: required deposits (k^r), deposit claims (d^r) (secured and tradeable IOUs)
2. Financial portfolio: reserves (m), government bonds (b^r), interbank borrowing (ℓ^r)

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Subject to a **leverage constraint** (collateral constraint holds automatically)

- ▶ A fraction θ of their return on assets should cover their payments on liabilities
- ▶ Finance $1 - \theta$ of their assets with bank capital (sweat equity) \rightarrow balance sheet cost

Asset	Liability & Equity
$r^m m$	d^r
$r^b b^r$	$r^\ell \ell^r$
	e ▶ equity

Wholesale Bank

1. Deposit contract: k^w , quantity of bonds if withdrawal (b'), and d^w
 - ρ depositors must trade with bonds (liquidity needs in settling wholesale payments)
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Subject to a collateral constraint (no leverage requirement \rightarrow no bank capital)

Asset	Liability	
$r^b b^w$	$r^b [\rho + (1 - \rho)\eta] b'$	\rightarrow <i>withdraw</i>
$r^\ell \ell^w$	$(1 - \rho)(1 - \eta) d^w$	\rightarrow <i>not withdraw</i>

- Endogenous withdrawal probability η adjusts the composition bank liabilities

Will wholesale bank depositors withdraw their funds?

Wholesale bank depositors' ex ante expected utility

$$\underbrace{-k^w}_{\text{deposits}} + \underbrace{[\rho + (1 - \rho)\eta]u(r^b b') + (1 - \rho)(1 - \eta)[\delta u(d^w) + (1 - \delta)u(0)]}_{\text{expected return on deposit contract}}$$

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Not withdraw: Get a tradeable claim to d^r units of consumption goods with probability δ

- (i) No banking panic: $\eta = 0$, if $u(r^b b') \leq \delta u(d^w) + (1 - \delta)u(0)$;
- (ii) Partial banking panic: $0 < \eta < 1$, if $u(r^b b') = \delta u(d^w) + (1 - \delta)u(0)$;
- (iii) Full banking panic: $\eta = 1$, if $u(r^b b') \geq \delta u(d^w) + (1 - \delta)u(0)$.

Perfectly Competitive Wholesale Banking

► retail bank's problem

► eq. conditions

- Maximize depositors' expected utility, **considering potential banking panic η**
(infinite mass of potential entrants & free entry)

$$\underbrace{-k^w}_{\text{deposits}} + \underbrace{[\rho + (1 - \rho)\eta]u(r^b b') + (1 - \rho)(1 - \eta)\delta u(d^w)}_{\text{expected return on deposit contract}}$$

Subject to

- Nonnegative profit:

$$\underbrace{k^w - (1 - \rho)(1 - \eta)\delta d^w}_{\text{profits from deposit contract}} - \underbrace{b^w - \ell^w + r^b [b^w - [\rho + (1 - \rho)\eta] b'] + r^\ell \ell^w}_{\text{profits from portfolio decision}} \geq 0$$

- Collateral constraint (holds for all wholesale banks ex-ante):

$$\underbrace{r^b [b^w - [\rho + (1 - \rho)\eta] b'] + r^\ell \ell^w}_{\text{returns on assets}} \geq \underbrace{(1 - \rho)(1 - \eta) d^w}_{\text{payments on liabilities}}$$

- Nonnegative constraints: $k^w, b', d^w, b^w, b^w - [\rho + (1 - \rho)\eta] b' \geq 0$

Equilibrium

No Bank Holds Government Bonds as Collateral

► scarcity of collateral

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Asset	Liability & Equity
$r^m m$	d^r
$r^b b^r$	$r^\ell \ell^r$
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Wholesale Bank

Asset	Liability
$r^b b^w$	$r^b [\rho + (1 - \rho)\eta] b'$
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Lemma 1 *Retail banks never hold government bonds*

► intuition

- Wholesale banks value bonds more as they are not subject to leverage requirements

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Asset	Liability
$r^b b^w = [\rho + (1 - \rho)\eta]b'$	$r^b [\rho + (1 - \rho)\eta]b'$
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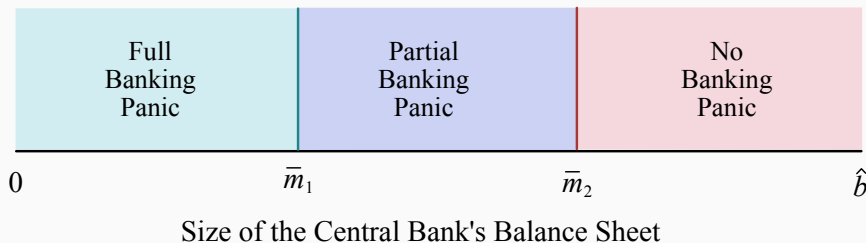
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Lemma 2 *Wholesale banks only purchase government bonds for depositors' withdrawal requests*

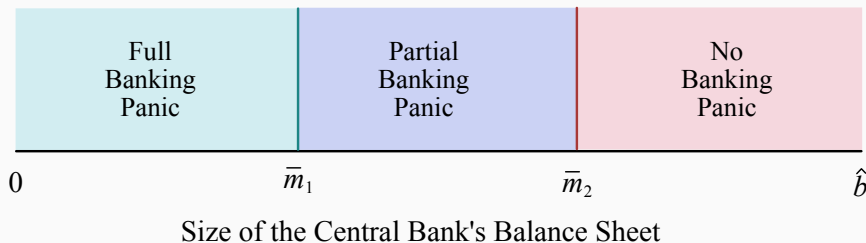
- Wholesale bank depositors directly use government bonds in exchange to avoid risk

Central Bank Balance Sheet and Wholesale Banking Panics



Partial panic ($0 < \eta < 1$): only case withdrawal prob. changes in response to policies
(constant η in full/partial panic)

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Main Result

An expansion of the central bank's balance sheet **mitigates wholesale banking panics** but **lowers asset returns and impedes transactions**.

► no/full panic

Mitigation of Wholesale Banking Panics

A central bank balance sheet expansion has three effects (open market operations)

1. Government bond supply \downarrow \longrightarrow interest rate on government bonds \downarrow (price \uparrow)
2. Reserve supply \uparrow \longrightarrow relax banks' constraints \longrightarrow returns on deposits \uparrow
 - Directly relax retail banks' leverage constraint
 - Indirectly relax wholesale banks' collateral constraint through the interbank market

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- \longrightarrow 3. Deposits become more attractive relative to bonds \longrightarrow withdrawal probability $\eta \downarrow$

Interaction of three effects determines the **GE effects** on *asset returns* and *transactions*

Reduction in Asset Returns & Trading Surplus

Retail Bank

Asset	Liability & Equity
$r^m m$	d^r
	$r^\ell \ell^r$
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Wholesale Bank

Asset	Liability
$r^b b^w$	$r^b [\rho + (1 - \rho)\eta] b'$
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An expansion in the size of the central bank's balance sheet ($\bar{m} \uparrow$ and $\bar{b} \downarrow$)

► Harms depositors trading with **government bonds**

- Decreased supply of government bonds dominates decreased demand for bonds
 - Lower interest rate on government bonds ($\frac{\partial r^b}{\partial \bar{m}} < 0$)
 - Lower trading volume for transactions settled with government bonds ($\frac{\partial c_2^b}{\partial \bar{m}} < 0$)

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- ▶ Harms depositors trading with government bonds: lower r^b, c_2^b
- ▶ Harms depositors trading with **wholesale deposits**
 - Increased demand for wholesale bank deposits dominates the increased supply
 - Lower trading volume for transactions settled with wholesale deposits ($\frac{\partial c_2^w}{\partial \bar{m}} < 0$)
 - Intensify banks' competition for collateral ($\frac{\partial r^\ell}{\partial \bar{m}} < 0$ and $\frac{\partial r^m}{\partial \bar{m}} < 0$)

Reduction in Asset Returns & Trading Surplus

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An expansion in the size of the central bank's balance sheet ($\bar{m} \uparrow$ and $\bar{b} \downarrow$)

- ▶ Harms depositors trading with bonds & wholesale deposits: lower r^b , c_2^b ; c_2^w , r^ℓ , r^m
- ▶ Harms depositors trading with **retail deposits**
 - Retail banks substitute their funding source to cheaper interbank borrowing
 - **Reduce the supply of retail deposits** (no shift in demand for retail deposits)
 - Lower trading volume for transactions settled with retail deposits ($\frac{\partial c_2^r}{\partial \bar{m}} < 0$)

Expanding the Reach of Central Bank Liabilities to Wholesale Banks

Giving Wholesale Banks Direct Access to Central Bank Liabilities

- ▶ Introduce central bank liabilities (*o*) that both retail and wholesale banks can hold
 - Example: Fed's overnight reverse repurchase agreements (ON-RRPs)

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- ▶ Monetary policy has two dimensions
 - Size of its balance sheet $s = \bar{m} + \bar{o}$ (same results as before)
 - Composition of reserves (\bar{m}) and ON-RRPs (\bar{o})

▶ central bank balance sheet

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▶ central bank balance sheet

Main Result: A swap of reserves (\bar{m}) for ON-RRPs (\bar{o})

- ▶ **Mitigates banking panics and increases asset returns & trading surplus**
- ▶ Serve as *counterfactual* for previous case as no change in government bond supply

Mitigation of Wholesale Banking Panics

Effective collateral supply (determined by \bar{o} for any s)

► collateral market clearing

$$\theta \times \overbrace{\bar{m}}^{\text{reserve supply}} + \underbrace{\bar{o}}_{\text{ON-RRP supply}} = \theta \times \overbrace{s}^{\text{balance sheet size}} + (1 - \theta) \bar{o}$$

- A swap **increases effective collateral supply** by avoiding retail banks' regulatory costs
- Wholesale banks provide more attractive deposits to compete for depositors:
 - **Mitigating wholesale banking panics** (withdrawal probability $\eta \downarrow$)

Moderate Shifts in Asset Demands

Central bank balance sheet expansions impede transactions because of

Large change in withdrawals η \longleftrightarrow Large shifts in demand for assets

- ▶ Two direct effects: increased collateral supply + decreased government bond supply

A swap of reserves for ON-RRPs generates moderate shifts in asset demands

- ▶ A swap **does not take out government bonds** (only depends on the size s)
 - No direct pressure that makes bonds less attractive \longrightarrow smaller change in η
 - **Opposite effects** on asset returns and transactions

Increase in Asset Returns & Trading Surplus

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Wholesale Bank

Asset	Liability
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$r^o o$	

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	e	$r^o o$	

A swap of reserves for ON-RRPs ($\bar{m} \downarrow$ and $\bar{o} \uparrow$)

► Benefits depositors trading with government bonds

- Decreased demand for government bonds (no shift in bond supply)
 - Higher interest rate on government bonds ($\frac{\partial r^b}{\partial \bar{m}} > 0$)
 - Higher trading volume for transactions settled with government bonds ($\frac{\partial c_2^b}{\partial \bar{m}} > 0$)

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	$r^\ell \ell^r \downarrow$	$r^\ell \ell^w \downarrow$	$(1 - \rho)(1 - \eta \downarrow) d^w \uparrow$
	e	$r^o o \uparrow$	

A swap of reserves for ON-RRPs ($\bar{m} \downarrow$ and $\bar{o} \uparrow$)

- ▶ Benefits depositors trading with government bonds: higher r^b, c_2^b
- ▶ Benefits depositors trading with wholesale deposits
 - Increased supply of wholesale deposits ($o \uparrow > \ell^w \downarrow$) dominates their increased demand
 - Higher trading volume for transactions settled with wholesale deposits ($\frac{\partial c_2^w}{\partial \bar{o}} > 0$)
 - Reduce banks' competition for collateral ($\frac{\partial r^\ell}{\partial \bar{o}} > 0$ and $\frac{\partial r^m}{\partial \bar{o}} > 0$)

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A swap of reserves for ON-RRPs ($\bar{m} \downarrow$ and $\bar{o} \uparrow$)

- ▶ Benefits depositors trading with bonds & wholesale deposits: higher $r^b, c_2^b; c_2^w, r^\ell, r^m$
- ▶ Benefits depositors trading with retail deposits
 - Retail banks substitute their funding source to cheaper deposits
 - Increased supply of retail banks' deposit claims (no shift in demand for these claims)
 - Higher trading volume for transactions settled with these claims ($\frac{\partial c_2^r}{\partial \bar{o}} > 0$)

Conclusions

- ▶ Two-sector banking model with flight-to-safety driven by wholesale banking panics
- ▶ Endogenous shifts of asset demand in response to central bank crisis interventions
- ▶ Expanding the balance sheet mitigates banking panics but impedes transactions
 - Differ from scenarios when there is no shift in asset demands (no/full banking panic)

Swapping reserves for ON-RRPs mitigates panics and facilitates transactions

- ▶ Moderate shifts in asset demands: swap of central bank liabilities does not take out government bonds, putting no direct pressure that makes bonds less attractive

Appendix

Related Literature

1. Monetary model with financial instability: Williamson (2019) + Gertler and Kiyotaki (2015)
 - Diamond-Dybvig type:
Robatto(2017,2014), Andolfatto, Berentsen, Martin (2020), Gu, Monnet, Nosal, and Wright (2023)
 - **Wholesale bank run** in the absence of sequential service constraints:
Gertler, Kiyotaki, and Prestipino (2016), Andolfatto and Nosal (2020), Huang and Keister (2024)
2. Central bank balance sheet and the role of central bank liabilities in financial stability
 - Reserves and ON-RRPs: Carlson, Duygan-Bump, Natalucci, Greenwood, Hanson, and Stein (2016), Nelson, Ochoa, Stein, and Van den Heuvel (2016), Bush, Kirk, Martin, Weed, and Zobel (2019)
3. Policy implications for *short-term funding markets*
 - Gorton and Metrick (2012), Martin, Skeie, and Thadden (2014), Arrata, Nguyen, Rahmouni-Rousseau, and Vari (2020)

Endogenous shifts in asset demand can lead to unintended policy implications!

Fiscal Authority & Central Bank

► back

- **Fiscal authority** issues government bonds (\hat{b}) and transfer revenue (τ_1) to depositors:

$$\hat{b} = \tau_1$$

- **Central bank** purchases $\hat{b} - \bar{b}$ with reserves \bar{m} :

► central bank balance sheet

$$\bar{m} = \hat{b} - \bar{b}$$

- Government liabilities are redeemed in period 3

- **Fiscal authority** taxes depositors τ_3 , pays off debt, transfers τ^{cb} to **central bank**:

$$r^b \hat{b} + \tau^{cb} = \tau_3$$

- **Central bank** pays off its debt:

$$r^m \bar{m} = r^b (\hat{b} - \bar{b}) + \tau^{cb}$$

Fiscal policy: determine the total government bonds supply $\hat{b} = \bar{m} + \bar{b}$ (exogenous, fixed)

Monetary policy: determine the size of the central bank's balance sheet, described by \bar{m}

Central Bank's Balance Sheet

Baseline case

Asset	Liability
$\hat{b} - \bar{b}$	\bar{m}

- ▶ Central bank purchases $\hat{b} - \bar{b}$ to back its reserves \bar{m}

After introducing ON-RRPs

Asset	Liability
$\hat{b} - \bar{b}$	\bar{m}
	\bar{o}

- ▶ Central bank purchases $\hat{b} - \bar{b}$ to back reserves \bar{m} and ON-RRPs \bar{o}

▶ back

▶ back ON-RRPs

Perfectly Competitive Retail Banking

- ▶ Maximize depositors' utility (infinite mass of potential entrants & free entry):

$$-k^r + u(d^r)$$

Subject to

- ▶ Nonnegative profit:

profits from deposit contract

$$\overbrace{k^r - d^r} \underbrace{-m - b^r + \ell^r + r^m m + r^b b^r - r^\ell \ell^r}_{\text{profits from portfolio decision}} \geq 0$$

- ▶ Leverage constraint:

returns on assets

$$\theta \overbrace{(r^m m + r^b b^r)} \geq \underbrace{d^r + r^\ell \ell^r}_{\text{payments on liabilities}}$$

- ▶ Nonnegative constraints: $k^r, d^r, m, b^r \geq 0$

Sweat Equity

Retail banks finance part of their assets by supplying their own capital

- ▶ Nonnegative profit constraint holds in equality due to free entry, implying

$$\underbrace{m + b^r - k^r - \ell^r}_{\text{equity raised at } t = 1} = \underbrace{r^m m + r^b - d^r - r^\ell \ell^r}_{\text{equity return at } t = 3} \equiv e$$

- **Leverage requirement** further implies a positive equity holdings ($e > 0$), recall

$$\overbrace{\theta (r^m m + r^b b^r)}^{\text{returns on assets}} \geq \underbrace{d^r + r^\ell \ell^r}_{\text{payments on liabilities}}$$

- ▶ "Sweat equity" requires banks to work \longrightarrow costly internal funding source

▶ back

Retail Banks Never Invest in Government Bonds: Intuition

Retail Bank		Wholesale Bank	
Asset	Liability & Equity	Asset	Liability
$r^m m$	d^r	$r^b b^w$	$r^b [\rho + (1 - \rho)\eta] b'$
r	$r^\ell \ell^r$	$r^\ell \ell^w$	$(1 - \rho)(1 - \eta) d^w$
	e		

- ▶ Retail banks invest in a positive stock of government bonds only if $r^b > r^\ell$
 - Strict inequality comes from their costs of holding assets due to leverage requirements
- ▶ Wholesale banks ask a higher return on loans than bonds, i.e., $r^\ell \geq r^b$
 - Government bonds provide a greater liquidity, which are always available to them
- ▶ Contradiction \longrightarrow retail banks never invest in bonds

No Banking Panic ($\eta = 0$) & Full Banking Panic ($\eta = 1$)

	∂c_2^r	∂c_2^w	∂c_2^b	∂r^m	∂r^ℓ	∂r^b
$\partial \bar{m}$	+	+	-	+	+	-

Expanding the size of the central bank's balance sheet has only two effects

- ▶ **government bond supply** ↓: reduce transactions settled with government bonds
- ▶ **effective collateral supply** ↑: increase transactions settled with deposit claims

No change in **withdrawal behavior** given η constant (endogenously determined)

- ▶ Different effects compared to the baseline case
- ▶ Central bank cannot improve welfare (in Pareto sense) by adjusting its balance sheet size

▶ back

Scarcity of Total Government Bond Supply

Assumption 1

Total supply of government bonds is scarce, such that $\theta \hat{b} < \alpha c^$, where $u'(c^*) = 1$.*

- ▶ Retail bank's leverage and wholesale bank's collateral constraints bind
 - Otherwise, depositors consume a satiated level c^* and monetary policy becomes neutral
 - Low return on safe assets, particularly, government bonds

▶ back

Characterization of Equilibrium

Express conditions on consumption allocation (c_2^r, c_2^b, c_2^w) and withdrawal probability η

$$c_2^r = d^r, \quad c_2^b = r^b b', \quad c_2^w = d^w$$

Depositors' consumption level reflects the overall total trading surplus/welfare
(competitive producers and bankers earn zero profit)

- ▶ No-arbitrage interbank market
- ▶ Collateral market clearing
- ▶ Bond market clearing
- ▶ One of depositors' incentive conditions to determine η
(no banking panic $\eta = 0$, partial banking panic $0 < \eta < 1$, and full banking panic $\eta = 1$)

Equilibrium Conditions

No-arbitrage Interbank Market:

$$\underbrace{u'(c_2^r)}_{\text{marginal return on retail bank's deposit claims}} = \underbrace{1 - \delta + \delta u'(c_2^w)}_{\text{marginal return on wholesale bank's deposit claims}}$$

- ▶ Equate depositors' marginal returns from trading with retail and wholesale deposits
 - ▶ intuition
- ▶ Marginal returns determine interest rates (consumption-based asset pricing)
 - e.g., $\frac{1}{r^\ell} = u'(c_2^r)$, marginal utility of trading retail deposits

Equilibrium Conditions

No-arbitrage Interbank Market:

$$u'(c_2^r) = 1 - \delta + \delta u'(c_2^w)$$

Collateral Market Clearing:

► ON-RRP

$$\underbrace{\theta \bar{m}}_{\text{effective collateral supply (i.e., reserves)}} = \underbrace{\alpha c_2^r [1 - \theta + \theta u'(c_2^r)]}_{\text{retail banks' demand for collateral}} + \underbrace{(1 - \alpha) (1 - \rho) (1 - \eta) c_2^w [1 - \theta \delta + \theta \delta u'(c_2^w)]}_{\text{wholesale banks' demand for collateral}}$$

- Expanding central bank balance sheet (\bar{m}) **increases the effective collateral supply**
- The severity of wholesale banking panics η determines the demand for collateral
 - By mitigating banking panics, policy shifts this demand **upward**

Equilibrium Conditions

No-arbitrage Interbank Market:

$$u'(c_2^r) = 1 - \delta + \delta u'(c_2^w)$$

Collateral Market Clearing:

$$\begin{aligned} \theta \bar{m} = & \alpha c_2^r [1 - \theta + \theta u'(c_2^r)] \\ & + (1 - \alpha) (1 - \rho) (1 - \eta) c_2^w [1 - \theta \delta + \theta \delta u'(c_2^w)] \end{aligned}$$

Bond Market Clearing

$$\underbrace{\hat{b} - \bar{m}}_{\text{bonds circulating in private sector, } \bar{b}} = \underbrace{(1 - \alpha) [\rho + (1 - \rho) \eta] c_2^b u'(c_2^b)}_{\text{wholesale bank depositors' demand for bonds}}$$

- ▶ Expanding central banks balance sheet **reduce the supply of government bonds**
- ▶ The severity of banking panics η determines the aggregate demand for bonds
 - By mitigating banking panics, policy shifts this demand **downward**

No-arbitrage Condition: Intuition

Retail Bank

Asset	Liability & Equity
$r^m m$	d^r
	$r^\ell \ell^r$
	e

Wholesale Bank

Asset	Liability
$r^b b^w$	$r^b [\rho + (1 - \rho)\eta] b'$
$r^\ell \ell^w$	$(1 - \rho)(1 - \eta) d^w$

- ▶ On the liability side of the retail bank

return rate on retail deposits = return rate on interbank borrowing

- ▶ Wholesale banks use claims on interbank lending back deposit claims

return rate on interbank lending = return rate on wholesale deposits adjusted by risk