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

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Flight-to-Safety

- Investors reallocate their portfolio from riskier assets toward safer ones

- Reflect *large shifts in asset demand* during financial crises

Flight-to-Safety

- ▶ Investors reallocate their portfolio from riskier assets toward safer ones

- ▶ Reflect *large shifts in asset demand* during financial crises

My focus: panics in the wholesale banking sector

- ▶ Beyond the coverage of financial regulations and supervision
    - Wholesale banks: fin. intermediaries operate 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)

- ▶ Have driven 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*

Key finding: Balance sheet expansions *mitigate panics but reduce asset returns/welfare*

▶ Expansions through open market operations involve purchasing Treasury bills

- Lower T-bill returns ⟶ reduce investors' incentive to seek refuge in them

- Decreased returns hinder transactions involving T-bills, like repo transactions

- *General asset returns/welfare reduction* through *endogenous shifts in asset demand*

  - Mitigating flight-to-safety ⟶ increased demand for bank liabilities, bidding down returns

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

Model

Three-period Two-Sector Banking Model

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

    1. Measure one of depositors:

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

    2. Measure one of producers: $\quad\quad \underbrace{-h_2}_{\text{work to produce goods for depositors}} \quad\quad + \quad \underbrace{c_3}_{\text{consume returns}}$

    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

▶ Government: fiscal authority and central bank ▸ details

Trading Frictions Give Rise to Demand for Assets

▶ Exchanges are essential because goods are perishable

  • Depositors trade **bilaterally** with producers in period 2, making **take-it-or-leave-it** offer

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

  • Depositors and banks trade goods and assets in a **Walrasian market** in period 1

Underlying assets

▶ Central bank reserves: restricted to retail banks only (less liquid)

▶ Government bonds: everyone, including depositors, can hold them (liquid)

Banking & Risk of Wholesale Banking Failure

- ▶ Banks have access to a **collateral technology** to secure their liabilities
  - Deposit claims: A valid means of payment between depositors and producers
  - Interbank loans: Allow wholesale banks to hold reserves indirectly

- ▶ An *exogenous* fraction $1 - \delta$ of wholesale banks fail in period 2 (collapse in collateral tech.)
  - Failed banks default on their liabilities and abscond with assets

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

- ▶ Depositors make their withdrawal decision with imperfect information in period 1

- ▶ Panicking depositors choose to withdraw with an **endogenous** probability η
  - Also, the fraction of panicking depositors flee to bonds, capturing the severity of panics

Retail Bank ▸ retail bank's problem

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)

Subject to a leverage constraint ($0 < \theta < 1$) (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 ▸ wholesale bank's problem

1. Deposit contract: k^w, quantity of bonds if withdrawal (b'), and d^w

    • ρ of depositors must trade with bonds (demand for bonds to support wholesale payments)

2. Financial portfolio: government bonds (b^w), interbank lending (ℓ^w)

Subject to a collateral constraint (no leverage requirement ⟶ no bank capital)

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

▶ Endogenous withdrawal probability η adjusts the composition bank liabilities

Will wholesale bank depositors withdraw their funds?

Wholesale bank depositors' ex ante expected utility

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

Withdraw: Get b' units of government bonds with gross interest rate of r^b

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

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

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

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

▸ timing

Equilibrium

No Bank Holds Government Bonds as Collateral

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

No Bank Holds Government Bonds as Collateral

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

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 their depositors' withdrawal requests

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

Today: Partial Banking Panic Equilibrium ▸ quilibrium type

Only case that withdrawal probability ($0 < \eta < 1$) changes in response to policies
(constant η in full/partial panic)

Proposition 1

*An expansion in the size of the central bank's balance sheet **mitigates wholesale banking panics**, i.e., $\frac{\partial \eta}{\partial \bar{m}} < 0$. However, this expansion **reduces welfare**, i.e., $\frac{\partial c_2^b}{\partial \bar{m}} < 0$, $\frac{\partial c_2^r}{\partial \bar{m}} < 0$, and $\frac{\partial c_2^w}{\partial \bar{m}} < 0$.* ▸ no/full panic

Mitigation of Wholesale Banking Panics

A central bank balance sheet expansion, through open market operations, has three effects

1. government bond supply ↓ ⟶ interest rate on government bonds ↓ (price ↑)

2. reserve supply ↑ ⟶ relax banks' constraints ⟶ returns on deposits ↑

   - Directly relax retail banks' leverage constraint

   - Indirectly relax wholesale banks' collateral constraint through the interbank market

→ 3. deposits become more attractive relative to bonds ⟶ withdrawal probability η ↓

Interaction of three effects determines the GE effects on asset returns and welfare

Reduction in Asset Returns & Welfare

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

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

▶ **Harms depositors trade with government bonds**: lower r^b and c_2^b

- 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 ($\frac{\partial c_2^b}{\partial \bar{m}} < 0$)

Reduction in Asset Returns & Welfare

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 trade with government bonds: lower r^b and c_2^b

▶ **Harms depositors trade with wholesale deposits**: lower c_2^w, r^ℓ, and r^m

- 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 & Welfare

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

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

▶ Harms depositors trade with government bonds: lower r^b and c_2^b

▶ Harms depositors trade with wholesale deposits: lower c_2^w, r^ℓ, and r^m

▶ **Harms depositors trade with retail deposits**: lower c_2^r

   • 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 ($\frac{\partial c_2^r}{\partial \bar{m}} < 0$)

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 reduces welfare
  - Differ from scenarios when there is no shift in asset demands (no/full banking panic)

Extension: Swapping reserves for ON-RRPs **mitigates panics and improves welfare!**

- Moderate shifts of asset demand: swap of central bank liabilities does not take out government bonds, putting no direct pressure on making bonds less attractive

Appendix

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 $\bar{o}$

▸ back   ▸ back ON-RRPs

Perfectly Competitive Retail Banking ▸ back

▶ 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

Perfectly Competitive Wholesale Banking ▸ back

▶ Maximize depositors' expected utility, considering potential banking panic η

(infinite mass of potential entrants & free entry)

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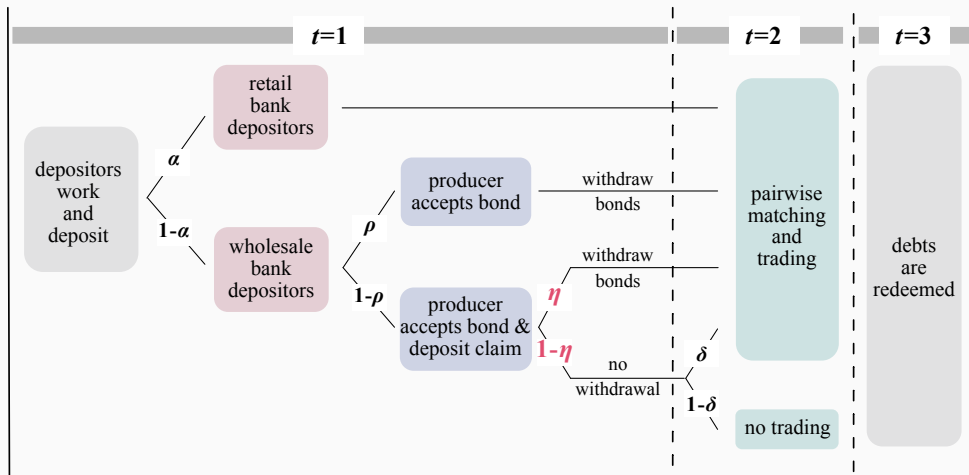
Subject to

▶ Nonnegative profits:

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

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

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

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

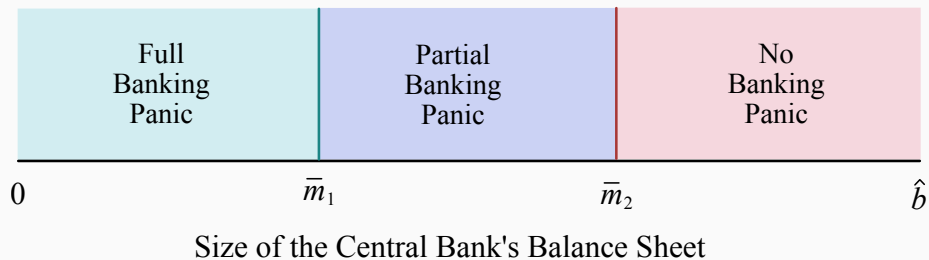# Retail Banks Never Invest in Government Bonds: Intuition

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

▶ back

How Monetary Policy Determines the Type of Equilibrium

Full Banking Panic	Partial Banking Panic	No Banking Panic

$0 \qquad \bar{m}_1 \qquad \bar{m}_2 \qquad \hat{b}$

Size of the Central Bank's Balance Sheet

▶ Two thresholds $\bar{m}_1$ and $\bar{m}_2$ characterize three types of equilibrium

▶ Expanding the size of the central bank's balance sheet mitigates banking panic

▶ These thresholds increase with the risk of wholesale banking failure $1 - \delta$

▶ back

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

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

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 overall 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:

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

Collateral Market Clearing:

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

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

▶ 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:

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

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

<p style="text-align:center">return rate on retail deposits $=$ return rate on interbank borrowing</p>

▶ Wholesale banks use claims on interbank lending back deposit claims

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

Expanding the Reach of Central Bank Liabilities to Wholesale Banks

Giving Wholesale Banks Direct Aceess to Central Bank Liabilities

Add a new central bank liability (*o*) in addition to reserves (*m*)

- ▶ Both retail and wholesale banks can hold this interest-bearing central bank liability
  - Example: Fed's overnight reverse repo (ON-RRP) facility

- ▶ Monetary policy has two dimensions ‣ central bank balance sheet
  - Size of its balance sheet $s = \bar{m} + \bar{o}$
  - Composition of its liabilities (relative supply of reserves and ON-RRPs)

Goals: Show a swap of reserves ($\bar{m}$) for ON-RRPs ($\bar{o}$)

- ▶ **Mitigates wholesale banking panics** and **improves welfare**

- ▶ Serve as a 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):

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

▶ 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 $\eta \downarrow$)

Welfare Improvement ▸ details

Recall that central bank balance sheet expansions reduce welfare because

A large change in withdrawals $\eta \longrightarrow$ large shifts in asset demands

A swap of reserves for ON-RRPs improves welfare

Bond market clearing:

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

▶ A swap does not take out government bonds (only depends on the size s)
  - Put no direct force that makes bonds less attractive $\longrightarrow$ change in η is not too large

Welfare Improvement

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

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

A swap of reserves for ON-RRPs benefits depositors trade 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 ($\frac{\partial c_2^b}{\partial \bar{m}} > 0$)

Welfare Improvement

	Retail Bank			Wholesale Bank	
Asset		Liability		Asset		Liability

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 benefits depositors trade with wholesale deposits

▶ Increased supply of wholesale deposits dominates their increased demand

- $o \uparrow > \ell^w \downarrow$: avoiding the inefficiency comes from the leverage requirement

- Higher trading volume for transactions settled with these claims ($\frac{\partial c_2^w}{\partial o} > 0$)

- Reduce banks' competition for collateral ($\frac{\partial r^\ell}{\partial o} > 0$ and $\frac{\partial r^m}{\partial o} > 0$)

Welfare Improvement

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 benefits depositors trade with retail depositors

▶ 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 ($\frac{\partial c_2^r}{\partial o} > 0$)