Monetary Policy Transmission with Endogenous Reserve Supply

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Motivation

- For the past few years, central banks have been unwinding QE
- Central banks navigating to the 'correct' size of their balance sheets to 'efficiently' implement monetary policy
- Effects of policy tightening through increases in policy rates are well known, growing literature on QT and bank reserve demand
- The Bank of England is simultaneously transitioning its operating framework
  - From: "supply-driven" reserves, backed by asset purchases (gilts)
  - To: "demand-driven" reserves, borrowed via repo facilities (STR and ILTR)

UK/US/EU

This Paper

Framework transition raises open questions:

1. How far can gilt holdings fall before frictions emerge in secured markets?
2. Do bank-NBFI interactions shape transmission under the new framework?
3. What is the quantity of total reserves consistent with "rate control"?

What we do: Build a structural model of the UK financial system with the BoE's STR + ILTR facilities. Calibrate to Nov. 2024–Jul. 2025; run scenarios.

This Paper – Results Preview

Framework transition raises open questions:

1. How far can gilt holdings fall before frictions emerge in secured markets? £250 B
2. Do bank-NBFI interactions shape transmission under the new framework? Crucially
3. What is the quantity of total reserves consistent with "rate control"? £550 B

What we do: Build a structural model of the UK financial system with the BoE's STR + ILTR facilities. Calibrate to Nov. 2024–Jul. 2025; run scenarios.

What we find:

→ BoE's PMRR is broadly consistent with our estimates

→ QT rule of thumb: ↓ £50 B in gilts, ↑ secured rate by 3bps, ↓ reserves by £20 B

→ Framework robust to bank and non-bank liquidity shocks

→ Eye towards repo market/rates being the key margin to monitor

Related Literature

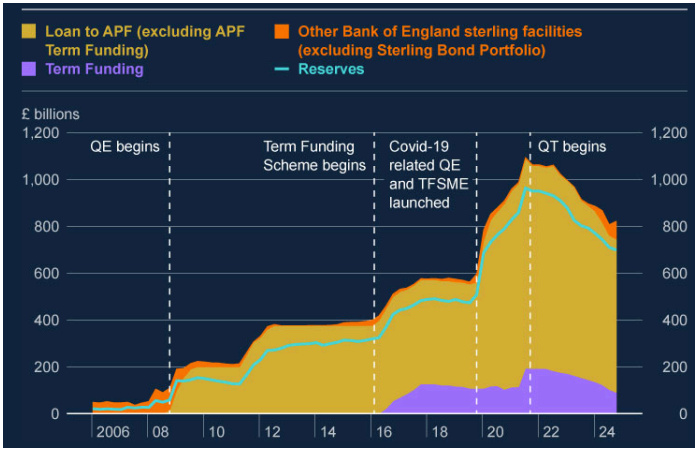
Closest predecessor:

- Anbil, Anderson, Cohen, & Ruprecht (2026)

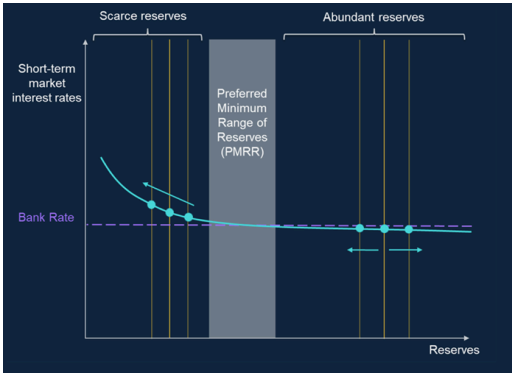
Related work:

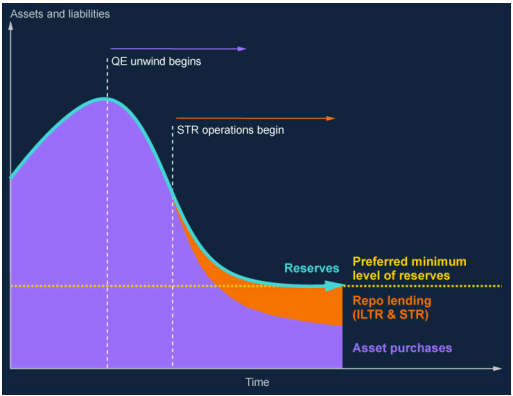
- *Reserve demand*
  - Lopez-Salido & Vissing-Jorgensen (2025), Lagos & Navarro (2023), Yang (2020)
- *Balance sheets & stability*
  - d'Avernas et al. (2024), Copeland et al. (2025), Arazi (2025)
- *UK QT/repo*
  - Fatouh et al. (2024), Kaminska et al. (2025), Bandera & Stevens (2024)
- *Discussions on possible frameworks/tools*
  - Duffie (2026), Anderson et al. (2026)

Institutional Background



Institutional Background





Institutional Background

Pre-2022: Bank Rate, floor system, abundant reserves supplied via QE gilt purchases.
2022–present: QT reduces gilt holdings, the BoE introduces new repo facilities:

BoE Facilities

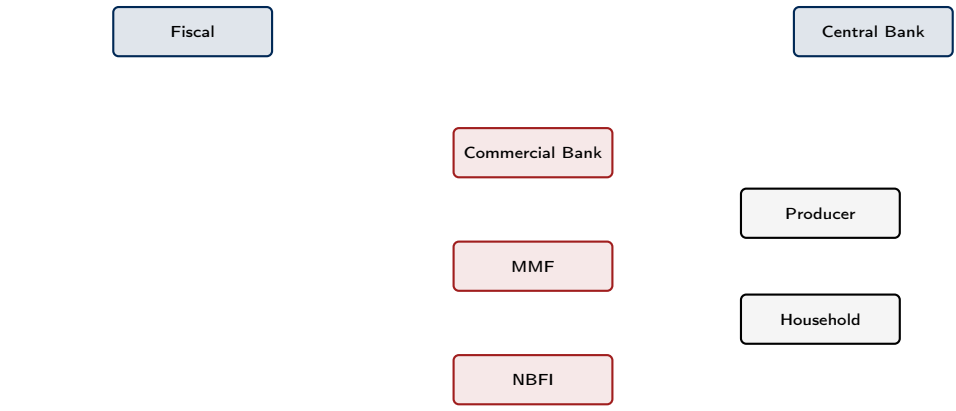
	Short-Term Repo (STR)	Indexed Long-Term Repo (ILTR)
Offering	Weekly (Tues)	Weekly (Thurs)
Term	7 days	6 months
Pricing	Fixed spread (0bps)	Adaptive auction spreads with minimums: A: 3bps, B: 5bps, C: 15bps
Collateral	"Level-A" only (gilts)	A: "Level-A" only (gilts) B: "Level-B" only (sov. debt, HQABS, RMBS) C: "Level-C" only (consumer/corporate loans)

⇓ *Model Generalization*

	Level-A Facility	Level-C Facility
Pricing	Fixed spread $\alpha_{\mathcal{A}}$, usage cost $\xi(m_{\mathcal{A}})$	Linear in usage: $\alpha_{\mathcal{C}}(\widetilde{m}_{\mathcal{C}})$
Collateral	"Level-A" only (gilts)	"Level-C" only (loans)

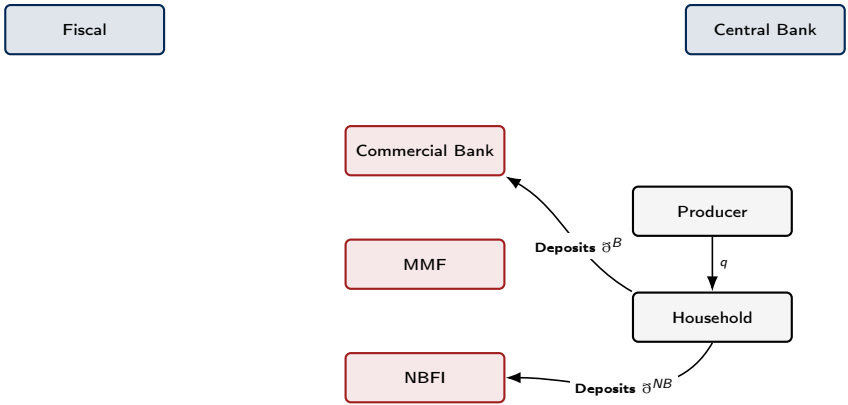
Facility Usage Full SMF Collateral

Model – Agents



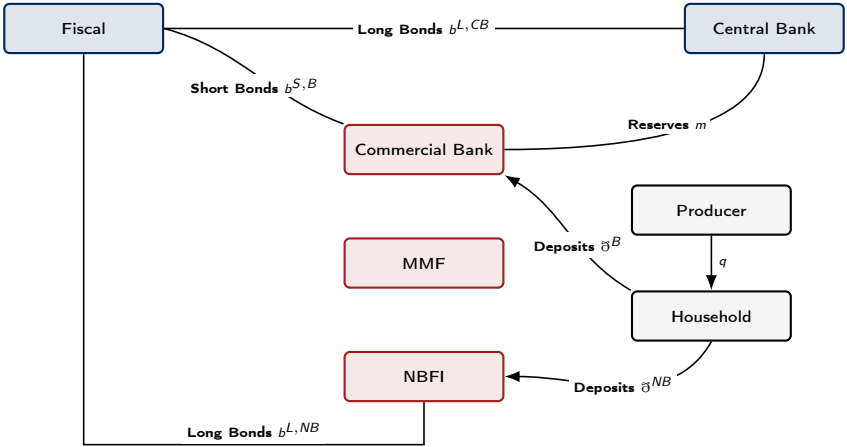
Five private agents + CB + fiscal. Two periods, deterministic, no private information.

Model – Deposit Allocation



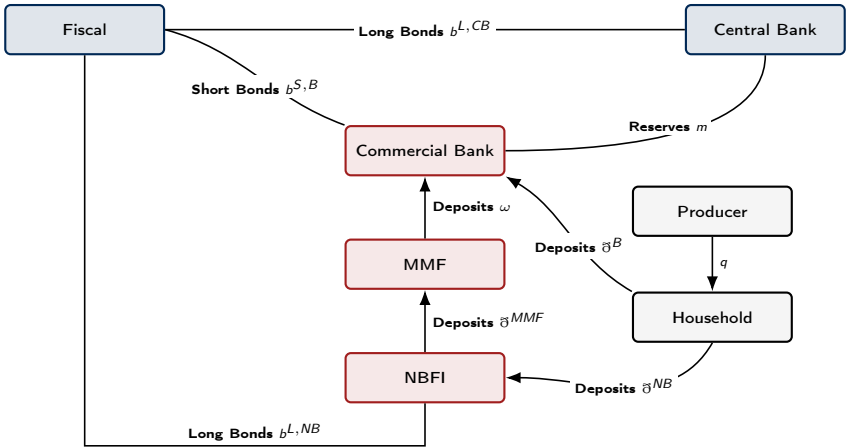
Households receive $\mathcal{M}$, allocate to bank or non-bank deposits. Acquire/consume the good from producers in both periods.

Model – Government Debt



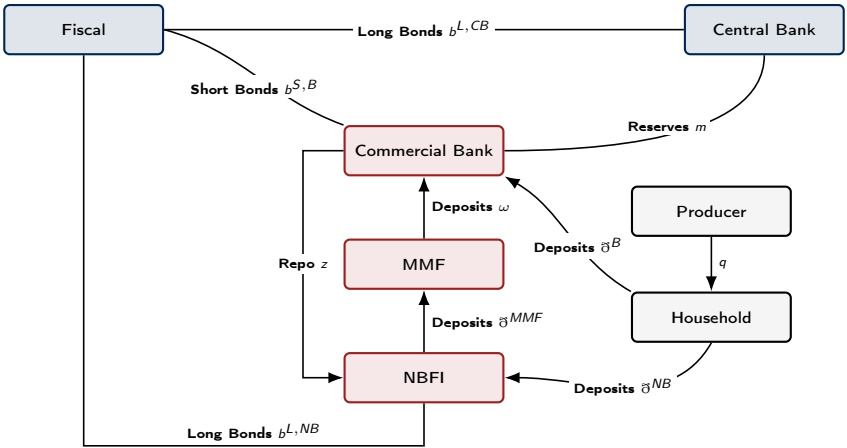
The CB holds legacy $b^{L,CB}$, determining (gilt-backed) reserves m and legacy private-sector bond holdings $b^{L,NB}$.

Model – Unsecured Lending



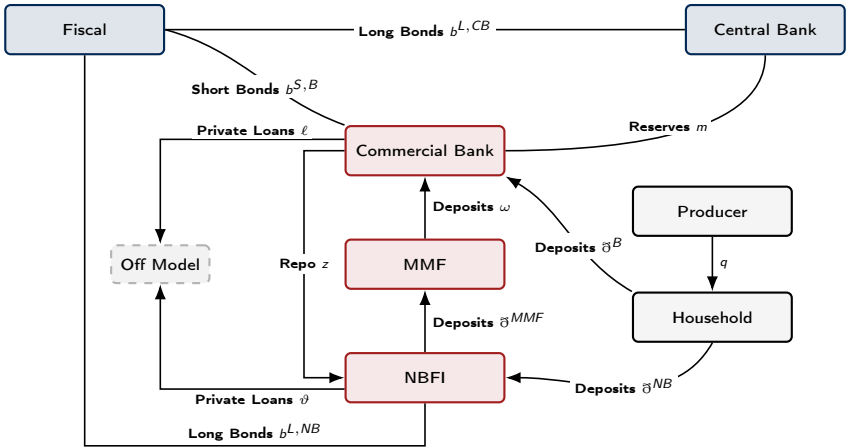
The NBFI holds deposits with the MMF for liquidity purposes; the MMF lends unsecured to the commercial bank.

Model – Secured Lending



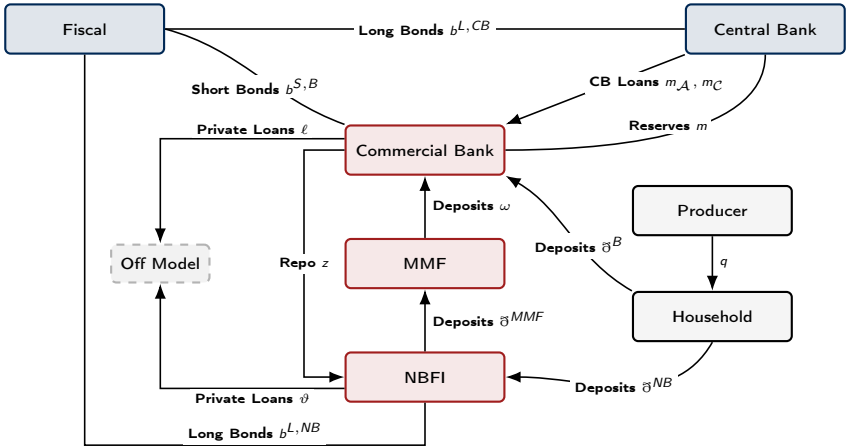
The commercial bank lends in repo to the NBFI.

Model – Off-Model Lending



Banks and non-banks make private loans to off-model agents.

Model – Central Bank Repo Facilities



The commercial bank acquires additional reserves through the central bank repo facilities to manage reserve scarcity costs, using government debt or private loans as collateral.

Gilts | Balance Sheets

Model – Frictions

Commercial Bank

- Reserve scarcity costs:

$$\mathcal{R}\left(\frac{\omega^B}{\overline{m} + \psi_S \overline{g}}\right)$$

- Increasing in wholesale liabilities relative to liquid assets (total reserves $\overline{m}$ plus unpledged gilts $\overline{g}$)
- Reduced-form representation of liquidity requirements, payment needs, risk management, etc. (Kumhof & Salgado-Moreno 2024, Vissing-Jorgensen 2023)

NBFI

- Liquidity costs:

$$\mathcal{L}\left(\frac{z^{NB} + d^{NB}}{\delta^{MMF} + \psi_L p_L b^{L,NB}}\right)$$

- Increasing in liabilities relative to liquid assets
- Reduced-form representation of liquidity management (e.g. LDI crisis, see Bandera & Stevens 2024)

→ *Both frictions generate endogenous portfolio substitution in response to policy*
→ *Frictions interact during policy changes*

Calibration

- Current cycle: Nov. 2024–Jul. 2025
- Independent parameters: $[(B^L, B^S), \quad (R, b^{L,CB}, \alpha_{\mathcal{A}}, \alpha_{\mathcal{C}}(\cdot)), \quad (i_\ell, i_\vartheta)]$
- Calibrate remaining parameters targeting aggregate moments

In-sample

	Data	Model	Error
i_{dB}	2.03%	2.03%	0
ρ	4.57%	4.57%	0
σ	4.47%	4.43%	−0.04
d^B	1.79T	1.78T	−0.01
ℓ	1.09T	1.09T	0
ω	0.740T	0.740T	0
m_A	65.7B	63.9B	−1.8
m_C	4.76B	2.55B	−2.2

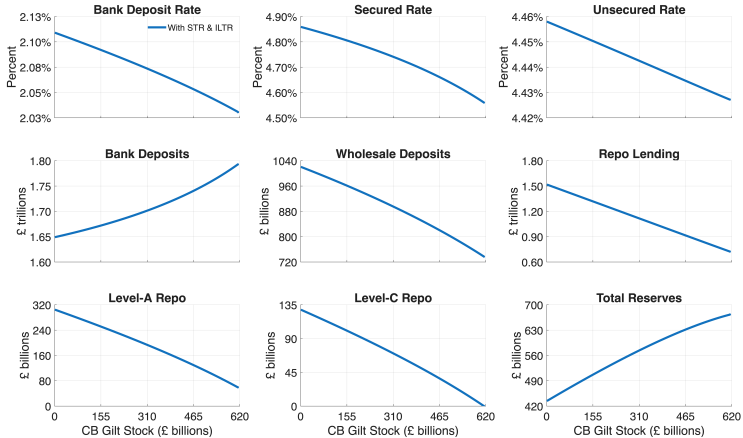
Out-of-sample, Aug. 2025 MPC

	Data	Model	Error
i_{dB}	1.80%	1.54%	−0.26
ρ	4.05%	4.07%	+0.02
σ	3.96%	3.92%	−0.04
d^B	1.82T	1.77T	−0.05
ℓ	1.14T	1.09T	−0.05
ω	0.753T	0.749T	−0.004
m_A	114.6B	85.9B	−28.7
m_C	10.6B	14.9B	+4.3

Policy: $R = 4.0\%$, $b^{L,CB} =$£578 B

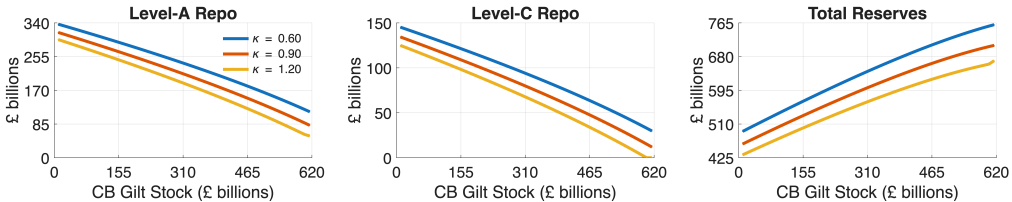
QT

Exercise. From calibration period, reduce central bank gilt holdings to zero.



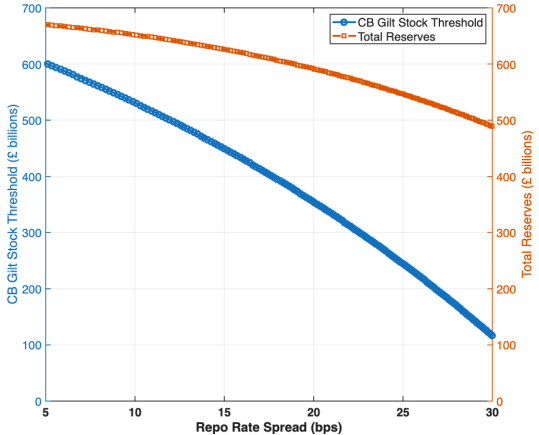
Liquidity Shocks

Exercise. From calibration period, reduce central bank gilt holdings to zero under different values of κ, the curvature on the reserve scarcity cost function $\mathcal{R}(\cdot)$.



Critical Thresholds

The QT reduction exercise gives a sequence of $(\rho - R, b^{L,CB}, \overline{m})$ – repo rate spreads, associated central bank gilt holdings, and total reserve levels.



Conclusion

Context:

- Central banks currently unwinding QE
- Bank of England currently transitioning its operating framework

What we do: Build a structural model of the UK financial system with the BoE's STR+ILTR facilities to study monetary policy transmission. Calibrate to current QT cycle; run scenarios.

What we learn:

- Bank-NBFI interactions central in transmission under the new framework
- BoE PMRR broadly consistent with our estimates of £250 B gilts and £550 B reserves
- QT rule of thumb: $\downarrow$ £50 B in gilts, $\uparrow$ 3 bps in ρ, $\downarrow$ £20 B in $\overline{m}$
- Framework is reasonably robust to liquidity shocks

Thank you.

Questions welcome.

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Appendix – UK/US/EU

Figure 1: Central bank assets as a share of national/regional GDP
Per cent (%) [a]

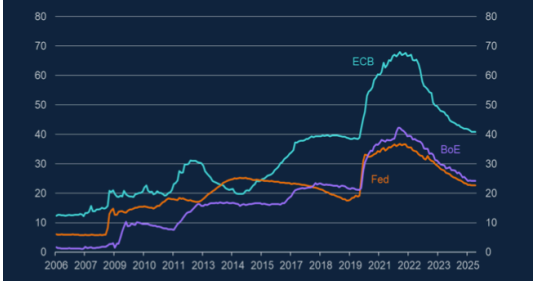

Figure 5: An overview of current QT policy settings across major central banks[a]

Central bank	Approach to QT	Current pace	Steady state reserves regime	Level of bank reserves	
				QE peak	Current
BoE	Passive roll-off and active sales	£25bn a quarter	Repo-led, demand-driven framework	£979bn	£671bn
Fed	Passive	$40bn per month ($5bn USTs, $35bn Agency-MBS)	Supply-driven framework	$4.3tn	$3.4tn
ECB	Passive	c.€40bn per month (APP and PEPP)	Demand-driven framework	€4.9tn	€2.9tn

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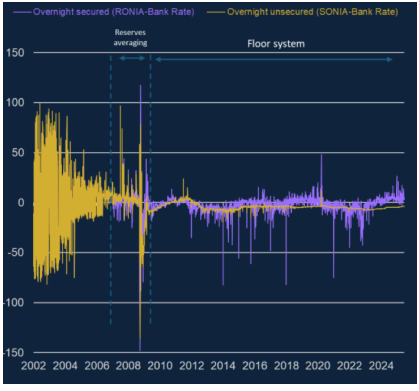
Appendix – Rate Control



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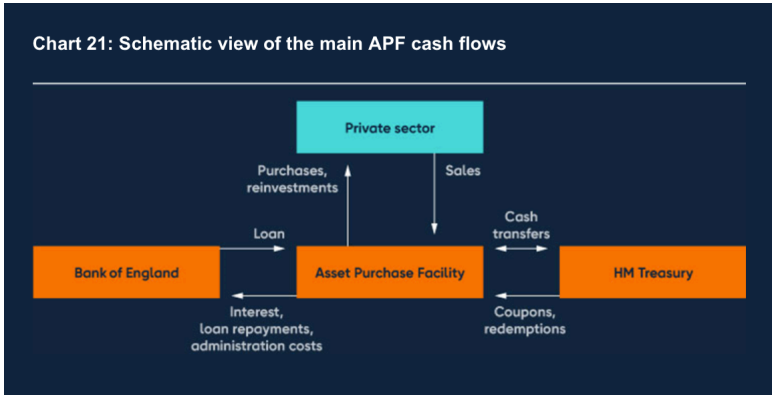
Appendix – APF Flow



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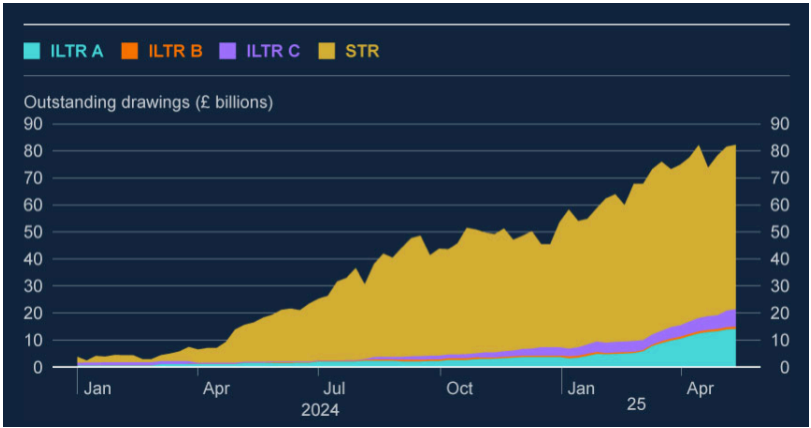
Appendix – Facility Usage



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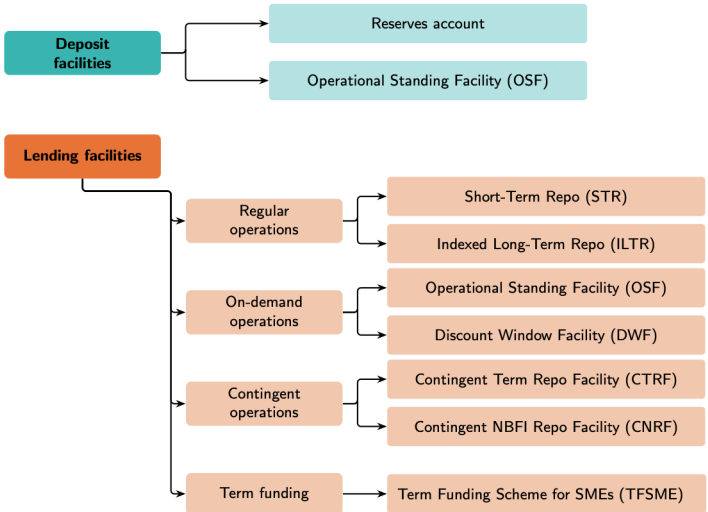
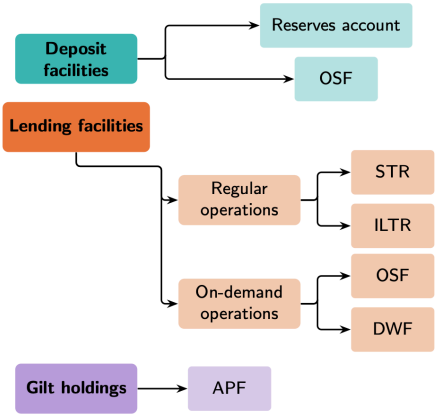
Appendix – Full SMF



Appendix – Condensed SMF



	OSF	DWF
Offering	On-Demand	On-Demand
Term	One day	Rollable (up to 30 days)
Pricing	Fixed Spread (+/-15bps)	Fixed Spreads (A: 15bps, B: 25bps, C: 50bps)
Collateral	"Level-A" only	"Level-A, B, or C"
Drawing	Reserves (lent or borrowed)	Gilts or Reserves (borrowed)

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Appendix – Collateral

- **Level A**
  - Gilts; HM Government marketable debt denominated in USD, EUR, or CAD; Bank of England Securities; Sovereign and Central Bank Debt (denominated in GBP, USD, EUR, or CAD from US, Canada, France, Germany, Netherlands)
- **Level B**
  - Sovereign and Central Bank Debt (denominated in domestic currency, GBP, USD, or EUR, from Australia, Austria, Belgium, Denmark, Finland, Ireland, Italy, Japan, Luxembourg, New Zealand, Norway, Portugal, Spain, Sweden, and Switzerland); Major International Institution Bonds (EU, ESM, EBRD, ADB x2, IADB); HM Government marketable debt denominated in other currency; HM Government Sukuk; FHLMC and FHLB Securities; RMBS; UK/US/EEA ABS backed by credit cards, auto loans, or student loans; Corporate Bonds and Commercial Paper (UK/US/EEA)
- **Level C**
  - Any other UK/US/EEA RMBS, or ABS; Portfolios of loans (consumer, SME, etc.)

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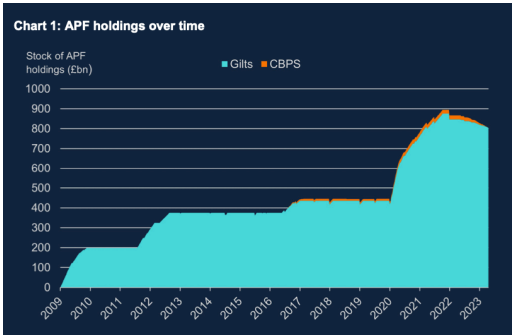
Appendix – Gilts



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Appendix – Balance Sheets

Central Bank

Long bonds $b^{L,CB}$	Reserves m^{CB}
Collateral (Level-A)	***Reserves*** m_A^{CB}
Collateral (Level-C)	***Reserves*** m_C^{CB}

Commercial Bank

Short bonds $b^{S,B}$	Deposits d^B
Private loans ℓ	Unsec. borrowing ω^B
Repo loans z^B	
Reserves m_A^B	***CB Repo (Level-A)***
Reserves m_C^B	***CB Repo (Level-C)***
Reserves m^B	

NBFI

Long bonds $b^{L,NB}$	Deposits d^{NB}
MMF deposits $\eth^{MMF}$	Repo borrowing z^{NB}
Private Loans ϑ	

MMF

Unsec. loans ω^{MMF}	Deposits d^{MMF}

Households

Bank Deposits $\eth^B$	Endowment $\mathcal{M}$
NBFI Deposits $\eth^{NB}$	

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Model Equations (Household)

$$\max_{q_0, q_1, \eth^B, \eth^{NB}} \quad u(q_0) + q_1 \tag{1}$$

$$\text{s.t.} \quad \mathcal{M} \geq \eth^B + \eth^{NB} \tag{2}$$

$$\eth^B \geq p_0 q_0 \tag{3}$$

$$(\eth^B - p_0 q_0)(1 + i_{d^B}) + \eth^{NB}(1 + i_{d^{NB}}) + \Pi \geq p_1 q_1 + T \tag{4}$$

Model Equations (Producer)

$$\max_{h_0, h_1 q_0^f, q_1^f} \quad w(\mathcal{B}) - g(h_0) - g(h_1) \tag{5}$$

$$\text{s.t.} \quad q_0^f \leq f(h_0) \tag{6}$$

$$q_1^f \leq f(h_1) \tag{7}$$

Model Equations (NBFI)

$$\Pi^{NB} \equiv \max_{\substack{d^{NB}, z^{NB} \\ b^{L,NB}, \eth^{MMF}, \vartheta}} (1 - p_L) b^{L,NB} + i_{d^{MMF}} \eth^{MMF} + i_\vartheta \vartheta \tag{8}$$

$$- i_{d^{NB}} d^{NB} - \rho z^{NB} - \mathcal{L}\left(\frac{z^{NB} + d^{NB}}{\eth^{MMF} + \psi_L p_L b^{L,NB}}\right)$$

$$\text{s.t.} \quad d^{NB} + z^{NB} \geq p_L b^{L,NB} + \eth^{MMF} + \vartheta \tag{9}$$

$$b^{L,NB} \geq (1 + \rho) z^{NB} \tag{10}$$

Model Equations (MMF)

$$\Pi^{MMF} \equiv \max_{d^{MMF},\omega^{MMF}} \quad \sigma\omega^{MMF} - \left(i_{d^{MMF}} + k^{MMF}\right) d^{MMF} \tag{11}$$

$$\text{s.t.} \quad d^{MMF} \geq \omega^{MMF} \tag{12}$$

Model Equations (Commercial Bank)

$$\Pi^B \equiv \max_{\substack{i_{d^B},\ell,b^{S,B},z^B,\\ \omega^B,m^B,m^B_{\mathcal{A}},m^B_{\mathcal{C}}}} (1-p_S)b^{S,B} + i_\ell \ell + \rho z^B + R m^B - \sigma \omega^B \tag{13}$$

$$- i_{d^B} d^B\left(i_{d^B}\right) - \alpha_{\mathcal{A}} m^B_{\mathcal{A}} - \xi\left(m^B_{\mathcal{A}}\right)$$

$$- \alpha_{\mathcal{C}}\left(\widetilde{m_{\mathcal{C}}}\right) m^B_{\mathcal{C}} - \chi(\ell) - \mathcal{R}\left(\frac{\omega^B}{\overline{m} + \psi_S \overline{g}}\right)$$

$$\text{s.t.} \quad d^B\left(i_{d^B}\right) + \omega^B \geq p_S b^{S,B} + \ell + z^B + m^B \tag{14}$$

$$p_s b^{S,B} + z^B \geq \mathcal{H}_{\mathcal{A}} m^B_{\mathcal{A}} \tag{15}$$

$$\ell \geq \mathcal{H}_{\mathcal{C}} m^B_{\mathcal{C}} \tag{16}$$

$$i_{d^B} \geq 0 \tag{17}$$

Model Equations (Consolidated Government)

The DMO issues B^S and B^L in $t = 0$ and pays out when the bonds mature in $t = 1$, financed by a lump-sum tax on households. The DMO budget constraint is then

$$(1 - p_S)B^S + (1 - p_L)B^L + \mathcal{M} = T \tag{18}$$

The central bank buys $b^{L,CB}$ at the market-clearing price p_L, and supplies traditional reserves m^{CB} remunerated at the Bank Rate R. It also supplies additional reserves through its repo operations, earning spreads above the Bank Rate ($\alpha_{\mathcal{A}}$ and $\alpha_{\mathcal{C}}$ ($\widetilde{m_{\mathcal{C}}}$)). The central bank's operating profits are therefore

$$\mathcal{E} \equiv (1 - p_L)b^{L,CB} + \alpha_{\mathcal{A}} m_{\mathcal{A}}^{CB} + \alpha_{\mathcal{C}} \left(\widetilde{m_{\mathcal{C}}}\right) m_{\mathcal{C}}^{CB} - Rm^{CB} \tag{19}$$

When the central bank remits any operating profits to the DMO, the consolidated government budget constraint is naturally then:

$$(1 - p_S)B^S + (1 - p_L)B^L + \mathcal{M} = T + \mathcal{E} \tag{20}$$

Equilibrium

A competitive equilibrium in this economy is

1. An allocation $\Gamma = \{\Gamma_f, \Gamma_{HH}, \Gamma_{NB}, \Gamma_{MMF}, \Gamma_B, \Gamma_{CB}\}$ where
   - $\Gamma_f = \left\{q_0^f, q_1^f\right\}$ is a producer allocation
   - $\Gamma_{HH} = \left\{q_0, q_1, \partial^B, \partial^{NB}\right\}$ is a household allocation
   - $\Gamma_{NB} = \left\{\vartheta, d^{NB}, z^{NB}, \partial^{MMF}, b^{L,NB}\right\}$ is an NBFI allocation
   - $\Gamma_{MMF} = \left\{d^{MMF}, \omega^{MMF}\right\}$ is a MMF allocation
   - $\Gamma_B = \left\{d^B, \ell, z^B, \omega^B, m_{\mathcal{A}}^B, m_{\mathcal{C}}^B, m^B, b^{S,B}\right\}$ is a monopoly bank allocation
   - $\Gamma_{CB} = \left\{m^{CB}, m_{\mathcal{A}}^{CB}, m_{\mathcal{C}}^{CB}\right\}$ is the central bank's liquidity provision
2. A price system $\mathcal{P} = \{p_0, \phi, \rho, \sigma, i_{d^B}, i_{d^{NB}}, i_{d^{MMF}}\}$, and
3. A government policy $\mathcal{G} = \left\{B^L, B^S, \mathcal{M}, T, b^{L,CB}, R, \alpha_{\mathcal{A}}, \alpha_{\mathcal{C}}(\cdot)\right\}$,

such that given prices and government policy,

1. Agents solve their respective problems
2. A consolidated government budget constraint balances
3. All markets clear

Functional Form Assumptions

[HH Utility]	$\frac{q_0^{1-\nu}}{1-\nu} + q_1$
[Producer Utility]	$\mathcal{B} - h_0 - h_1$
[Production Function]	ϕh
[NBFI Liquidity Cost]	$\frac{\hbar}{1+\tau}\left(\frac{z^{NB}+d^{NB}}{\eth^{MMF}+\psi_L p_L b^{L,NB}}\right)^{1+\tau}$
[Bank loan monitoring cost]	$\frac{1}{2}\beta(\ell)^2$
[Bank repo operation cost]	$\frac{1}{2}\gamma\left(m_{\mathcal{A}}^{B}\right)^2$
[Reserve scarcity cost]	$\frac{\eth}{1+\kappa}\left(\frac{\omega^B}{\overline{m}+\psi_S\overline{g}}\right)^{1+\kappa}$
[Level-C Pricing Function]	$\alpha_{\mathcal{C}} + \varepsilon_{\mathcal{C}}\widetilde{m_{\mathcal{C}}}$