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

Fengfan Xiang

University of Western Ontario

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- ▶ Investors or depositors reallocate their portfolio from riskier to safer assets

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

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- ▶ <u>Wholesale banks</u>: fin. intermediaries outside of the regular banking system
  (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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- ▶ <u>Wholesale Banking Panics</u>: 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 $\longrightarrow$ reduce investors' flight-to-safety incentive
- **General asset return reduction** through endogenous shifts in asset demand
  - Mitigate flight-to-safety $\longrightarrow$ increase demand for bank liabilities, bidding down returns

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- **General asset return reduction** through endogenous shifts in asset demand

  - Mitigate flight-to-safety $\longrightarrow$ increase demand for bank liabilities, bidding down returns

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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   3. Infinite measure of bankers self-select to operate retail or wholesale banks:

$$c_1^B - h_1^B + c_3^B - h_3^B$$

   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** $\longrightarrow$ no unsecured IOU $\longrightarrow$ exchanges are supported by assets

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Underlying Assets (scarce in aggregate)

- ▶ 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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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

Timing
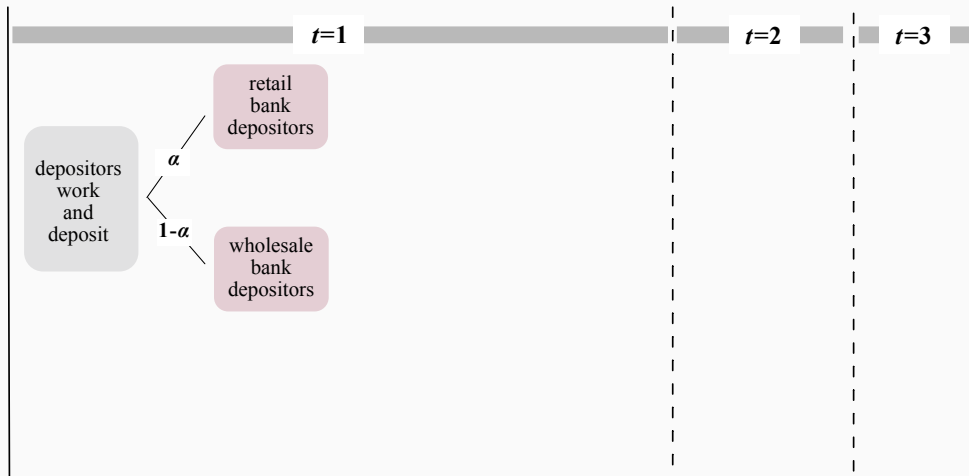
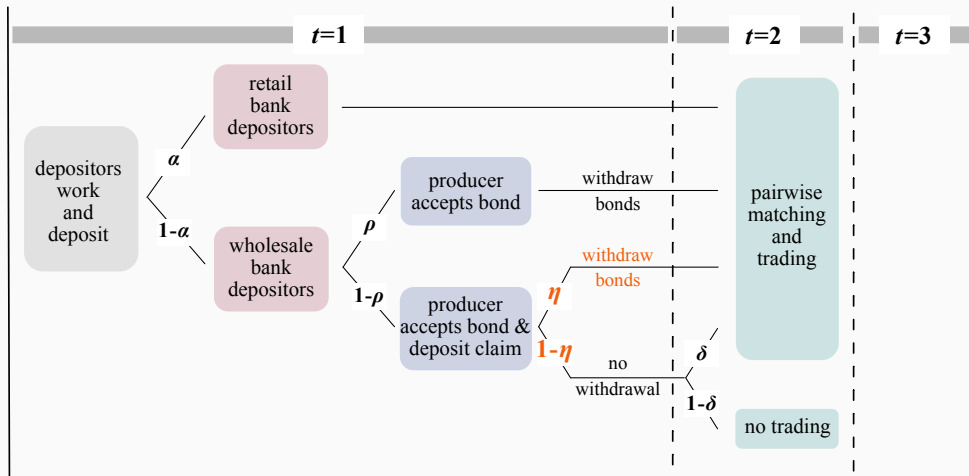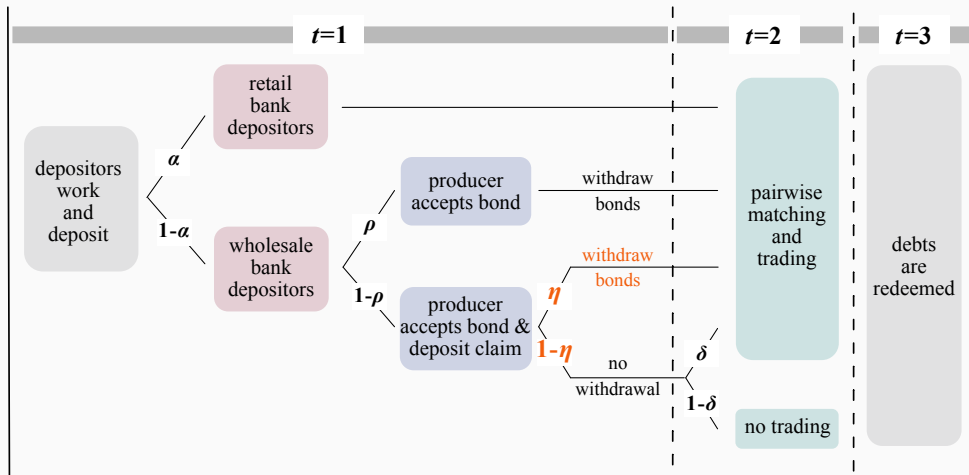# Timing
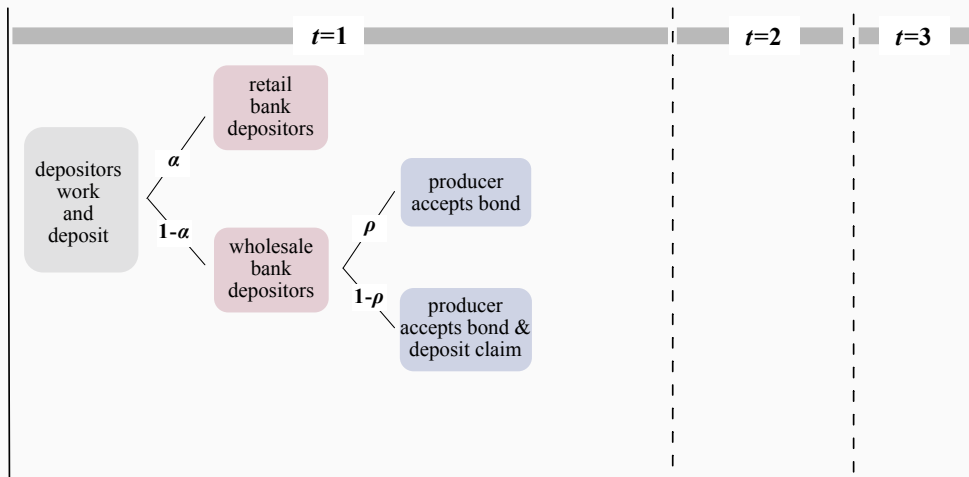
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Retail Bank

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) $\longrightarrow$ 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 $\longrightarrow$ no bank capital)

Asset	Liability	
$r^b b^w$	$r^b[\rho + (1-\rho)\eta]b'$	$\longrightarrow$ *withdraw*
$r^\ell \ell^w$	$(1-\rho)(1-\eta)d^w$	$\longrightarrow$ *not withdraw*

▶ Endogenous withdrawal probability η adjusts the composition bank liabilities

Will wholesale bank depositors withdraw their funds?

Wholesale bank depositors' ex ante expected utility

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

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(i) No banking panic: $\quad\quad\quad\quad \eta = 0, \quad$ if $u\left(r^b b'\right) \leq \delta u\left(d^w\right) + (1-\delta)u\left(0\right);$

(ii) Partial banking panic: $\quad 0 < \eta < 1, \quad$ if $u\left(r^b b'\right) = \delta u\left(d^w\right) + (1-\delta)u\left(0\right);$

(iii) Full banking panic: $\quad\quad\quad \eta = 1, \quad$ if $u\left(r^b b'\right) \geq \delta u\left(d^w\right) + (1-\delta)u\left(0\right).$

Perfectly Competitive Wholesale Banking

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

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Subject to

▶ Nonnegative profit:

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

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▶ 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

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

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Lemma 1 *Retail banks never hold government bonds*

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

No Bank Holds Government Bonds as Collateral ▸ scarcity of collateral

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

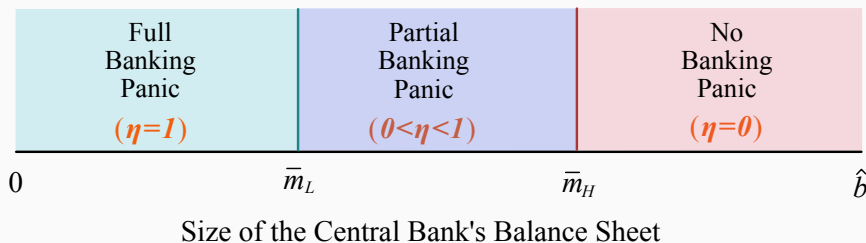**Lemma 1** *Retail banks never hold government bonds*   ▸ intuition

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

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

| Full Banking Panic ($\eta=1$) | Partial Banking Panic ($0<\eta<1$) | No Banking Panic ($\eta=0$) |

| 0 | $\bar{m}_L$ | $\bar{m}_H$ | $\hat{b}$ |

Size of the Central Bank's Balance Sheet

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

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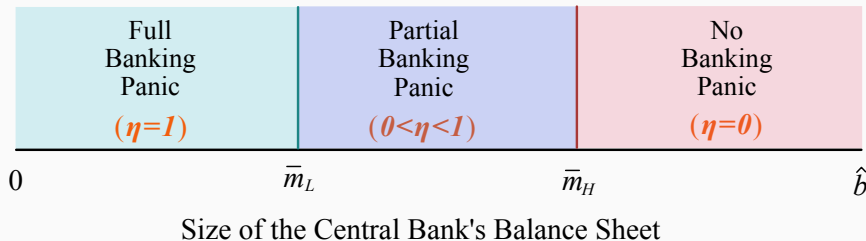
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Size of the Central Bank's Balance Sheet

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

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

Equilibrium Conditions under Partial Banking Panic $u(c_2^b) = \delta u(c_2^w)$

No-arbitrage Interbank Market (equate marginal returns from trading with retail/wholesale deposits)

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

Collateral Market Clearing

▸ details

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

$$+ \underbrace{(1-\alpha)(1-\rho)(1-\eta)c_2^w \left[1 - \theta\delta + \theta\delta u'\left(c_2^w\right)\right]}_{\text{wholesale banks' demand for collateral}}$$

Bond Market Clearing

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

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

Reduction in Asset Returns & Trading Surplus

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

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

Reduction in Asset Returns & Trading Surplus: Government Bonds

Retail Bank		Wholesale Bank	
Asset	Liability & Equity	Asset	Liability
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	$r^\ell \ell^r$	$r^\ell \ell^w$	$(1-\rho)(1-\eta)d^w$
	e		

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**

- Lower interest rate on government bonds ($\frac{\partial r^b}{\partial \bar{m}} < 0$)

- Lower trading volume for transactions settled with government bonds ($\frac{\partial c_2^b}{\partial \bar{m}} < 0$)

Reduction in Asset Returns & Trading Surplus: Wholesale Deposits

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

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: lower r^b, c_2^b

▶ Harms depositors trading with **wholesale deposits**

  • 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: Retail Deposits

Retail Bank			Wholesale Bank	
Asset	Liability & Equity		Asset	Liability
$r^m m \uparrow$	$d^r \downarrow$		$r^b b^w$	$r^b[\rho + (1-\rho)\eta]b'$
	$r^\ell \ell^r \uparrow$		$r^\ell \ell^w$	$(1-\rho)(1-\eta)d^w$
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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 Aceess to Central Bank Liabilities

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

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▶ Monetary policy has two dimensions   ▸ central bank balance sheet

- Size of its balance sheet $s = \bar{m} + \bar{o}$ (same results as before)

- Composition of reserves ($\bar{m}$) and ON-RRPs ($\bar{o}$)

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- Composition of reserves ($\bar{m}$) and ON-RRPs ($\bar{o}$)

Main Result

A swap of reserves ($\bar{m}$) for ON-RRPs ($\bar{o}$) **mitigates banking panics** and **increases asset returns and promotes transactions**

Mitigation of Wholesale Banking Panics

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

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

▶ A swap increases effective collateral supply by avoiding retail banks' regulatory costs

▶ Wholesale banks provide more attractive deposits to compete for depositors:

$\longrightarrow$ Mitigating wholesale banking panics (withdrawal probability $\eta \downarrow$)

Moderate Shifts in Asset Demand

▶ A swap of reserves for ON-RRPs does not take out government bonds

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

- No direct pressure that makes bonds less attractive $\longrightarrow$ moderate change in η
- **Opposite effects** on asset returns and transactions

By contrast, central bank balance sheet expansions impede transactions because

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

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

Increase in Asset Returns & Trading Surplus

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

Increase in Asset Returns & Trading Surplus: Government Bonds

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Asset	Liability	Asset	Liability
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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** (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 ($\frac{\partial c_2^b}{\partial \bar{m}} > 0$)

Increase in Asset Returns & Trading Surplus: Wholesale Deposits

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

- 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 $\frac{\partial r^m}{\partial \bar{o}} > 0$)

Increase in Asset Returns & Trading Surplus: Retail Deposits

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

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^ℓ, 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 in 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

▶ **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 $\bar{m}$:

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

▶ 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 $\bar{o}$

Perfectly Competitive Retail Banking

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

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

Subject to

▶ Nonnegative profit:

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

▶ Leverage constraint:

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

▶ 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

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

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

Retail Banks Never Invest in Government Bonds: Intuition

	Retail Bank			Wholesale Bank	
Asset	Liability & Equity		Asset	Liability	
$r^m m$	d^r		$r^b b^w$	$r^b[\rho + (1-\rho)\eta]b'$	
$\not{b}$	$r^\ell \ell^r$		$r^\ell \ell^w$	$(1-\rho)(1-\eta)d^w$	
	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

	∂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

Scarcity of Total Government Bond Supply

Assumption 1

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

▶ Retail bank's leverage and wholesale bank's collateral constraints bind

- Otherwise, depositors consume a satiated level $c^\star$ 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:

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

▶ 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:

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

Collateral Market Clearing:

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

$$+ \underbrace{(1 - \alpha)(1 - \rho)(1 - \eta)\, c_2^w \left[1 - \theta\delta + \theta\delta u'\left(c_2^w\right)\right]}_{\text{wholesale banks' demand for collateral}}$$

▶ 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:

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

Collateral Market Clearing:

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

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: Inituition

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

▶ 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