Monetary Tightening, Quantitative Easing, and Financial Stability*

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Abstract

This paper analyses the effects of central bank balance sheet policies on financial and price stability in a framework with endogenous disruptions in financial intermediation. Central bank balance sheet expansions increase the frequency of financial stress episodes and their duration by inducing financial intermediaries to take on more risk in normal times and slowing their recapitalisation during a stress episode. Rapid monetary policy tightening induces financial stress that can be mitigated by central bank balance sheet expansions at significant cost to price stability. The optimal monetary policy mix balances the welfare costs of inflation and financial stress with the efficiency costs of balance sheet expansions. Optimal policy leans towards prevention of financial stress via accommodative conventional policy and limited balance sheet interventions.

Keywords: Quantitative easing, financial stability, monetary policy, financial crises.

JEL Codes: E52, E44, E58.

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1 Introduction

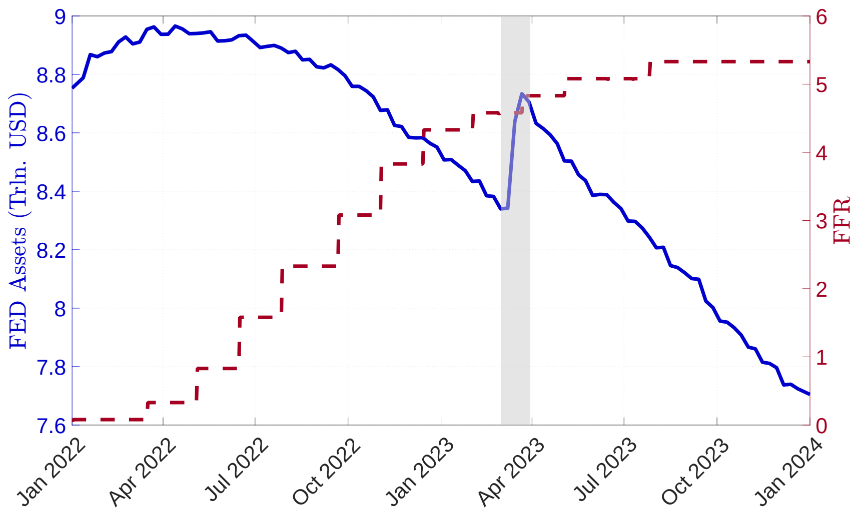
Since 2008, central bank balance sheet policies have become routine financial stability tools. Major central banks have deployed quantitative easing (QE) during financial stress episodes — from the Global Financial Crisis to the COVID-19 market turmoil. Financial markets now price in anticipated central bank support during stress (Haddad, Moreira, and Muir 2025), yet a fundamental question remains unanswered: if financial intermediaries (banks) expect central bank support during crises, to what extent does QE create moral hazard, and does it make financial instability more frequent and persistent?

The period of post-COVID inflation exposed the stakes of this question. Faced with surging inflation, central banks aggressively raised policy rates to restore price stability. Yet rapid tightening destabilised financial markets — triggering the UK Liability Driven Investment crisis in September 2022 and the failures of Silicon Valley Bank and Credit Suisse in March 2023. Central banks responded by expanding balance sheets to stabilise financial markets whilst simultaneously continuing to raise rates. For instance, Figure 1 illustrates this policy combination in the United States, where the Federal Reserve's balance sheet expanded sharply in March 2023 even as the policy rate continued rising — exposing the fundamental tension between price and financial stability objectives following the SVB crash.

Despite extensive research on QE's stabilisation properties during crises, the literature has not characterised whether and how anticipated interventions affect financial stress frequency through ex ante incentive distortions. Existing models either maintain permanently binding financial frictions — abstracting from crisis frequency (Gertler and Karadi 2011; Chen, Cúrdia, and Ferrero 2012; Del Negro et al. 2017a) — or employ real frameworks that cannot evaluate monetary policy tradeoffs (Bocola 2016; Akinci and Queralto 2022; Akinci et al. 2023). These frameworks are unable to capture how anticipated balance sheet interventions distort incentives across normal times and crises, nor can they evaluate the role of conventional and balance sheet policy when both price and financial stability are at stake.

This paper addresses three questions about balance sheet policies spanning financial stress management and long-run stability. First, does anticipated QE increase financial stress frequency and duration, and through what channels? Second, when central banks need to simultaneously raise interest rates to combat inflation and stabilise financial markets, can balance sheet policies resolve the tension between price and financial stability? Third, conditional on these tradeoffs, what is the optimal mix of conventional and balance sheet policies, and how does it depend on the efficiency costs of balance sheet operations — capturing potential fiscal distortions and the central

Figure 1: Federal Reserve Assets and Policy Rate



Note: Federal Reserve Assets (left, solid blue line, trillions US dollars), Effective Federal Funds Rate (right, dashed red line, percentage points).

bank's relative inefficiency at intermediation?

To answer these questions, I make three contributions. First, I develop and globally solve a New Keynesian model with occasionally binding financial constraints — where banks endogenously transition between constrained and unconstrained states — allowing me to quantify how anticipated balance sheet interventions affect crisis frequency, which frameworks with permanently binding constraints preclude. Second, I decompose QE's destabilising effects into distinct ex ante and ex post channels operating through banks' endogenous behaviour: anticipated interventions weaken precautionary incentives, increasing normal-times leverage, whilst QE during stress slows recapitalisation by reducing portfolio returns. Third, I characterise optimal policy, demonstrating that prevention through accommodative conventional policy dominates intervention through ex post QE when balance sheet operations are costly.

I demonstrate that routine use of balance sheet policies creates a financial stability trap — a self-reinforcing vicious cycle where anticipated interventions weaken banks' precautionary incentives and generate more frequent crises. Under aggressive quantitative easing, financial stress frequency increases from 9% under no balance sheet interventions to nearly 50%, revealing severe moral hazard: anticipated interventions generate the very instability they aim to address. This destabilisation operates through two channels: ex ante, anticipating central bank support leads banks to operate with higher leverage in normal times (the risk channel); ex post, QE reduces banks' portfolio returns during stress, slowing recapitalisation and prolonging crisis duration (the recapitalisation channel). I further show that QE cannot fully resolve the fundamental tradeoff between price and financial stability during conventional monetary tightening

— by stabilising credit markets, balance sheet interventions prevent the deflationary forces that policy rate increases rely upon to restore price stability, sustaining inflationary pressures. Lastly, optimal policy favours stress prevention over management. Accommodative conventional policy that prevents financial stress ex ante, thereby avoiding the need for balance sheet interventions, dominates aggressive inflation targeting with ex post QE interventions when balance sheet operations entail efficiency costs.

I now turn to the mechanisms underlying these results. The model's central mechanism operates through banks' endogenous choice of leverage. Banks face a tradeoff: higher leverage increases returns by allowing them to scale up lending relative to equity, but reduces the buffer before hitting their leverage constraint, raising the probability that adverse shocks push them into costly fire sales. The risk channel operates ex ante: expecting stabilisation during downturns reduces the expected cost of hitting leverage constraints, weakening precautionary incentives. This leads banks to rationally choose higher leverage, increasing the probability that adverse shocks push them to their constraints. Once constrained, they engage in fire sales of firm equity that depress asset prices and trigger credit crunches. The recapitalisation channel operates ex post: by purchasing higher-yield assets in exchange for low-yield reserves, the central bank reduces banks' average portfolio returns during stress episodes, slowing their recovery. Lower net worth accumulation prolongs the time banks remain constrained, extending stress duration.

QE's interaction with conventional monetary policy creates a fundamental tension during tightening cycles. When policy rate increases trigger financial stress and leverage constraints bind, powerful deflationary forces emerge: credit crunches reduce lending, depressing investment and labour demand, which lowers wages and aggregate demand, exerting downward pressure on inflation. These disinflationary pressures amplify tightening's effectiveness at restoring price stability. Balance sheet interventions stabilise credit markets and support investment, preventing the binding constraints from generating these dynamics. This maintains financial stability but sustains inflationary pressures, reinforcing the fundamental policy tradeoff.

These findings jointly shape the design of optimal policy, providing a formal framework for the lean-versus-clean debate over whether central banks should prevent crises ex ante or respond aggressively ex post. Aggressive balance sheet commitments increase crisis frequency through moral hazard, whilst QE during tightening cycles cannot simultaneously stabilise financial markets and restore price stability. Whether aggressive intervention strategies are optimal depends on the efficiency costs of deploying QE. When balance sheet operations entail no efficiency costs, a "clean" strategy dominates: the central bank aggressively targets inflation, tolerating the higher stress frequency and deploying QE to manage financial stress despite the inflationary pressures. When QE entails substantial efficiency costs, a “lean” strategy becomes optimal: the central bank responds less aggressively to inflation, tolerating some inflation persistence to avoid inducing financial stress through rapid tightening — preventing crises ex ante rather than relying on costly interventions.

Related literature. To analyse the financial stability implications of QE, the paper employs a framework where QE has real effects and financial crises stress occurs endogenously, building on literature that breaks the Wallace (1981) irrelevance hypothesis through financial market imperfections. Seminal works such as Gertler and Karadi (2011), Cúrdia and Woodford (2011), Chen, Cúrdia, and Ferrero (2012), and Del Negro et al. (2017a) demonstrate that in models with financial frictions or segmented markets, QE effectively lowers risk premia and stimulates the economy, with Krishnamurthy and Vissing-Jorgensen (2011) and Gagnon et al. (2011) providing empirical evidence through portfolio rebalancing channels (see also Stein (2012) and Woodford (2012) on optimal policy with financial frictions). However, these frameworks maintain permanently binding financial constraints, precluding analysis of crisis frequency and intermediaries' precautionary leverage choices in normal times — the central focus of this paper.

To analyse stress frequency and duration, this paper adopts a framework with occasionally binding financial constraints pioneered by Mendoza (2010) and Bianchi (2011) in the small open economy context, and recently applied to financial crises by Bocola (2016), Elenev (2017), Elenev, Landvoigt, and Van Nieuwerburgh (2021), Akinci and Queralto (2022), and Akinci et al. (2023). This strand of the literature predominantly uses real models; this paper employs a monetary model that enables joint analysis of conventional and balance sheet policies. By integrating occasionally binding constraints into a monetary framework, this paper analyses how anticipated balance sheet interventions distort banks' precautionary incentives and affect the likelihood and duration of financial stress.

Extensive evidence from loan-level studies documents how accommodative monetary policy induces excessive risk-taking (Borio and Zhu 2012; Jiménez et al. 2014; Dell'Ariccia, Laeven, and Suarez 2017). Theoretical work analyses ex-ante moral hazard and expected support (Farhi and Tirole 2012; Kareken and Wallace 1978) from ex-post distortions when asset purchases compress credit spreads and impair recapitalisation (Karadi and Nakov 2021). This paper integrates both the ex-ante risk channel and the ex-post recapitalisation channel within a stochastic framework with state-dependent financial constraints, demonstrating that anticipated interventions drastically increase crisis frequency through weakened precautionary incentives, whilst QE during stress slows recovery by compressing banks' returns.

Recent work examines the sequencing of balance sheet and conventional monetary policies during tightening cycles. Benigno and Benigno (2022) analyse trade-offs in raising policy rates whilst reducing central bank balance sheets, whilst Airaudo (2023) studies quantitative tightening under passive monetary and active fiscal policy. Motivated by 2022-2023 episodes where central banks simultaneously tightened conventional policy whilst expanding balance sheets to stabilise financial markets, Haas (2023) suggests such interventions can support financial stability without compromising price stability. This paper analyses the same policy combination but finds that QE during a tightening cycle sustains inflationary pressures by stabilising credit and investment. Haas (2023) employs a bank-run framework without productive capital, which naturally generates smaller effects of QE on output and inflation, explaining the contrasting results.

The optimal policy analysis contributes to the lean-versus-clean debate over whether central banks should prevent crises ex ante or respond aggressively ex post. Bernanke and Gertler (1999, 2001) argued for the "clean" approach — that flexible inflation targeting is sufficient and direct asset price targeting is inadvisable — whilst post-crisis reassessment by Svensson (2017) questioned the effectiveness of leaning policies through formal cost-benefit analysis. By incorporating banks' precautionary behaviour in response to anticipated interventions, this paper demonstrates that the optimal approach depends critically on balance sheet policy efficiency costs: when QE is costless, aggressive inflation targeting with responsive ex post interventions dominates; when QE entails substantial efficiency costs, accommodative conventional policy that prevents crises ex ante becomes optimal.

The paper proceeds as follows. Section 2 outlines the model and calibration. Section 3 shows that the calibrated model produces empirically relevant financial stress dynamics and can account for long-run business cycle moments. Section 4 looks into the stabilisation properties of QE and its implications for financial stress frequency and duration. Further, it presents the policy counterfactuals in a financial stress episode driven by rapid monetary tightening. Section 5 studies the optimal conventional and balance sheet policy mix. Section 6 concludes the paper.

2 Model

The model captures how QE affects financial stability through financial intermediaries' occasionally binding leverage constraints. This structure enables the analysis of both the stabilising effects of QE during crises and its impact on crisis frequency and duration.

The key element of the framework is that bank constraints bind occasionally, creating state-dependent financial frictions. In normal times, financial intermediation is frictionless. During downturns, banks reach their leverage constraints, triggering financial stress episodes with asset fire sales, volatile investment, and elevated credit spreads.

Banks face a moral hazard problem, as they can divert a fraction of their assets. Crucially, it is harder for banks to divert safe assets, such as central bank reserves and short-term Treasury debt, than risky assets. Consequently, banks with more safe assets face less severe leverage constraints. This creates the transmission mechanism for QE: by injecting safe assets into the financial system, QE relaxes banks' leverage constraints during financial stress. Moreover, QE stabilises asset prices, which dampens the fire sale dynamics in a stress episode.

The model includes standard New Keynesian elements: a representative household consumes final goods, supplies labour to non-financial firms, holds partially-liquid long-term public debt, and makes deposits with banks. The production sector follows a standard New Keynesian structure with monopolistically competitive intermediate firms facing price rigidities as in Calvo (1983), competitive final goods firms, and investment goods producers subject to investment adjustment costs. The central bank sets the short-term interest rate and implements QE by purchasing either public long-term debt from households or private non-financial firm equity from banks. The Treasury issues short- and long-term debt inelastically and levies lump-sum taxes on households.

The remainder of this section outlines the model and calibration.

2.1 Households

Representative households consume final goods, supply labour, hold bank deposits, and purchase long-term Treasury debt. Households' portfolio choice between deposits and long-term debt creates a transmission channel for QE: when the central bank purchases long-term debt, it affects the term premium and shifts households' portfolio towards bank deposits.

The household maximises the following infinite stream of discounted instantaneous utilities

$$\max_{\{C_t, L_t, D_t, B^H_{L,t}\}_{t=0}^{\infty}} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t U(C_t, L_t),$$

where β is the discount factor, C_t is consumption, and L_t is labour.

The per-period household budget constraint in real terms is given by

$$C_t + D_t + (1 + \xi_{L,t})B^H_{L,t} = w_t L_t + \frac{R^d_{t-1}}{\pi_t} D_{t-1} + \frac{R_{L,t}}{\pi_t} B^H_{L,t-1} + \Xi_t,$$

where $\pi_t = P_t/P_{t-1}$ is the gross inflation rate, D_t is deposits, w_t is the real wage, $B^H_{L,t}$ is the real market value of long-term debt held by the household, Ξ_t represents profits from bank and firm ownership, and $\xi_{L,t}$ is the adjustment cost of long-term debt holdings that introduces a term premium, given by

$$1 + \xi_{L,t} = \bar{\xi}_L \left(\frac{B^H_{L,t}}{B^H_L} \right)^{\xi},$$

where ξ denotes the elasticity of the adjustment cost with respect to long-term debt holdings and $\bar{\xi}_L$ is the steady-state term premium. This adjustment cost makes long-term debt partially liquid and allows central bank purchases to affect the term premium. B^H_L denotes the steady-state level of long-term debt holdings.

2.2 Non-financial firms

The production sector follows a standard New Keynesian structure with three types of firms. Capital goods producers transform final goods into investment, subject to adjustment costs, which amplify fire sale dynamics during financial stress. Final goods producers are perfectly competitive and aggregate intermediate inputs using CES technology. Intermediate goods producers are monopolistically competitive and face price rigidities as in Calvo (1983).

Capital goods producers face investment adjustment costs and choose investment to solve

$$\max_{I_{t+s}} \mathbb{E}_t \Lambda_{t,t+s} \left\{ Q_{t+s} - 1 - \Phi(I_t) \right\} I_{t+s}$$

where Q_t is the price of capital, $\Lambda_{t,t+s}$ is the households' stochastic discount factor, and $\Phi(I_t)$ represents adjustment costs.

The aggregate capital stock evolves according to:

$$K_t = I_t + (1 - \delta) K_{t-1}$$

where I_t is investment and δ is the depreciation rate.

Final goods producers aggregate differentiated intermediate inputs with an elasticity of substitution ϵ, yielding the demand schedule:

$$y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\epsilon} y_t \tag{1}$$

Intermediate firms produce using a Cobb-Douglas technology, $y_t(i) = A_t k_{t-1}(i)^{\alpha} l_t(i)^{1-\alpha}$, where A_t is total factor productivity, α is the capital share, and are subject to Calvo price rigidities. They solve:

$$\max_{P_t(i), l_t(i), k_t(i)} \mathbb{E}_0 \sum_{s=0}^{\infty} \theta^s \Lambda_{t,t+s} \left\{ \left(\frac{P_t(i)}{P_{t+s}} - mc_{t+s}(i) \right) y_{t+s}(i) \right\},$$

where θ is the probability of not being able to adjust the price, subject to the demand for intermediate goods (1) and the production technology constraint.

The solution yields a standard New Keynesian Phillips curve and demand schedules for labour and capital.

2.3 Financial intermediaries

Banks, modelled in the spirit of Gertler and Karadi (2011), are specialists in the intermediation of funds between households and firms, using deposits and their net worth to purchase firm equity and safe assets. The individual banker's balance sheet is:

$$Q_t k_t^I + b_{S,t}^I = n_t + d_t \tag{2}$$

where $Q_t k_t^I$ represents firm equity holdings, $b_{S,t}^I$ is safe assets, n_t is net worth, and d_t is deposits. Safe assets comprise short-term Treasury debt and central bank reserves. The two assets are assumed to have the same return profile and are therefore treated as a single asset.

The flow budget constraint of a banker is given by

$$n_t = \left(R_t^k - \frac{R_{t-1}^d}{\pi_t}\right) Q_{t-1} k_{t-1}^I + \left(\frac{R_{t-1} - R_{t-1}^d}{\pi_t}\right) b_{S,t-1}^I + \frac{R_{t-1}^d}{\pi_t} n_{t-1}. \tag{3}$$

Financial friction. Banks are subject to a moral hazard problem: they can choose to divert a fraction of their total assets and to default. Banks only default if their franchise value is lower than the value of the assets they can divert. Thus, banks are subject to the following incentive constraint:

$$V_t \geq \Theta(x_t)(Q_t k_t^I + b_{S,t}^I), \tag{4}$$

where $x_t = b_{S,t}^I / (Q_t k_t^I + b_{S,t}^I)$ is the safe asset ratio. The function $\Theta(x_t)$ is decreasing and convex in the safe asset ratio; it is harder for banks to divert safe assets. When banks hold more safe assets, they can divert a smaller fraction of their portfolio. However, the marginal benefit of increasing safe assets diminishes—the convexity assumption captures that moving from a very risky portfolio to a moderately risky one has a larger impact on divertibility than moving from a moderately risky to a very safe portfolio.

Bank optimisation problem. Banks maximise their franchise value, the present discounted value of future profits from continued operation. The franchise value of the bank is given by:

$$\max_{k_t^I, b_{S,t}^I, d_t} V_t = \mathbb{E}_t \sum_{s=0}^{\infty} \sigma_b^s (1 - \sigma_b) \left(\Lambda_{t,t+s+1} n_{t+s+1} + \Lambda_{t,t+s+1} \zeta_{t+s}^b b_{S,t+s}^I \right), \tag{5}$$

where σ_b denotes the exogenous probability of a banker staying in business in the next period; $\sigma_b < 1$ ensures that banks do not accumulate net worth indefinitely. ζ_t^b denotes an exogenous shock process that governs the banker's preference for safe assets. This preference serves two important roles: first, it creates a realistic wedge between equity and safe asset returns in normal times, allowing the model to match observed credit spreads during tranquil periods; second, it acts as a financial shock that affects the likelihood of reaching the leverage constraint.

Banks solve Equation (5) subject to the incentive constraint (4), the balance sheet constraint (2), and the flow of funds constraint (3). I provide technical details on the solution to the banker problem in Appendix A.

Credit spreads, regime determination, and aggregation. The solution to the banker problem yields the following first-order condition that determines the credit spread:

$$\mathbb{E}_t \Omega_{t,t+1} \left(R^k_{t+1} - \frac{R_t}{\pi_{t+1}} \right) = \zeta^b_t - \frac{\bar{\lambda}_t}{1+\bar{\lambda}_t} \Theta'(x_t), \tag{6}$$

where $\Omega_{t,t+1}$ is the banker stochastic discount factor and $\bar{\lambda}_t$ denotes the Lagrange multiplier on the constraint in Equation (4). Note that when the constraint is not binding, the condition collapses to $\mathbb{E}_t \Omega_{t,t+1} \left(R^k_{t+1} - R_t/\pi_{t+1} \right) = \zeta^b_t$, which determines the credit spread in equilibrium with no financial stress. In the absence of bankers' preference for safe assets, i.e. $\zeta^b_t = 0$, this condition implies that, in tranquil times, the equity spread is zero and, thus, intermediation is frictionless.

The incentive constraint of the banking sector gives rise to the real effects of QE. Consider (4) expressed as an upper bound on leverage:

$$\phi_t \leq \bar{\phi}_t = \frac{\upsilon_t}{\Theta(x_t) - \bar{\mu}_t}, \tag{7}$$

where $\phi_t = (Qk^I_t + b^I_{S,t})/n_t$ is leverage, $\bar{\phi}_t$ is the upper bound on leverage, υ_t represents the gross discounted returns from deposit funding and $\bar{\mu}_t$ is total excess returns.

The key component that determines the severity of the constraint is the divertible assets ratio, $\Theta(x_t)$. Individual banks are unable to influence the aggregate quantity of safe assets in the financial system. Thus, in a financial stress episode, banks sell non-financial firm equity to increase their safe asset ratio. Sales of firm equity lead to a decrease in equity prices, decline of bank net worth, and a further round of equity sales that form a vicious cycle. By injecting the safe assets in the financial system and, thus, increasing the safe asset ratio, the central bank can directly affect the upper bound on leverage and dampen the effects of the equity sales. QE increases safe asset provision thus decreasing $\Theta(x_t)$ which leads to higher $\bar{\phi}_t$. Alternatively, QE can directly stabilise the asset prices, thus dampening the fire-sale dynamics and stabilising the net worth of commercial banks.

When banks are far from their leverage constraint, intermediation is frictionless with $\bar{\mu}_t = 0$. When leverage is at its upper bound, $\phi_t = \bar{\phi}_t$, credit spreads open and excess returns are above zero, $\bar{\mu}_t > 0$. This implies the following complementary slackness (regime determination) condition:

$$\min\left(\bar{\mu}_t, \bar{\phi}_t - \phi_t\right) = 0, \quad \bar{\mu}_t \geq 0, \quad \bar{\phi}_t - \phi_t \geq 0. \tag{8}$$

Each period, a $1-\sigma_b$ fraction of banks exit business and an equivalent number of banks emerges receiving a start-up fraction γ of total non-financial firm equity holdings. Aggregation across banks yields an expression for aggregate net worth:

$$N_t = \sigma_b \left[\left(R_t^k - \frac{R_{t-1}^d}{\pi_t} \right) Q_{t-1} K_{t-1}^I + \frac{\left(R_{t-1} - R_{t-1}^d \right)}{\pi_t} B_{S,t-1}^I + \frac{R_{t-1}^d}{\pi_t} N_{t-1} \right] + (1-\sigma_b)\gamma Q_{t-1} K_{t-1}^I. \tag{9}$$

2.4 Central Bank

The monetary authority sets the policy rate and implements asset purchases. The policy rate is set according to a Taylor-type rule of the form

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R} \right)^{\rho_R} \left(\pi_t^{\phi_\pi} X_t^{\phi_y} \right)^{1-\rho_R} \exp \varepsilon_t^R, \tag{10}$$

where ρ_R denotes the policy rate inertia, ϕ_π and ϕ_y are coefficients governing feedback to inflation and output gap deviations, respectively, ε_t^R is an exogenous disturbance, and X_t is defined as the output gap between the realised output Y_t and a counterfactual measure of real activity that would have occurred in the same economy with no price rigidities and no frictions in financial intermediation.

Balance sheet policy consists of purchases of long-term government debt and non-financial firm equity and the provision of reserves to financial intermediaries. If central bank balance sheet expansion is done through the acquisition of private non-financial firm equity, it is referred to as private QE, whilst public QE is done through the acquisition of public long-term debt from households.

The budget constraint of the monetary authority is given by

$$\frac{R_{t-1}}{\pi_t} B_{S,t-1}^{cb} + \frac{R_{L,t}}{\pi_t} B_{L,t-1}^{cb} + R_t^k Q_{t-1} K_{t-1}^{cb} = B_{L,t}^{cb} + B_{S,t}^{cb} + Q_t K_t^{cb} + \Lambda_t^{cb} + C_t, \tag{11}$$

where Λ_t^{cb} denotes the transfers from the central bank to the Treasury. $B_{S,t}^{cb}$ is a composite of public short-term debt and central bank reserves. By assumption, these assets have the same risk-return profile and are therefore aggregated into a single variable. K_t^{cb} denotes holdings of non-financial firm equity.

Balance sheet expansions involve efficiency costs C_t that proxy for the unmodelled resource costs and political economy constraints of large-scale interventions in reduced-form, similar to Karadi and Nakov (2021):

$$C_t = \varkappa \left\{ \left(\frac{B_{L,t}^{cb}}{B_L^{cb}} - 1 \right) + \left(\frac{K_t^{cb}}{K^{cb}} - 1 \right) \right\}, \tag{12}$$

where $\varkappa$ is a scaling parameter. The paper abstracts from quantitative tightening, allowing only for non-negative deviations of central bank assets from their steady-state levels. Consequently, the adjustment cost is always positive or zero.

When the central bank implements balance sheet policy, the following revenue-neutrality condition holds:

$$B_{L,t}^{cb} + Q_t K_t^{cb} + B_{S,t}^{cb} = 0. \tag{13}$$

This condition implies that if the central bank expands its assets via the acquisition of either public or private assets, it has to expand its liabilities by issuing central bank reserves to banks.

2.5 Treasury

The Treasury collects lump-sum taxes from households τ_t, receives transfers from the central bank Λ_t^{cb}, and issues short-term and long-term debt inelastically, similar to Elenev et al. (2021). The budget constraint of the Treasury is given by:

$$\tau_t + \bar{B}_L + \bar{B}_S + \Lambda_t^{cb} = \frac{R_{t-1}}{\pi_t}\bar{B}_S + \frac{R_{L,t}}{\pi_t}\bar{B}_L. \tag{14}$$

Issuance of public debt follows a constant maturity structure, $\bar{B}_S = \varrho \bar{B}_L$, with ϱ determining the ratio of short-term to long-term debt. Furthermore, the debt issuance is inelastic. This ensures that fiscal policy accommodation does not mute the effects of unconventional monetary policy that are the focus of the paper.

Public short-term debt issued by the Treasury is held by financial intermediaries or the central bank:

$$\bar{B}_S = B_{S,t}^{cb} + B_{S,t}^{I}. \tag{15}$$

Long-term debt issued by the Treasury is held by the central bank or by households:

$$\bar{B}_L = B_{L,t}^{cb} + B_{L,t}^{H}. \tag{16}$$

As this paper focuses on the effects of QE, it abstracts from modelling distortionary effects of fiscal policy, such as distortionary taxation or endogenous debt issuance. The effects of fiscal policy and its interplay with central bank policy are, thus, left for future research.

2.6 Market clearing and equilibrium

Non-financial firm equity holdings either belong to financial intermediaries or the central bank:

$$K_t = K_t^I + K_t^{cb}.$$

Output of final goods is either consumed, invested, or used for central bank balance sheet interventions:

$$Y_t = C_t + (1 + \Phi(I_t))\, I_t + \mathcal{C}_t.$$

The competitive equilibrium is a set of 38 variables: 15 quantities $\{ C_t, L_t, K_t, K_t^I, K_t^{cb}, I_t, Y_t, N_t, B_{S,t}^{cb}, B_{S,t}^I, B_{S,t}, B_{L,t}^{cb}, B_{L,t}^H, B_{L,t}, \tau_t \}$, 9 prices $\{ mc_t, z_t^k, w_t, \pi_t, Q_t, R_t^k, R_t^d, R_t, R_{L,t}\}$, 9 banker variables $\{ \Omega_{t,t+1}, \mu_t^K, \mu_t^B, \upsilon_t, \psi_t, \phi_t, x_t, \bar{\mu}_t, \bar{\phi}_t \}$, and 3 exogenous processes $\{A_t, M_t, \zeta_t^b\}$ that satisfy the equilibrium conditions outlined in Appendix C such that consumption goods, labour, firm equity, long- and short-term debt, and deposit markets are cleared.

2.7 Functional forms and calibration

Functional forms. I assume that the household utility function takes the form presented in Auclert and Rognlie (2023), which is a generalisation of CRRA and Greenwood, Hercowitz, and Huffman (1988) (GHH) preferences:

$$U(C_t, L_t) = \frac{\left(C_t - \psi\chi\frac{L_t^{1+\nu}}{1+\nu}\right)^{1-\sigma}}{1-\sigma} - (1-\psi)\chi\frac{L_t^{1+\nu}}{1+\nu}, \tag{17}$$

where ν is the inverse-Frisch elasticity of labour supply, and σ is the coefficient of relative risk aversion. When $\psi = 1$, the utility function collapses to GHH preferences and when $\psi = 0$, it collapses to CRRA preferences. $\psi \in (0, 1)$, as will be shown later, is calibrated to match the correlation between consumption and hours worked. This specification is essential for capturing the sharp consumption decline during financial crises, which drives the welfare costs of financial instability.

Capital goods producers face the investment adjustment costs as in Christiano, Eichenbaum, and Evans (2005)

$$\Phi(I_t) = \frac{\kappa_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2, \tag{18}$$

where κ_I is a scaling parameter. The investment adjustment costs are essential to generate the fire sale dynamics in times of financial stress.

Finally, the banks' absconding proportion is given by the following function of the ratio of safe assets on their balance sheet

$$\Theta(x_t) = \left(1 - \frac{\lambda_b}{\kappa}x_t^{\kappa}\right), \tag{19}$$

where $\kappa > 0$ is the elasticity of absconding proportion with respect to safe assets and λ_b is a scaling parameter.

Calibration. Some parameters are calibrated to match first moments in the data. β is set to match an average interest rate of 3%, short-term debt to GDP is set to 15%, whilst ϱ is calibrated such that long-term debt to GDP is around 100%. Central bank assets to GDP are set to 25%. The share of public assets on the central bank balance sheet is calibrated to 60%.[1] The steady-state term premium matches the average of 1%.

1. See Appendix B.1 for details.

Table 1: Moment matching

Parameter	Value	Moment	Data	Model
ψ	0.65	$corr(g^C, g^L)$	0.88	0.93
σ_A	0.70	$std(g^C)$	0.81	0.81
σ_M	0.70	$std(\pi)$	0.82	0.68
ρ_A	0.90	$acorr(g^Y)$	0.36	0.48
ρ_M	0.92	$acorr(\pi)$	0.95	0.95

Note: g^C and g^L denote growth rates of consumption and hours worked, respectively. g^Y denotes output growth rate.

Other parameters are calibrated to values standard in the literature. The constant relative risk aversion coefficient σ is set to 2. The inverse-Frisch elasticity of labour supply is set to 1/3. The elasticity of substitution across intermediate inputs is set to match a 25% markup. Capital depreciation δ is set to a standard value of 0.025; the probability of not being able to adjust the price in a given period, θ, is set to 3/4. The feedback coefficients to inflation and output gap deviations are set to be equal to 2 and 0.1, respectively, and Taylor rule inertia is set to 0.72, consistent with estimates in Bianchi, Faccini, and Melosi (2022). The elasticity of long-term yield to long-term debt holdings is set equal to the estimate in Chen, Cúrdia, and Ferrero (2012).

Parameters of the banking sector are calibrated as follows. Parameters that govern the severity of the incentive compatibility constraint, θ^b, κ, and λ^b, are set to match an average occurrence of financial stress of around 10% and such that $\Theta(x_t)$ is decreasing and convex. σ^b is set to 0.925 as in Akinci and Queralto (2022) implying that on average banks exit after 14 quarters. γ is then calibrated to match a steady-state leverage of approximately six.

The exogenous processes and ψ are calibrated to match the data moments in the US data. ψ is set to match the correlation between growth rates of consumption and hours worked. Autoregressive coefficients and standard deviations of TFP and markup processes (ρ_A, ρ_M, σ_A, σ_M) are chosen to match the standard deviation and autocorrelation of growth rates of GDP, and inflation. Table 1 summarises the targets and outcomes of the moment matching exercise. Safe asset preference shock parameters (ρ_B, σ_B) are calibrated to match the volatility of credit spreads during periods of financial tranquillity.

Table 2: Parameter values

Symbol	Value	Description	Source/Target
		Households	
β	0.99	Discount factor	Interest rate 3%
σ	2	Relative risk aversion	Standard
χ	2.842	Relative disutility of labour	Labour 1/3 of time
ν	0.3333	Inverse Frisch	Gertler and Kiyotaki (2010)
ξ	0.025	Elasticity of LTD adj. cost	Chen, Cúrdia, and Ferrero (2012)
$\bar{\xi}_L$	0.002532	s.s. term premium	1% term premium
		Production	
ϵ	5	Elasticity of sub. across int. inputs	25% Markup
δ	2.5%	Capital depreciation	Standard
α	0.33	Capital share	Standard
κ_I	1.35	Investment adjustment cost	–
θ_p	0.75	Calvo probability	–
		Bankers	
θ_b	0.5875	Fraction of divertible funds	10% frequency of fin. stress
κ	0.1266		–
λ_b	0.1094		–
σ_b	0.925	Continuation probability	Akinci and Queralto (2022)
γ	0.2		Leverage 6
ζ^b	0.0025	Safe asset preference	1% equity spread
		Monetary policy	
ρ_R	0.72	Policy rate inertia	Bianchi, Faccini, and Melosi (2022)
ϕ_π	2	Inflation feedback coefficient	Bianchi, Faccini, and Melosi (2022)
ϕ_y	0.075	Output feedback coefficient	Bianchi, Faccini, and Melosi (2022)
$(B_L^{cb} + K^{cb})/4Y$	0.25	CB Assets to GDP	Data
$B_L^{cb}/(B_L^{cb} + K^{cb})$	0.6	Treasurys to CB Assets	Data
		Fiscal policy	
$B_S/4Y$	15%	ST Gov. debt to GDP	Data
ϱ	0.125	Maturity structure of public debt	Data
		Exogenous Processes	
ρ_A	0.9	TFP persistence	
ρ_M	0.92	Markup shock persistence	
ρ_B	0.55	Safe asset preference persistence	
σ_A	0.7%	TFP std. deviation	
σ_R	0.05%	MP shock std. deviation	
σ_M	0.7%	Markup shock std. deviation	
σ_B	0.0202%	Safe asset preference std. deviation	

Table 3: Model v. Data performance

	g^Y	g^C	g^I	Spread	Inflation
Standard deviation					
Model	0.90	0.81	1.94	1.37	0.68
Data	0.93	0.81	2.39	0.93	0.82
	[0.66, 1.07]	[0.81, 1.24]	[1.77, 3.12]	[0.48, 0.94]	[0.82, 2.50]
Correlation with g^Y					
Model	-	0.94	0.78	-0.40	-0.16
Data	-	0.59	0.68	-0.40	0.02
	-	[0.59, 1.00]	[0.46, 0.77]	[-0.69, -0.40]	[-0.13, 0.51]
Auto correlation					
Model	0.48	0.23	0.50	0.93	0.95
Data	0.36	0.06	0.53	0.90	0.95
	[-0.01, 0.81]	[-0.14, 0.22]	[-0.08, 0.57]	[0.82, 0.90]	[0.83, 0.95]

Note: g^Y, g^C, and g^I denote growth-rates of output, consumption, and investment, respectively. Spread is annualised credit spread. The data are expressed in units of the GDP deflator. Data moments pertain to the US. Square brackets denote the min-max range for each moment across the data for Italy, Spain, Germany, France, the United Kingdom, and the United States. Source: Akinci and Queralto (2022), author's calculations.

3 Quantitative properties

This section evaluates the model's empirical performance along two dimensions. First, I assess how well the calibrated model matches key business cycle moments across major economies. Second, I examine whether the model reproduces the stylised facts of financial stress episodes documented in Akinci and Queralto (2022).

Long-run business cycle moments. Table 3 summarises key business cycle moments for the United States alongside ranges from Germany, France, Italy, Spain, and the UK. The table reports standard deviations, cross-correlations, and autocorrelations of growth rates of output, consumption, investment, credit spreads, and inflation.

The model demonstrates strong external validity on non-targeted moments. Whilst some parameters are calibrated to match specific data moments (see Table 1), the model's performance on non-targeted statistics provides evidence of its empirical relevance.

The model captures non-targeted volatilities effectively. Output growth volatility

(0.9%) closely matches the data (0.93%). Investment growth volatility (1.94%) falls within the cross-country range (1.77%, 3.12%) and is close to the US investment volatility (2.39%). Overall, the model succeeds in matching the relative volatilities observed in the US. Investment is most volatile, followed by output, then consumption.

The model generates realistic co-movements between variables. The correlation between consumption and output growth (0.94) falls within the data range [0.59, 1.00], albeit at the upper end. Investment growth correlates with output (0.78) at a level close to the US data (0.68).

For credit spreads, the model successfully captures their countercyclical and persistent nature. The correlation between credit spreads and output growth (-0.40) exactly matches the US data. The model generates credit spread autocorrelation (0.93) close to the US data (0.9). However, the model generates excessive credit spread volatility (1.37%) compared to the data (0.93%).

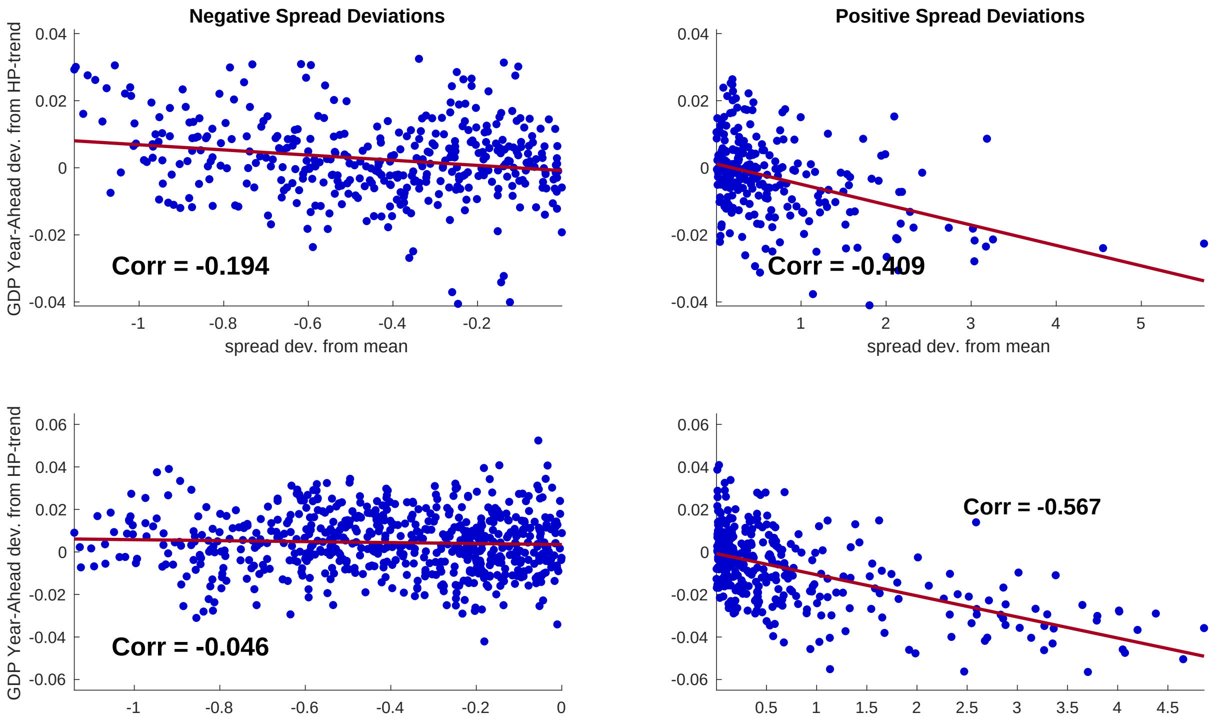
Inflation dynamics are reasonably well captured. The model produces inflation volatility (0.68%) that falls slightly short of matching that of the US data (0.82%). Inflation exhibits weak negative correlation with output growth (-0.16), falling slightly outside the empirical range [-0.13, 0.51]. The model is calibrated to match the strong autocorrelation of inflation (0.95) in the US data.

Overall, the model demonstrates strong external validity on key non-targeted moments whilst remaining consistent with the broad patterns observed across advanced economies. Having established this foundation, I now examine the model's ability to replicate the stylised facts of financial stress episodes.

Output deviations and credit spreads. The data reveal an asymmetric relationship between credit spreads and economic activity. Whilst credit spreads are generally countercyclical, the strength of this relationship is state-dependent. When credit spreads are below their mean, they exhibit mild countercyclicality with output (correlation of -0.194). However, when credit spreads are above their mean, they become strongly negatively correlated with output deviations (correlation of -0.409). The model successfully replicates this asymmetric pattern, generating correlations of -0.046 and -0.567 in normal and stress times, respectively.

This asymmetric relationship reflects the state-dependent nature of the financial friction. In normal times, banks operate far from their leverage constraints, allowing

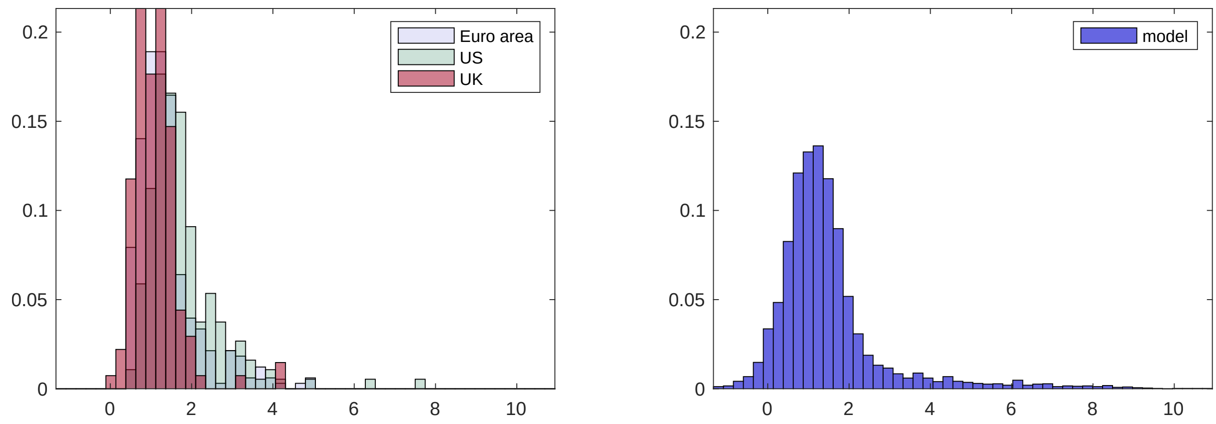
Figure 2: Output and Credit Spreads



Note: The model is simulated for 10,000 periods. Leverage constraint binds around 10% of the simulated sample. Left panel plots the relationship between the cyclical component of output four periods ahead and the credit spread when credit spread is below sample mean. Right panel plots the same relationship when credit spread is above mean. The top panel shows the relationship between output and credit spreads in the data, whilst the bottom panel is related to the model.

frictionless financial intermediation. Banks effectively channel funds between households and non-financial firms, and credit spreads exhibit only weak correlation with real activity. However, once banks reach their leverage constraints, financial intermediation becomes severely impaired. The binding constraint triggers a fire sale of firm equity as banks attempt to improve their balance sheet composition. This fire sale depresses investment and equity prices, creating a vicious cycle: falling equity prices depress bank net worth, further tightening the leverage constraint, which leads to additional equity sales. Simultaneously, the central bank cuts interest rates to stimulate economic activity whilst equity returns spike, generating high and volatile credit spreads. The result is a strong negative correlation between spreads and output during stress

Figure 3: Credit spreads: data and model



Note: data sourced from BoE, FRED, Akinci and Queralto (2022). Model is simulated for 10,000 periods.

episodes.

Figure 2 illustrates this nonlinear relationship between credit spreads and output deviations in both data and model, demonstrating the model's ability to capture the state-dependent nature of financial frictions.

Distribution of credit spreads. The model generates a right-skewed distribution of credit spreads that matches empirical patterns across the US, the UK, and the Euro area. The left panel of Figure 3 shows credit spread distributions for the Euro area, US, and UK, all exhibiting substantial right skewness with most observations concentrated near zero but occasional spikes to high values. The right panel demonstrates that the model successfully replicates this distributional pattern.

This right-skewed distribution arises from the occasionally binding nature of the leverage constraint. During normal times, when banks operate far from their leverage constraints, credit spreads remain low and stable, driven primarily by banks' stochastic preference for safe assets. However, during infrequent financial stress episodes, when the constraint binds, banks initiate fire sales of firm equity to increase their safe asset ratio and alleviate the leverage constraint. This creates upward pressure on firm equity yield whilst also depressing investment and, as a consequence, the output gap. The central bank attempts to stabilise the output gap by reducing the policy rate. The resulting divergence between equity and safe asset returns generates the sharp credit spread spikes observed during financial stress episodes.

This distributional match provides important quantitative validation of the model, showing that it can replicate both the typical low-spread environment and the tail events that characterise financial stress episodes.

Average financial stress episode. As documented in Akinci and Queralto (2022), financial stress episodes are characterised by severe declines in output, investment, consumption, and spikes in credit spreads. Figure 4 demonstrates that the model successfully replicates both the magnitude and persistence of these stress dynamics. A financial stress episode in the model is defined as a period where the leverage constraint of the banking sector binds for at least two consecutive periods.

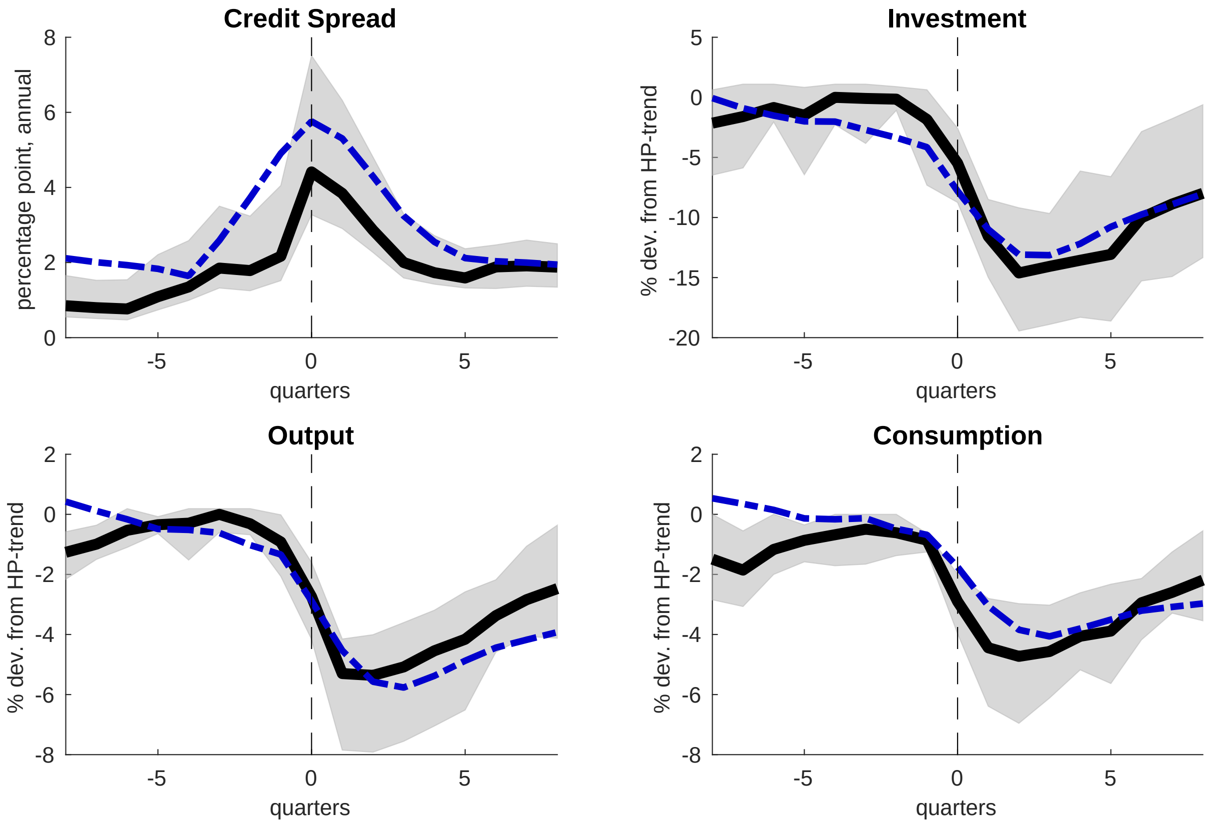
During a typical financial stress episode, the model generates credit spread spikes of around five percentage points (annualised), with investment experiencing the most severe contraction of approximately 10% below trend. Output and consumption decline by around 4% each, consistent with the empirical evidence. The model accurately captures the empirical ranking of crisis severity: investment suffers the largest decline, followed by output and consumption with similar magnitudes.

The model reproduces the highly persistent nature of financial crises documented in the data. Credit spreads remain elevated for three to four quarters after the initial spike before gradually declining, though they remain above normal levels for extended periods. Real variables exhibit similarly persistent effects reflecting the gradual nature of bank recapitalisation and the unwinding of financial frictions.

The model-implied variable paths (dashed blue lines) generally fall within the empirical ranges across all variables. The framework captures the key empirical regularity that financial crises are characterised not just by sharp initial contractions, but by prolonged periods of below-trend performance as the financial system recapitalises.

These crisis dynamics reflect the model's financial friction mechanism. Financial stress episodes are triggered when adverse shocks push bank leverage to its upper bound, rendering financial intermediation frictional. Once constrained, banks initiate equity fire sales to improve their balance sheet composition, depressing equity prices and investment. The persistence of these effects stems from the slow recapitalisation process, as banks need to rebuild their net worth to alleviate the leverage constraint.

Figure 4: Average financial crisis



Note: Credit spread, policy rate, and inflation are percentage points. Other variables are in percent deviations from HP-trend. Solid black line - data mean, shaded regions - min. and max. values of variables in the data. Average financial crisis episode is defined as a period where the leverage constraint of the banking sector binds for at least two consecutive periods. The financial stress episode starts in period zero. The plot shows dynamics of aggregate variables eight periods prior to and after the first period where the leverage constraint starts to bind.
Sources: Akinci and Queralto (2022), FRED, Bank of England, author's calculations.

The model's ability to replicate the average crisis dynamics as well as long-run business cycle moments and other financial stress stylised facts provides strong empirical validation, particularly given its relatively parsimonious structure compared to medium-scale DSGE models with wage rigidities and consumption habits.

4 Balance Sheet Policy and Financial Stress

This section examines how central bank balance sheet policies affect macroeconomic and financial stability. The analysis proceeds in two parts. First, I evaluate rule-based QE policies that target credit spread deviations, which serve as natural indicators of financial stress. Second, I examine QE effectiveness during monetary tightening cycles by subjecting the model economy to an inflationary shock that triggers sharp policy rate increases and induces financial stress.

QE rules. Throughout this section, I assume that the central bank implements the following rules for the acquisition of long-term debt from households and private non-financial firm equity from banks:

$$\frac{B^{cb}_{L,t}}{B^{L,cb}} = \left(\frac{S_t}{S}\right)^{\phi^B_{QE}} \quad , \quad \frac{K^{cb}_t}{K^{cb}} = \left(\frac{S_t}{S}\right)^{\phi^K_{QE}} , \tag{20}$$

where $\phi^i_{QE} > 0, i \in \{B, K\}$ is the elasticity of long-term debt and non-financial firm equity purchases with respect to the credit spread, $S_t \equiv \mathbb{E}_t\{R^K_{t+1} - R_t/\pi_{t+1}\}$; if the credit spread increases, indicating a financial stress episode, the central bank increases its holdings of either private or public assets. The balance sheet expansion is financed by the issuance of central bank reserves to financial intermediaries via the central bank revenue neutrality condition (13).

The policy rules in Equation (20) are financial stability QE, meaning the central bank balance sheet is only used to stabilise the financial sector and not to achieve other policy goals such as inflation stabilisation.

The two types of QE operate through distinct transmission mechanisms that have important implications for financial stability. The most immediate difference lies in their balance sheet effects. Public QE increases the provision of reserves to banks, which alleviates their moral hazard problem by raising the safe asset proportion of their portfolios. Although this intervention increases bank leverage, it simultaneously raises the upper bound for leverage, effectively loosening the leverage constraint. In contrast, private QE maintains constant bank leverage by swapping firm equity for reserves, leaving balance sheet size unchanged whilst directly improving the safe asset composition.

Beyond balance sheet effects, the two policies differ in their impact on the yield curve. Public QE exerts downward pressure on long-term yields, incentivising households to shift their portfolios towards bank deposits. This portfolio rebalancing reduces deposit rates through the household no-arbitrage condition, which positively impacts bank net worth. Private QE, however, does not directly affect the long yield.

Perhaps most importantly for financial stability, these mechanisms create differential effects on banks' recapitalisation capacity. During crisis episodes, private QE swaps high-yield private assets for low-yield safe assets, directly distorting banks' excess returns and hampering their ability to rebuild capital. Public QE, whilst supporting bank profitability through lower deposit rates, does not directly alter the quantity of banks' private asset holdings.

These transmission differences generate distinct effects on macroeconomic stability and financial stress frequency, which I examine in the following subsections.

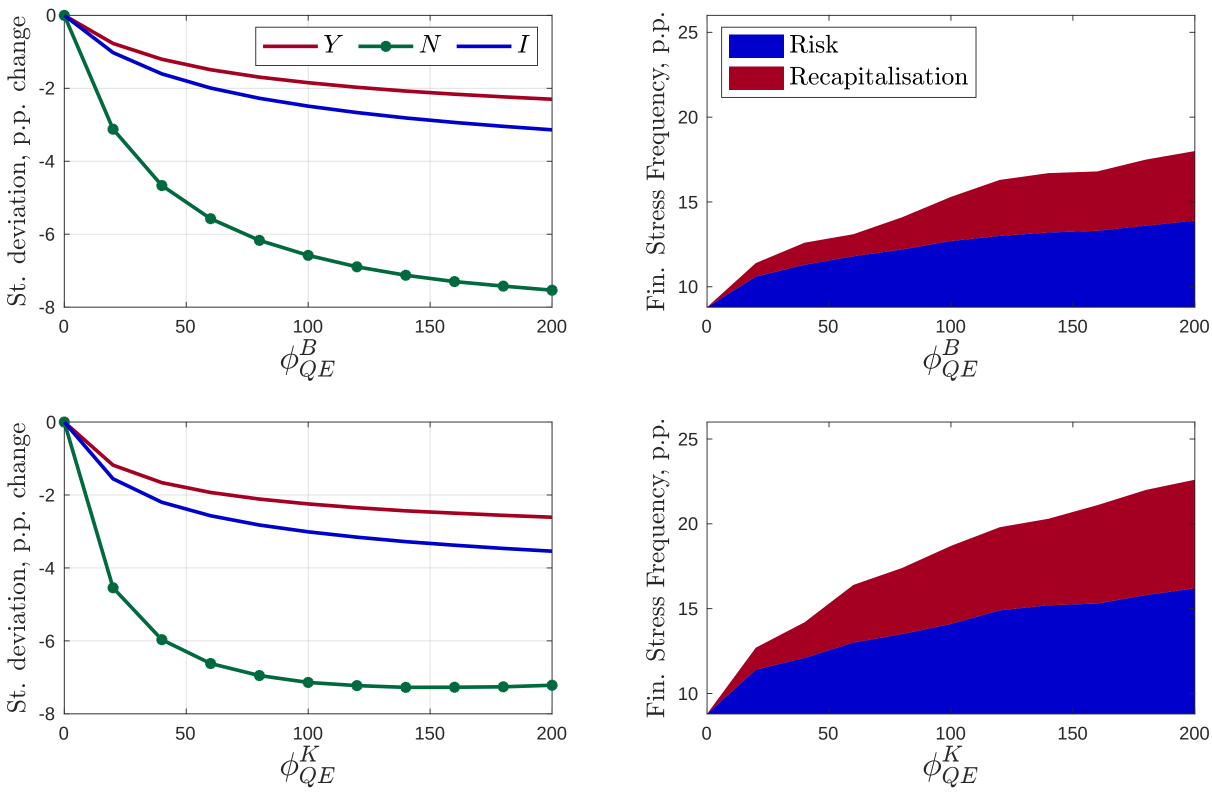
4.1 Stabilisation and Stress Frequency

To explore the stabilisation properties of balance sheet rules, I simulate the model under the two QE policy rules defined in Equation (20). Using the simulated data, I calculate standard deviations of key variables and the frequency of financial stress episodes compared to the baseline case with no balance sheet interventions. The results are presented in Figure 5.

The left panel shows that balance sheet interventions effectively stabilise macroeconomic aggregates and bank variables. Standard deviations of output, investment, and bank net worth are significantly lower under QE because balance sheet interventions increase central bank reserves provision to commercial banks and stabilise asset prices, thereby mitigating the severity of their leverage constraints during financial stress.

Private QE demonstrates slightly stronger stabilisation effects than public QE due to its direct impact on fire sale dynamics. When the central bank acquires private firm assets from commercial banks, it directly purchases these assets, thereby stabilising their prices and alleviating the vicious cycle of fire sales that characterises financial stress episodes. Public QE, whilst increasing the provision of safe assets, does not directly affect non-financial firm equity demand and thus provides less direct stabilisation of the underlying fire sale mechanism.

Figure 5: Stabilisation and Stress Frequency



Note: Left - standard deviations expressed as deviations from quarterly mean, change in p.p. relative to baseline with no balance sheet interventions. Right - frequency of financial stress episodes, i.e. banks' leverage constraint is binding, decomposed in recapitalisation and risk channels. Top panel pertains to public QE, whilst bottom panel is related to private QE.

The right panel reveals a trade-off between macroeconomic stabilisation and stress frequency: balance sheet expansions targeted at alleviating financial stress increase the frequency of financial stress episodes. Under the baseline with constant central bank balance sheet size, the bank leverage constraint binds approximately 9% of the time. When the central bank adopts public QE with moderate elasticity ($\phi^B_{QE} = 20$), stress frequency rises to around 12%. Under more aggressive public QE, ($\phi^B_{QE} = 200$), stress frequency increases to 18% of the simulated sample.

Private QE generates qualitatively similar results but with more pronounced effects. The more aggressive the central bank intervention (higher ϕ^K_{QE}), the more frequent the financial stress episodes become. Under the most aggressive simulated private QE rule ($\phi^K_{QE} = 200$), financial stress episodes occur approximately 23.5% of the time, compared to 18% under equally aggressive public QE. This higher stress frequency under private QE reflects the stronger stabilisation it provides, particularly for bank net worth, the variable banks seek to maximise. By making financial stress less painful for banks, QE reduces banks' incentives to exercise precautionary behaviour.

This creates a fundamental policy dilemma: whilst QE effectively stabilises variables during crisis episodes, it simultaneously makes such episodes more likely to occur. The magnitude of this trade-off is economically significant and more severe for private QE than public QE, reflecting the differential impact of the two policies on banks' incentives to avoid financial stress.

QE and financial stress frequency. The higher frequency of financial stress episodes induced by balance sheet policies operates through two distinct channels: changes in bank risk-taking behaviour (risk channel) and banks' impaired recapitalisation ability during financial stress episodes (recapitalisation channel).

The risk channel operates through banks' precautionary behaviour. Banks exhibit precautionary behaviour when they assign non-zero probability of their leverage constraint binding in the future, as binding constraints severely deteriorate their net worth and franchise value. This precautionary behaviour manifests as holding fewer private assets — effectively extending fewer loans to firms — which results in lower leverage and reduces the likelihood of hitting the leverage constraint. The importance of this behaviour is demonstrated in Table 4: when banks do not anticipate hitting their leverage constraint at any point in time (asterisk column), stress frequency reaches 22.08%, but when they factor in this risk and exhibit precautionary behaviour, stress frequency drops to 8.79% — a reduction of over 13 percentage points.

QE reduces this precautionary motive by making financial stress episodes less destabilising for bank net worth. When banks anticipate central bank intervention during stress episodes, they expect milder consequences for their net worth. This reduced concern about financial stress weakens their incentive to maintain conservative balance sheets, leading them to choose higher leverage and operate closer to their leverage constraints.

The recapitalisation channel operates through QE's distortionary effects on bank returns during stress episodes. QE reduces credit spreads during financial stress, which lowers banks' excess returns and impairs their ability to recapitalise. This effect is more

Table 4: Stress frequency: risk and recapitalisation channels

	Baseline		Public QE			Private QE		
ϕ^i_{QE}	0*	0	20	60	100	20	60	100
Stress Frequency	22.08	8.79	11.39	13.09	15.28	12.69	16.38	18.68
Δ from Baseline	13.29	-	2.60	4.30	6.49	3.90	7.59	9.89
Recapitalisation	-	-	0.80	1.30	2.60	1.30	3.40	4.60
Risk	-	-	1.80	3.00	3.90	2.60	4.20	5.29

Note: Columns correspond to different intervention types: Baseline – no intervention, Public QE – CB intervenes via long-term debt purchases, Private QE – CB intervenes via non-financial firm equity. Stress frequency measured as ratio of number of periods when leverage constraint is binding to sample length. Δ from Baseline - increase in stress frequency under QE policies. Recapitalisation: contribution of QE to stress due to distortion in bank recapitalisation. Risk: contribution of QE to stress related to higher risk-taking by banks. Asterisk denotes simulation where risk of hitting the constraint is not approximated; agents put zero weight on the probability of leverage constraint becoming binding at any point. All values in percentage points.

pronounced under private QE, which swaps banks' high-yield private assets for low-yield safe assets, directly reducing banks' excess returns. Under public QE, private assets remain on banks' balance sheets, and the policy contributes to bank profitability through lower deposit rates, resulting in higher excess returns than under private QE.

To quantify each channel's contribution, I simulate the model under identical shock sequences with varying QE intensities. The decomposition works as follows: If a financial stress episode occurs only under QE but not in the baseline, or starts earlier under QE, it reflects the risk channel—banks operating closer to their leverage constraints due to reduced precautionary behaviour. If a financial stress episode occurs in both regimes but lasts longer under QE, the additional duration is attributed to the recapitalisation channel—banks' impaired ability to rebuild capital and exit the constrained state.

These two channels may interact non-linearly which affects the decomposition. The risk channel induces banks to adopt higher ex-ante leverage in anticipation of QE. When negative shocks materialise, a highly leveraged bank experiences deeper initial declines in net worth. Recapitalising from a lower base mechanically takes longer, regardless of any direct QE effects on bank incentives during the crisis. The current methodology attributes all additional crisis duration to the recapitalisation channel, thereby conflating this mechanical effect with the pure incentive effects of QE on bank behaviour prior to stress episodes. Consequently, the decomposition should be interpreted as providing an upper bound for the recapitalisation channel's direct contribution, whilst the risk channel's full impact — including its indirect consequences for crisis severity — is understated.

For public QE, the risk channel dominates across all policy intensities. As the elasticity of central bank asset purchases increases, it leads to uniformly better stabilisation of bank net worth, which progressively reduces banks' precautionary motive. Even under the most aggressive public QE policy, the risk channel (3.90 percentage points) exceeds the recapitalisation channel (2.60 percentage points), reflecting public QE's primary effect of reducing banks' fear of financial stress.

Private QE exhibits a different pattern. Whilst the risk channel initially dominates for moderate interventions, the recapitalisation channel becomes increasingly important as policy intensity rises. Under the most aggressive private QE, the recapitalisation channel reaches 4.60 percentage points—a significant effect that adds roughly half the stress frequency observed under the no-QE baseline. This reflects private QE's severe distortion of bank returns through the direct swapping of high-yield private assets for low-yield safe assets, which significantly impairs banks' ability to recapitalise during stress episodes.

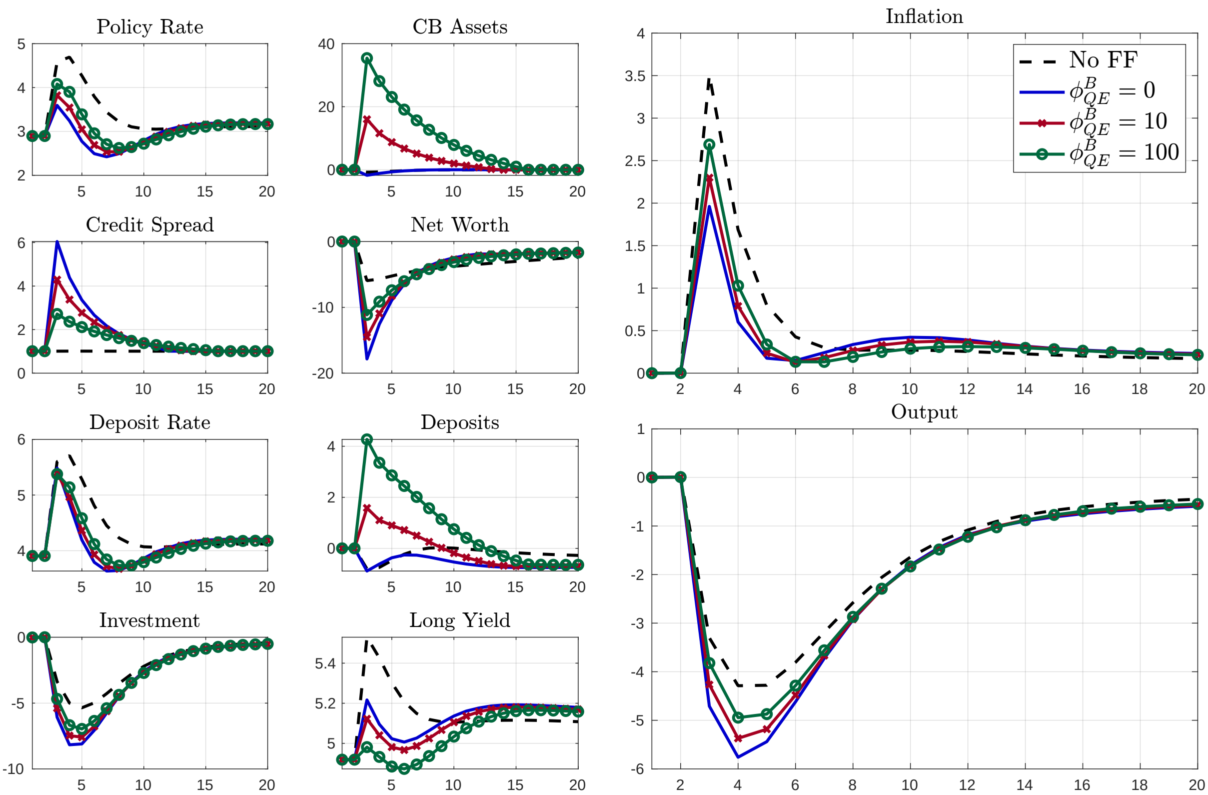
The quantitative significance of these effects underscores a fundamental policy trade-off: whilst QE effectively stabilises the economy during crisis episodes, it creates moral hazard that makes such episodes more frequent and, especially in the case of private QE, more persistent.

4.2 QE in a Tightening Cycle

To study the implications of QE on financial and price stability in a tightening cycle, I subject the model economy to a markup shock that drives up inflation, triggers policy rate hikes, and leads to endogenous financial stress. Figure 6 plots the simulated paths of selected variables under four scenarios: no financial frictions (dashed black line), financial frictions with no QE intervention (solid blue line), and financial frictions with moderate (solid red line) and aggressive (solid green line) public QE responses.

The markup shock translates to 3.5% inflation on impact. In the frictionless economy, this inflationary pressure prompts aggressive monetary tightening and leads to sharp declines in output and investment of 4.5% and 5%, respectively. However, the

Figure 6: Does QE increase inflation in tightening cycle?



Note: 7% markup shock materialises in period 3. All variables are in deviations from stochastic steady state except inflation, interest rates, deposit rate, long yield, and credit spread, which are annualised rates. Dashed black line – no financial friction. Solid blue line – no intervention. Solid red line – public QE, $\phi^B_{QE} = 10$. Solid green line – public QE, $\phi^B_{QE} = 100$.

presence of financial frictions fundamentally alters this dynamic.

In the presence of financial frictions and without QE, the initial monetary tightening pushes banks to their leverage constraints, triggering financial stress and equity fire sales. This creates a pronounced decline in investment and output, accompanied by credit spread spikes. Crucially, the financial friction acts as a sudden stop mechanism that constrains inflation propagation: as banks reach their constraints, the resulting credit crunch depresses investment, labour demand, and aggregate demand, leading to lower inflation than in the frictionless case.

QE intervention mitigates these effects by alleviating banks' leverage constraints and mitigating the severity of the credit crunch. The policy also depresses long-term yields, incentivising households to shift their portfolios towards bank deposits. These effects substantially reduce the decline in investment and output compared to the no-intervention case.

However, this financial stabilisation comes at a significant cost to price stability. Since QE weakens the financial friction that was constraining inflation, it allows more complete inflation transmission. The improved financial stability enables more aggressive policy rate tightening under QE. Yet even with higher policy rates, inflation remains persistently higher under QE because the effects of the financial sector's sudden stop are dampened.

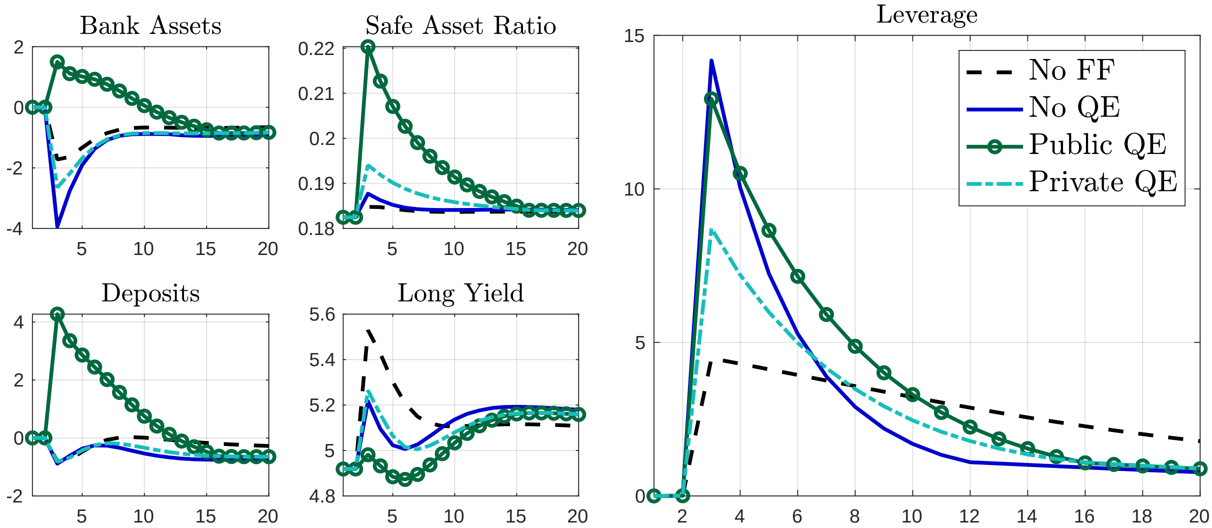
The enhanced financial stability under QE also creates a persistence problem. Financial stress episodes last longer under QE because the policy compresses banks' total excess returns through three channels: banks pay higher deposit rates on expanded deposit bases as policy rates rise, credit spreads are compressed by the intervention, and banks hold more low-yielding central bank reserves relative to higher-yielding firm equity. These compressed returns impair banks' recapitalisation capacity, preventing them from exiting financial stress as quickly as they would without intervention.

This experiment highlights that QE does not resolve the fundamental trade-off between price and financial stability. Whilst QE effectively stabilises financial conditions and real activity during tightening cycles, implementing such policies inevitably compromises price stability by allowing inflation to propagate more fully through the economy.

4.3 Transmission of Public and Private QE

To illustrate the distinct transmission channels of public and private QE, Figure 7 compares their effects on key financial variables conditional on the same markup shock as in Section 4.2. The interventions are calibrated to deliver equivalent stabilisation of real variables, isolating the differences in transmission mechanisms rather than overall effectiveness.

Figure 7: Key Bank Variables under Public and Private QE



Note: 7% markup shock materialises in period 3. Dashed black line – no financial friction. Solid blue line – no intervention. Solid red line – public QE, $\phi^B_{QE} = 100$. Solid green line – private QE calibrated to yield the same credit spread on impact as public QE ($\phi^K_{QE} = 50$).

Balance sheet effects differ markedly between the two policies. Public QE expands banks' balance sheets by increasing both their safe asset holdings and leverage, as the central bank purchases government bonds from households and provides reserves to banks. Under private QE, by contrast, the bank balance sheet size contracts due to valuation effects: as the central bank purchases firm equity at depressed prices and provides reserves in return, the decline in equity valuations causes overall balance sheet contraction. This contraction improves the safe asset ratio through both portfolio rebalancing and the reduction in total assets.

Yield curve transmission reveals another key distinction. Public QE exerts substantial downward pressure on long-term government yields, as the central bank's bond purchases reduce the supply available to private investors. This yield compression incentivises households to shift toward bank deposits, leading to lower deposit rates that support bank profitability. Private QE leaves both long-term yields and deposit rates largely unchanged, as it does not directly affect government bond markets or household portfolio allocation.

Recapitalisation implications emerge through these differential effects on bank returns. Private QE directly reduces banks' exposure to high-yield private assets during the crisis, limiting their ability to benefit from elevated equity returns that would otherwise facilitate rapid recapitalisation. Public QE, whilst supporting bank profitability through lower funding costs, preserves banks' holdings of private assets, allowing them to benefit more from crisis-period elevated yields on private assets.

These transmission differences explain why private QE, despite providing equivalent real stabilisation, tends to create more persistent financial stress episodes and higher stress frequency than public QE, as demonstrated in Section 4.1.

5 Optimal Monetary Policy

This section analyses the optimal mix of interest rate and balance sheet policies. The central bank faces a fundamental trade-off between price and financial stability: whilst QE effectively mitigates financial stress episodes, it simultaneously increases their frequency and duration, and compromises price stability during tightening cycles.

This raises several policy questions: Should the central bank tolerate higher inflation through less aggressive interest rate policy to reduce financial stress frequency? How extensively should the central bank commit to balance sheet expansions during financial stress? How can these two monetary policy tools be optimally combined to balance price and financial stability objectives?

This section addresses these questions through two complementary exercises. First, I demonstrate that the central bank can reduce financial stress frequency by placing greater weight on output gap stabilisation in its policy rate rule, though this comes at the cost of higher inflation volatility. Second, I characterise the optimal policy mix that balances the stabilisation benefits of QE against its efficiency costs and adverse effects on bank precautionary behaviour.

Interest rate policy and stress incidence. Banks in the model face interest rate risk. Rapid increases in the real interest rate induced by aggressive monetary tightening lead to capital decumulation, declines in the price of capital, and contractions in financial sector net worth, ultimately causing the leverage constraint to bind. To reduce financial

Table 5: Conventional policy and financial stress frequency.

Output gap parameter (ϕ_y)	**Stress frequency (%)**	**Inflation std. (%)**
0.075	9.2	0.87
0.100	8.4	1.00
0.200	4.8	1.63
0.300	4.5	2.44
0.400	3.5	3.59
0.500	2.0	5.25

Note: Stress frequency – ratio of number of periods where bank leverage constraints are binding to sample length. Credit gap (output loss) – percent decline in non-financial firm equity (output) relative to baseline economy with no financial frictions. Welfare loss – change in household welfare relative to baseline economy without financial frictions.

stress frequency, the central bank can react less aggressively to inflation by placing greater weight on output gap stabilisation in its policy rule (10).

Table 5 illustrates this trade-off by simulating the model under different values of the output gap feedback coefficient ϕ_y. The results reveal a clear relationship: increasing ϕ_y from 0.075 to 0.5 reduces stress frequency from 9.2% to 2.0%, but raises quarterly inflation volatility from 0.87% to 5.25%.

The underlying mechanism operates through real interest rate volatility. When the central bank emphasises output gap stabilisation, shocks generate smaller changes in real interest rates. This dampens the interest rate risk, thereby making the leverage constraint less likely to bind. However, this financial stability benefit requires tolerating substantially higher inflation volatility, creating a fundamental policy trade-off between price and financial stability. Furthermore, I analyse how QE can be used to mitigate this trade-off.

5.1 Optimal policy mix

This section analyses optimal policy within the class of simple rules for conventional and balance sheet policies considered in the paper. The exercise determines the welfare-maximising combination of interest rate and QE policy parameters that balances the following sources of welfare costs: losses from inflation volatility due to nominal rigidities, investment adjustment costs induced by real rate changes, the costs of financial stress episodes, and the efficiency costs of QE interventions.

The optimal policy choice involves a fundamental trade-off between preventing financial stress ex ante through conventional monetary policy versus treating it ex post through balance sheet interventions. As demonstrated in Section 4.1, QE commitment creates moral hazard by distorting banks' precautionary behaviour. Banks anticipate central bank support and operate closer to their leverage constraints. This increases both the frequency and duration of financial stress episodes through the risk channel (reduced precautionary behaviour) and the recapitalisation channel (impaired ability to exit stress episodes).

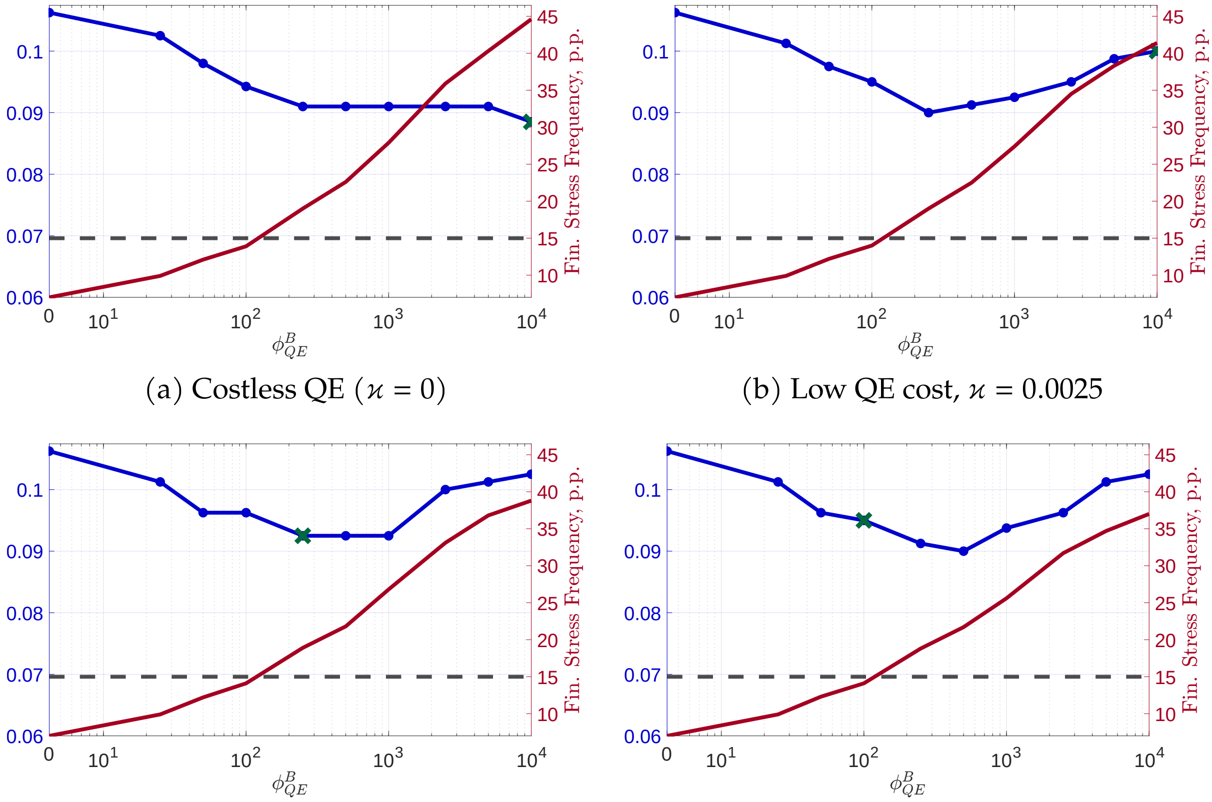
To analyse the optimal policy mix, I simulate the model under different values of the policy rate feedback coefficient, ϕ_y, the elasticity of QE, ϕ^B_{QE}, and the cost of QE, $\varkappa$. For each QE elasticity value, I determine the output gap feedback coefficient that maximises household welfare. Figure 8 shows these optimal ϕ_y values (blue line) and the corresponding financial stress frequency (red line) under different QE cost scenarios.

Costless QE and frictionless policy benchmark. Consider the case of costless QE shown in Figure 8a that illustrates the role of financial frictions in monetary policy design. The dashed black line at $\phi_y \approx 0.07$ represents the unconstrained optimum — the optimal output gap coefficient in an economy without financial frictions. This benchmark reflects the optimal balance between minimising welfare losses from nominal price rigidities and investment adjustment costs induced by interest rate adjustments.

When financial frictions are present but QE is costless, the optimal policy exhibits a clear pattern. The blue line shows that for low QE elasticity, it is optimal to emphasise output gap stabilisation to reduce financial stress frequency directly through conventional policy. As QE elasticity increases, it becomes optimal to reduce the weight on output gap stabilisation and instead rely more heavily on QE to address financial stress ex post. This explains why the optimal ϕ_y is decreasing in the elasticity of QE, ϕ^B_{QE}.

The green cross marks the globally optimal policy combination under costless QE: $\phi^B_{QE} = 10^4$ with $\phi_y = 0.09$. This represents aggressive inflation targeting (ϕ_y close to the unconstrained optimum) combined with highly elastic QE that can fully stabilise financial stress. Even though this policy leads to the highest financial stress frequency due to moral hazard effects (as shown by the red line reaching its peak), the costless nature of interventions means the central bank can perfectly offset the financial friction

Figure 8: Optimal monetary policy mix



(a) Costless QE ($\varkappa = 0$)

(b) Low QE cost, $\varkappa = 0.0025$

(c) Medium QE cost ($\varkappa = 0.005$)

(d) High QE cost ($\varkappa = 0.01$)

Note: Blue line illustrates the value of output gap coefficient in the Taylor rule, ϕ_y (left axis) that implies the highest household welfare given elasticity of public QE, ϕ^B_{QE}. Red line plots the implied frequency of financial stress episodes (right axis). The green cross on the blue lines shows the globally optimal combination of ϕ_y and ϕ^B_{QE}. The black dashed line corresponds to the optimal value of ϕ_y in the same economy without financial frictions. Each subfigure corresponds to a different value of QE efficiency costs.

without welfare consequences. The moral hazard becomes irrelevant because highly elastic QE can mitigate the adverse effects of the financial friction regardless of the frequency of it becoming binding.

Introducing QE efficiency costs. In reality, central bank balance sheet expansions involve significant efficiency and political costs that extend beyond the scope of this paper. The central bank conducting highly aggressive balance sheet expansions — whilst theoretically optimal under costless QE — is practically undesirable due to concerns about market functioning and intermediation efficiency. These unmodelled costs justify introducing explicit efficiency costs of balance sheet interventions, captured by parameter $\varkappa$ in Equation (12).

When QE bears efficiency costs, the moral hazard effects become economically significant because more frequent stress episodes require more costly interventions. This alters the optimal policy logic, shifting the trade-off from pure stabilisation toward a balance between prevention and treatment of financial stress.

Under low efficiency costs (Figure 8b, $\varkappa = 0.0025$), the moral hazard effects begin to matter for policy design. The optimal policy combination remains at high QE elasticity ($\phi^B_{QE} = 10^4$) but shifts toward greater emphasis on output gap stabilisation ($\phi_y = 0.10$). This adjustment reflects the central bank's recognition that moral hazard increases financial stress frequency, making it worthwhile to reduce stress incidence through conventional policy even whilst maintaining highly elastic QE. This allows the central bank to shift its policy stance from treatment of consequences of financial stress to its prevention.

The rising red line demonstrates how higher QE elasticity increases financial stress frequency through both distorted bank behaviour and greater real interest rate volatility from more aggressive inflation targeting until the inflection point of the blue line at $\phi^B_{QE} = 500$. As QE becomes more aggressive, the central bank leans towards more accommodative interest rate policy to reduce frequency and severity of financial stress. Beyond the inflection point, it becomes optimal for the central bank to attach progressively higher weight to inflation targeting. While the efficiency costs remain modest, the central bank finds it optimal to lean slightly toward financial stress prevention rather than pure post-crisis intervention.

As efficiency costs rise (Figure 8c, $\varkappa = 0.005$), the optimal policy shifts more decisively toward prevention of financial stress. The globally optimal combination becomes $\phi^B_{QE} = 250$ with $\phi_y \approx 0.0925$. This represents a substantial reduction in QE elasticity combined with greater emphasis on output gap stabilisation relative to the low-cost scenario.

The economic intuition is clear: as QE becomes more expensive, the interaction between moral hazard and policy-induced real interest rate volatility becomes costly. Banks' distorted precautionary behaviour creates a higher propensity for financial stress, which aggressive inflation targeting further exacerbates. Rather than treating frequent stress episodes with costly interventions, the central bank finds it optimal to reduce their occurrence through more accommodative conventional policy and more moderate QE responsiveness.

Under high efficiency costs (Figure 8d, $\varkappa = 0.01$), this pattern intensifies further. The optimal policy becomes $\phi^B_{QE} = 100$ with $\phi_y \approx 0.095$, representing a shift toward prevention-oriented policy. The central bank emphasises output gap stabilisation and does not commit to reactive QE to minimise the sources of financial stress: the risk-seeking behaviour of the banks, the distortions that impede recapitalisation, and additional stress from real rate volatility.

Efficiency costs of QE fundamentally change the optimal approach to financial stability. Rather than relying on balance sheet interventions to address stress ex post, the central bank increasingly relies on conventional policy to prevent stress ex ante. The high efficiency costs make frequent interventions prohibitively expensive, even when they would be effective at stabilising financial conditions.

The progression across cost scenarios reveals a fundamental principle: as QE efficiency costs rise, moral hazard amplifies the welfare costs of aggressive inflation targeting. Banks operating closer to their leverage constraints due to anticipated central bank support become more vulnerable to policy-induced real rate volatility. When interventions are costly, this creates a vicious cycle where aggressive inflation targeting generates more frequent stress episodes requiring commitment to aggressive QE responses that induce even more financial stress.

The optimal policy response is to break this cycle through more moderate conventional policy that reduces financial stress frequency. This represents a shift from a treatment-oriented approach under costless QE to an increasingly prevention-oriented approach as efficiency costs rise, demonstrating how practical constraints on central bank balance sheet policy fundamentally alter the optimal conduct of monetary policy in a framework with occasional financial crises.

6 Conclusion

This paper demonstrates that routine use of balance sheet policies creates a financial stability trap: anticipated interventions weaken banks' precautionary incentives, generating the very instability they aim to address. I establish three main findings. First, anticipated QE drastically increases crisis frequency through weakened precautionary behaviour and impaired recapitalisation. Second, QE cannot resolve the fundamental tradeoff between price and financial stability during tightening cycles. Third, optimal policy depends critically on QE efficiency costs, with crisis prevention dominating crisis management when balance sheet operations are costly.

Anticipated QE increases financial stress frequency through two distinct channels. Ex ante, expecting central bank support weakens banks' precautionary behaviour, leading them to operate with higher leverage in normal times. Ex post, by purchasing higher-yield assets in exchange for low-yield reserves, QE reduces banks' portfolio returns during stress, slowing recapitalisation and prolonging crisis duration. Under aggressive QE policies, the financial stress frequency increases from 9% to nearly 50%. Anticipated interventions generate the very instability they aim to address.

QE cannot resolve the fundamental tradeoff between price and financial stability during monetary tightening. When policy rate increases trigger financial stress and leverage constraints bind, powerful deflationary forces emerge: credit crunches depress investment, demand for labour, and, thus, aggregate demand, exerting downward pressure on inflation. Balance sheet interventions stabilise credit and investment, preventing these deflationary forces and thereby sustaining inflationary pressures. Financial stabilisation via balance sheet interventions undermines inflation stabilisation.

Incorporating banks' precautionary behaviour reveals a vicious cycle central to optimal policy design: aggressive balance sheet commitments weaken precautionary incentives, generating more frequent stress that requires more aggressive interventions. This self-reinforcing instability fundamentally shapes the choice between "clean" and "lean" strategies. When balance sheet operations are costless, the central bank can tolerate this cycle, aggressively targeting inflation whilst deploying QE ex post to manage the resulting financial stress despite higher frequency and inflationary pressures. When QE entails efficiency costs, the compounding nature of this vicious cycle becomes prohibitively expensive: stronger interventions generate more moral hazard, requiring more interventions. A "lean" strategy becomes optimal, breaking the cycle through accommodative conventional policy that prevents stress ex ante.

These findings challenge the post-crisis consensus that central banks should respond aggressively to financial stress through balance sheet interventions. Whilst QE stabilises markets during acute crises, routine reliance on such interventions creates moral hazard that undermines long-run financial stability. The 2022-2023 episodes — where central banks simultaneously tightened policy whilst expanding balance sheets — illustrate the fundamental tension this paper characterises. When balance sheet operations entail efficiency costs, central banks should favour crisis prevention over crisis management, leaning against the wind rather than cleaning up after the crisis.

References

Airaudo, Florencia. 2023. "Exit Strategies from Quantitative Easing: The role of the fiscal-monetary policy mix." *ECB working paper.*

Akinci, Ozge, Gianluca Benigno, Marco Del Negro, and Albert Queralto. 2023. "The Financial (In)Stability Real Interest Rate, r**." Unpublished manuscript.

Akinci, Ozge, and Albert Queralto. 2022. "Credit Spreads, Financial Crises, and Macroprudential Policy." *American Economic Journal: Macroeconomics* 14 (2): 469–507.

Auclert, Adrien, and Matthew Rognlie. 2023. "A note on multipliers in NK models with GHH preferences." *Unpublished,* https://web.stanford.edu/~aauclert/ghh_nk.pdf.

Benigno, Gianluca, and Pierpaolo Benigno. 2022. "Managing monetary policy normalization." *Federal Reserve Bank of New York Staff Report.*

Bernanke, Ben S., and Mark Gertler. 1999. "Monetary Policy and Asset Price Volatility." *Federal Reserve Bank of Kansas City Economic Review* 84 (4): 17–51.

———. 2001. "Should Central Banks Respond to Movements in Asset Prices?" *American Economic Review* 91 (2): 253–257.

Bianchi, Francesco, Renato Faccini, and Leonardo Melosi. 2022. *A Fiscal Theory of Trend Inflation.* NBER Working Paper Series. NBER.

Bianchi, Javier. 2011. "Overborrowing and Systemic Externalities in the Business Cycle." *American Economic Review* 101 (7): 3400–3426. https://doi.org/10.1257/aer.101.7.3400.

Bocola, Luigi. 2016. "The Pass-Through of Sovereign Risk." *Journal of Political Economy* 124, no. 4 (August): 879–926. ISSN: 1537-534X. https://doi.org/10.1086/686734. http://dx.doi.org/10.1086/686734.

Borio, Claudio, and Haibin Zhu. 2012. "Capital regulation, risk-taking and monetary policy: A missing link in the transmission mechanism?" *Journal of Financial Stability* 8 (4): 236–251.

Calvo, Guillermo A. 1983. "Staggered Prices in a Utility-Maximising Framework." *Journal of Monetary Economics* 12 (3): 383–398.

Chen, Han, Vasco Cúrdia, and Andrea Ferrero. 2012. "The Macroeconomic Effects of Large-Scale Asset Purchase Programmes." *The Economic Journal* 122 (564): 289–315.

Christiano, Lawrence J., Martin S. Eichenbaum, and Charles L. Evans. 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy." *Journal of Political Economy* 113 (1): 1–45.

Cúrdia, Vasco, and Michael Woodford. 2011. "The Central-Bank Balance Sheet as an Instrument of Monetary Policy." *Journal of Monetary Economics* 58 (1): 54–79.

Del Negro, Marco, Gauti B. Eggertsson, Andrea Ferrero, and Nobuhiro Kiyotaki. 2017a. "The Great Escape? A Quantitative Evaluation of the Fed's Liquidity Facilities." *American Economic Review* 107 (3): 824–857.

———. 2017b. "The Great Escape? A Quantitative Evaluation of the Fed's Liquidity Facilities." *American Economic Review* 107 (3): 824–857.

Dell'Ariccia, Giovanni, Luc Laeven, and Gustavo A. Suarez. 2017. "Bank Leverage and Monetary Policy's Risk-Taking Channel: Evidence from the United States." *The Journal of Finance* 72 (2): 613–654.

Elenev, Vadim. 2017. "Mortgage Credit, Aggregate Demand, and Unconventional Monetary Policy." *SSRN Electronic Journal,* ISSN: 1556-5068. https://doi.org/10.2139/ssrn.2951397. http://dx.doi.org/10.2139/ssrn.2951397.

Elenev, Vadim, Tim Landvoigt, Patrick Shultz, and Stijn Van Nieuwerburgh. 2021. "Can Monetary Policy Create Fiscal Capacity?" *SSRN Electronic Journal,* ISSN: 1556-5068. https://doi.org/10.2139/ssrn.3896402. http://dx.doi.org/10.2139/ssrn.3896402.

Elenev, Vadim, Tim Landvoigt, and Stijn Van Nieuwerburgh. 2021. "A Macroeconomic Model With Financially Constrained Producers and Intermediaries." *Econometrica* 89 (3): 1361–1418. ISSN: 0012-9682. https://doi.org/10.3982/ecta16438. http://dx.doi.org/10.3982/ECTA16438.

Farhi, Emmanuel, and Jean Tirole. 2012. "Collective Moral Hazard, Maturity Mismatch, and Systemic Bailouts." *American Economic Review* 102 (1): 60–93.

Gagnon, Joseph, Matthew Raskin, Julie Remache, and Brian Sack. 2011. "The Financial Market Effects of the Federal Reserve's Large-Scale Asset Purchases." *International Journal of Central Banking* 7 (1): 3–43.

Gertler, Mark, and Peter Karadi. 2011. "A Model of Unconventional Monetary Policy." *Journal of Monetary Economics* 58 (1): 17–34.

Gertler, Mark, and Nobuhiro Kiyotaki. 2010. "Financial Intermediation and Credit Policy in Business Cycle Analysis." *Handbook of Monetary Economics* 3:547–599.

Greenwood, Jeremy, Zvi Hercowitz, and Gregory Huffman. 1988. "Investment, Capacity Utilization, and the Real Business Cycle." *American Economic Review* 78 (3): 402–417.

Haas, Alexander. 2023. "Monetary Policy in a Tightening Cycle Raising nominal rates without causing a financial crisis." *Working paper.*

Haddad, Valentin, Alan Moreira, and Tyler Muir. 2025. "Whatever It Takes? The Impact of Conditional Policy Promises." *American Economic Review* 115, no. 1 (January): 295–329. ISSN: 1944-7981. https://doi.org/10.1257/aer.20230486. http://dx.doi.org/10.1257/aer.20230486.

Jiménez, Gabriel, Steven Ongena, José-Luis Peydró, and Jesús Saurina. 2014. "Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk-Taking?" *Econometrica* 82 (2): 463–505.

Karadi, Peter, and Anton Nakov. 2021. "Effectiveness and addictiveness of quantitative easing." *Journal of Monetary Economics* 117 (January): 1096–1117. ISSN: 0304-3932. https://doi.org/10.1016/j.jmoneco.2020.09.002. http://dx.doi.org/10.1016/j.jmoneco.2020.09.002.

Kareken, John H., and Neil Wallace. 1978. "Deposit Insurance and Bank Regulation: A Partial-Equilibrium Exposition." *The Journal of Business* 51, no. 3 (January): 413. ISSN: 1537-5374. https://doi.org/10.1086/296006. http://dx.doi.org/10.1086/296006.

Krishnamurthy, Arvind, and Annette Vissing-Jorgensen. 2011. "The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy." *Brookings Papers on Economic Activity* 42 (2): 215–287.

Mendoza, Enrique G. 2010. "Sudden Stops, Financial Crises, and Leverage." *American Economic Review* 100 (5): 1941–1966.

Stein, Jeremy C. 2012. "Monetary policy as financial-stability regulation." *The Quarterly Journal of Economics* 127 (1): 57–95.

Svensson, Lars E. O. 2017. "Cost-benefit analysis of leaning against the wind." *Journal of Monetary Economics* 90:193–213.

Wallace, Neil. 1981. "A Modigliani-Miller Theorem for Open-Market Operations." *American Economic Review* 71 (3): 267–274.

Woodford, Michael. 2012. *Inflation Targeting and Financial Stability.* Technical report 17967. NBER Working Paper.

A Solution of the banker problem

Banks maximise the franchise value given by Equation (5) subject to the incentive constraint (4), balance sheet constraint (2), and the flow of funds constraint (3).

The banker problem can be reformulated such that banks choose leverage $\phi_t \equiv (Q_t k_t^I + b_{S,t}^I)/n_t$ and safe asset ratio x_t to maximise the franchise-value-to-net worth ratio, ψ_t, subject to (A1):

$$\psi_t = \max_{x_t,\phi_t} \left((\mu_t^K + \mu_t^B)(1 - x_t) + (\mu_t^B + \zeta_t^b)x_t \right) \phi_t + \upsilon_t$$

subject to the incentive compatibility constraint

$$\left((\mu_t^K + \mu_t^B)(1 - x_t) + (\mu_t^B + \zeta_{t+s}^b)x_t \right) \phi_t + \upsilon_t \geq \Theta(x_t)\phi_t, \tag{A1}$$

where the following definitions of the banker's discounted equity spread, safe asset spread, and return on deposits are used:

$$\upsilon_t \equiv \mathbb{E}_t \Lambda_{t,t+1}(1 - \sigma_b + \sigma_b \psi_{t+1}) \frac{R_t^d}{\pi_{t+1}},$$

$$\mu_t^K \equiv \mathbb{E}_t \Lambda_{t,t+1}(1 - \sigma_b + \sigma_b \psi_{t+1}) \left(R_{t+1}^k - \frac{R_t}{\pi_{t+1}} \right),$$

$$\mu_t^B \equiv \mathbb{E}_t \Lambda_{t,t+1}(1 - \sigma_b + \sigma_b \psi_{t+1}) \left(\frac{R_t}{\pi_{t+1}} - \frac{R_t^d}{\pi_{t+1}} \right).$$

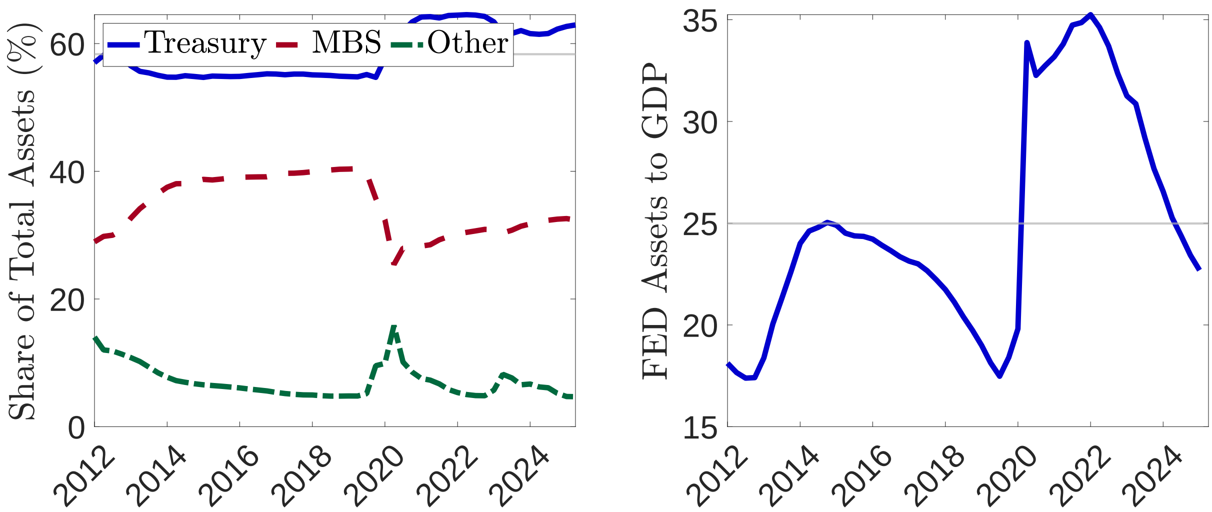
Solution to the problem implies the following first order condition:

$$\mu_t^K = \zeta_t^b + \bar{\mu}_t \frac{\lambda x_t^{\kappa-1}}{(1 - \frac{\lambda}{\kappa} x_t^\kappa)}, \tag{A2}$$

where $\bar{\mu}_t$ is total excess return given by

$$\bar{\mu}_t = (\mu_t^K + \mu_t^B)(1 - x_t) + (\mu_t^B + \zeta_t^B)x_t. \tag{A3}$$

Figure 9: FED Asset Composition



Note: Left panel: FED Assets composition, 2012 - 2025. Solid blue line - Treasury securities held outright (FRED: TREAST). Dashed red line - Mortgage-backed securities (FRED: WSHOMCB). Dotted green line - difference between total assets (FRED: WALCL) and sum of Treasury securities and MBS. Right panel: FED Assets to GDP, 2012 - 2025. Solid blue line - Treasury securities held outright (FRED: TREAST). Dashed red line - Mortgage-backed securities (FRED: WSHOMCB). Dotted green line - Total assets (FRED: WALCL). Solid gray line plots mean of share of Treasury securities in total assets. Right panel: FED Assets to GDP, 2012 - 2025. Solid gray line plots mean of FED Assets to GDP.

B Calibration Details

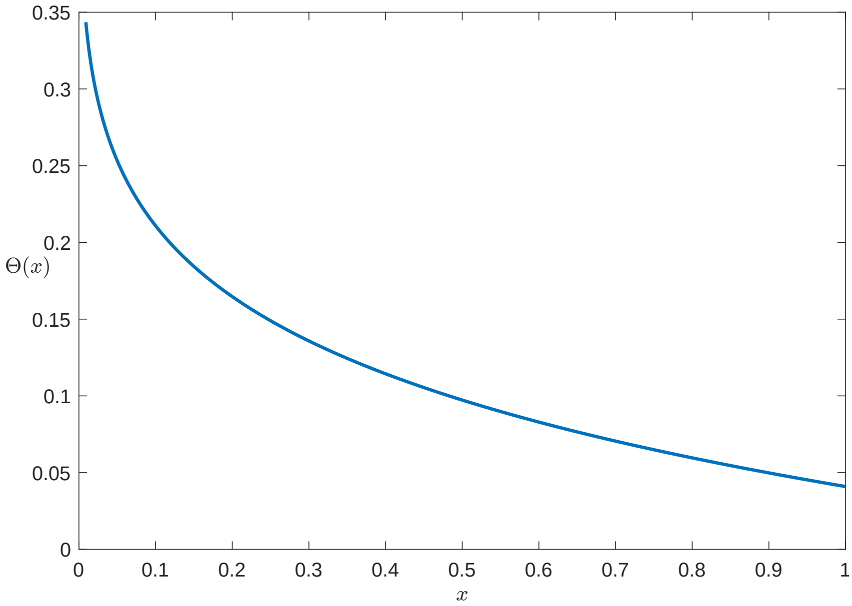
This section provides additional calibration details.

B.1 Central Bank Balance Sheet

The share of public assets on the balance sheet of the central bank is calibrated to match the average of 60% over the period between 2012 and 2025 as shown in the left panel of Figure 9. Over the period, the share of public assets on the FED balance sheet has been relatively stable at around 60%.

The share of FED assets to GDP is calibrated to match the average of 25% over the period between 2012 and 2025 as shown in the right panel of Figure 9. The ratio of FED assets to GDP, however, has not been stable; in 2012, it was as low as 17% and in 2022, it was as high as 35%. whilst the size of the central bank balance sheet in the model is only important for determining the ratio of safe assets to total assets of private financial intermediaries, it is set such that it implies that this ratio is roughly 0.2, consistent with the data (Akinci and Queralto 2022), yielding CB assets to GDP of 25%. This figure is consistent with the average of 25% over the period between 2012 and 2025 as shown in the right panel of Figure 9.

Figure 10: Functional form of $\Theta(x)$



Note: Functional form of $\Theta(x_t)$. Horizontal axis shows values of safe asset proportion in bankers' portfolio. Vertical axis shows the proportion of divertible funds.

B.2 Functional form of absconding ratio

Functional form of $\Theta(x_t)$ is crucial for analysis of financial stress episodes as it governs the severity of the ICC in Equation (7). $\Theta(x_t)$ is assumed to be decreasing and convex in safe asset ratio x_t. These assumptions imply that if the banker's portfolio consists mostly of safe assets, the proportion of divertible funds is low and, by implication, the ICC is less severe. If the proportion of safe assets in portfolio, x_t, is high, however, increasing it further does not render the constraint a lot less severe.

C Equilibrium conditions

Households Household optimisation implies the conditions for labour supply

$$w_t = \psi \chi L_t^{\nu} + (1-\psi) L_t^{\nu} \left(C_t - \chi \frac{L_t^{1+\nu}}{1+\nu} \right)^{\sigma} \tag{C1}$$

Euler equation for long-term debt

$$\mathbb{E}_t \Lambda_{t,t+1} \left(\frac{R_{L,t+1}}{\pi_{t+1}} \right) = 1 + \xi_{L,t} \tag{C2}$$

Euler equation for deposits

$$\mathbb{E}_t \Lambda_{t,t+1} \left(\frac{R_t^d}{\pi_{t+1}} \right) = 1 \tag{C3}$$

where $\Lambda_{t,t+s}$ is households stochastic discount factor given by

$$\Lambda_{t,t+s} = \beta^s \mathbb{E}_t \left\{ \frac{U_{C_{t+s}}}{U_{C_t}} \right\}$$

Capital goods producers Law of motion for capital

$$K_t = I_t + (1-\delta) K_{t-1}, \tag{C4}$$

Price of equity

$$Q_t = 1 + \frac{\kappa_I}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 + \kappa_I \left(\frac{I_t}{I_{t-1}} - 1 \right) \frac{I_t}{I_{t-1}} - \kappa_I \mathbb{E}_t \Lambda_{t,t+1} \left(\frac{I_{t+1}}{I_t} - 1 \right) \frac{I_{t+1}^2}{I_t^2} \tag{C5}$$

Intermediate goods producers Producer optimisation implies the following conditions for capital-labour ratio, capital demand, and output

$$Y_t = \frac{A_t K_{t-1}^{\alpha} L_t^{1-\alpha}}{\vartheta_t} \tag{C6}$$

$$mc_t = \frac{1}{A_t} \left(\frac{z_t^k}{\alpha} \right)^{\alpha} \left(\frac{w_t}{1-\alpha} \right)^{1-\alpha} \tag{C7}$$

$$\frac{1-\alpha}{\alpha} = \frac{w_t L_t}{z_t^k K_{t-1}}. \tag{C8}$$

Inflation determination As indicated in the main text, proportion θ of firms cannot adjust their prices and a complimentary proportion $1-\theta$ can do so, hence inflation is given by

$$\pi_t^{1-\epsilon} = (1-\theta)(\pi_t^*)^{1-\epsilon} + \theta, \tag{C9}$$

where π_t^* is growth rate of optimal price given by

$$\pi_t^* = M_t \frac{X_{1,t}}{X_{2,t}}$$

$$X_{1,t} = U_{C_t} mc_t Y_t + \beta\theta\pi_{t+1}^{\epsilon} X_{1,t+1}$$
$$X_{2,t} = U_{C_t} Y_t + \beta\theta\pi_{t+1}^{\epsilon-1} X_{2,t+1}$$

Price dispersion is given by

$$\vartheta_t = (1-\theta)\left(\frac{\pi_t}{\pi_t^*}\right)^{\epsilon} + \theta\pi_t^{\epsilon}\vartheta_{t-1}$$

Banks I use the following auxiliary definitions for banker SDF, discounted equity spread, discounted safe asset spread, and discounted real deposit rate:

$$\Omega_{t,t+1} = \mathbb{E}_t\Lambda_{t,t+1}(1-\sigma_b+\sigma_b\psi_{t+1}) \tag{C10}$$
$$\mu_t^K = \mathbb{E}_t\Omega_{t,t+1}\left(R_{t+1}^k - \frac{R_t}{\pi_{t+1}}\right) \tag{C11}$$
$$\mu_t^B = \mathbb{E}_t\Omega_{t,t+1}\left(\frac{R_t}{\pi_{t+1}} - \frac{R_t^d}{\pi_{t+1}}\right) \tag{C12}$$
$$\upsilon_t = \mathbb{E}_t\Omega_{t,t+1}\frac{R_t^d}{\pi_{t+1}} \tag{C13}$$

Safe asset to portfolio ratio

$$x_t = \frac{B_{S,t}^I}{Q_t K_t^I + B_{S,t}^I} \tag{C14}$$

Franchise value to net-worth

$$\psi_t = \upsilon_t + \bar{\mu}_t\phi_t \tag{C15}$$

Maximum leverage ratio

$$\bar{\phi}_t = \frac{\upsilon_t}{\theta(1-\frac{\lambda}{\kappa}x_t^{\kappa}) - \bar{\mu}_t} \tag{C16}$$

Total excess returns

$$\bar{\mu}_t = (\mu_t^K + \mu_t^B)(1-x_t) + (\mu_t^B + \zeta_t^B)x_t \tag{C17}$$

Realised leverage

$$\phi_t = \frac{Q_t K_t^I + B_{S,t}^I}{N_t} \tag{C18}$$

Banker optimality condition

$$\mu_t^K = \zeta_t^b + \bar{\mu}_t\frac{\lambda x_t^{\kappa-1}}{(1-\frac{\lambda}{\kappa}x_t^{\kappa})} \tag{C19}$$

Net-worth evolution

$$N_t = \sigma_b\left[\left(R_t^k - \frac{R_{t-1}^d}{\pi_t}\right)Q_{t-1}K_{t-1}^I + \frac{(R_{t-1}-R_{t-1}^d)}{\pi_t}B_{S,t-1}^I + \frac{R_{t-1}^d}{\pi_t}N_{t-1}\right]$$
$$+ (1-\sigma_b)\gamma Q_{t-1}K_{t-1}^I \tag{C20}$$

Regime determination equation

$$\bar{\mu}_t(\bar{\phi}_t - \phi_t) = 0 \tag{C21}$$

Return on equity

$$R_t^k = \frac{z_t^k + (1-\delta)Q_t}{Q_{t-1}} \tag{C22}$$

Central Bank Conventional monetary policy is governed by a Taylor rule

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left(\pi_t^{\phi_\pi} X_t^{\phi_y}\right)^{1-\rho_R} \exp \varepsilon_t^R \tag{C23}$$

Long-term debt purchases

$$\frac{B_{L,t}^{cb}}{B^{L,cb}} = \left(\frac{S_t}{S}\right)^{\phi_{QE}^B} \tag{C24}$$

Non-financial firm equity purchases

$$\frac{K_t^{cb}}{K^{cb}} = \left(\frac{S_t}{S}\right)^{\phi_{QE}^K} \tag{C25}$$

Reserves provision is given by the following revenue neutrality condition

$$Q_t K_t^{cb} + B_{L,t}^{cb} + B_{S,t}^{cb} = 0 \tag{C26}$$

Treasury Consolidated budget constraint

$$\tau_t + R_t^k Q_{t-1} K_{t-1}^{cb} + B_{L,t}^H + B_{S,t}^I = \frac{R_{t-1}}{\pi_t} B_{S,t-1}^I + \frac{R_{L,t}}{\pi_t} B_{L,t-1}^H + Q_t K_t^{cb} + C_t, \tag{C27}$$

where

$$C_t = \varrho \left\{ \left(\frac{B_{L,t}^{cb}}{B_L^{cb}} - 1\right) + \left(\frac{K_t^{cb}}{K^{cb}} - 1\right) \right\}$$

Constant maturity structure condition

$$\bar{B}_S = \varrho \bar{B}_L \tag{C28}$$

Short-term debt issuance

$$B_{S,t} = \bar{B}_S \tag{C29}$$

Market clearing and equilibrium Resource constraint is given by

$$Y_t = C_t + I_t \left(1 + \frac{\kappa_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right) + C_t \tag{C30}$$

Short-term bond markets clear

$$\bar{B}_S = B_{S,t}^{cb} + B_{S,t}^I \tag{C31}$$

Long-term bond markets clear

$$\bar{B}_L = B_{L,t}^{cb} + B_{L,t}^H \tag{C32}$$

Firm equity markets clear

$$K_t = K_t^{cb} + K_t^I \tag{C33}$$

Exogenous processes Total Factor Productivity

$$A_t = 1 - \rho^A + \rho^A A_{t-1} + \varepsilon_t^A \tag{C34}$$

Markup shock

$$M_t = \bar{M}(1 - \rho^M) + \rho^M M_{t-1} + \varepsilon_t^M \tag{C35}$$

Banker's safe asset preference

$$\xi_t^b = \bar{\xi}^b(1 - \rho^b) + \rho^b \xi_{t-1}^b + \varepsilon_t^b \tag{C36}$$

D Unconstrained static equilibrium

Wider economy. I drop time sub-indices for variables in steady state. In a non-inflationary steady state $\pi = 1$, $R^d = 1/\beta$. Cost of capital is equal to unity, $Q = 1$. Since the leverage constraint is not binding, $R^k = R^d = 1/\beta$, and $R = (R^k - \xi^b)/\beta$. It follows that

$$z^k = R^K - 1 + \delta \tag{D1}$$

Marginal cost is equal to inverse of markup, $\mathcal{M} = \frac{\epsilon}{\epsilon - 1} = mc^{-1}$.

The definition of marginal cost implies

$$mc = \left(\frac{z^k}{\alpha}\right)^{\alpha}\left(\frac{w}{1-\alpha}\right)^{1-\alpha} \implies w = (1-\alpha)\left[\frac{\alpha mc^{\frac{1}{\alpha}}}{z_k}\right]^{\frac{\alpha}{1-\alpha}}. \tag{D2}$$

Using the condition for labour supply yields labour

$$L = \left(\frac{w}{\chi}\right)^{\frac{1}{\nu}} \tag{D3}$$

Output is then given by

$$Y = \frac{wL}{(1-\alpha)mc} \tag{D4}$$

Capital is given by

$$K = \frac{\alpha mc Y}{z^k} \tag{D5}$$

Investment is given by

$$I = \delta K \tag{D6}$$

It is straightforward to solve for consumption given market clearing.

Government Steady-state values of B_S, B_L^{cb}, and K^{cb} are calibrated.

$$B_S^{cb} = -B_L^{cb} - K^{cb} \tag{D7}$$

Safe assets and central bank reserves are given by

$$B_S^I = B_S - B_S^{cb} \tag{D8}$$

Long-term government debt

$$B_L = \varrho^{-1} B_S \tag{D9}$$

Private holdings of long-term debt

$$B_L^H = B_L - B_L^{cb} \tag{D10}$$

Consolidated government budget constraint yields

$$\tau = (R_L - 1)B_L^H + (R - 1)B_S^I \tag{D11}$$

Financial sector Bank reserves and short-term assets B^I is determined residually. Thus, safe asset ratio is given by

$$x = \frac{B^I}{K^I + B^I} \tag{D12}$$

From evolution of net-worth

$$N = \left(\frac{(1-\sigma_b)\gamma K^I - \xi^b \sigma_b B^I_S}{1 - \sigma_b R^d} \right) \tag{D13}$$

Leverage is given by

$$\phi = \frac{K^I + B^I_S}{N} \tag{D14}$$

and deposits are determined residually via balance sheet

$$D = K^I + B^I_S - N \tag{D15}$$

Steady state expressions for other bank variables immediately follow. This completes the steady state solution.