Banking Regulation: The Countercyclical Buffer Paradox*

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Abstract

This paper studies Basel countercyclical capital requirement in a quantitative macro-finance model in which banks diversify idiosyncratic risk through lending and issue deposits that serve as safe assets. Bank owners bear undiversifiable failure risk. The welfare-maximizing constant capital requirement is 14%. A planner who sets state-contingent requirements without commitment preserves lending when banks are poorly capitalized. Paradoxically, this discretionary buffer yields lower ex-ante welfare than the constant requirement. It helps once a crisis state is reached, whereas the constant rule makes such states less likely.

Keywords: Capital Regulation, Macro-prudential Policy, Macroeconomic Stability.

JEL: C63, C68, E27, G12, G21, G22, G23

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1 Introduction

After the Global Financial Crisis, Basel III moved beyond regulating each financial institution in isolation and added a macroprudential layer. A key element is the countercyclical capital buffer (CCyB) (Basel Committee on Banking Supervision, 2010). Regulators raise the buffer when credit grows and release it when losses arrive, so that banks build capital in good times and draw on it in bad times, when the economy needs credit most. The aim is to limit fire sales and their spillovers. Bank regulation also has other macroeconomic effects, including on the provision of safe assets.

This paper studies bank capital regulation in a setting in which banks play a dual role. They grant risky loans and thereby diversify the idiosyncratic risk of individual producers. They also issue deposits, which serve as a safe asset alongside the central bank's outside money. Households can thus reduce their exposure to idiosyncratic risk in two ways: by shedding it to banks, or by self-insuring through trading a highly valued safe asset. Banks themselves are subject to bank-specific jump risk and can fail.

The paper makes two contributions. First, we build a quantitative macrofinance model with banks and safe assets. The model quantifies how capital requirements reallocate risk between households, who self-insure with safe assets, and bank owners (experts), who bear the undiversifiable failure risk of their own bank. It also decomposes welfare into the distribution of wealth, consumption and growth, households' retained idiosyncratic risk, and bank owners' jump risk. Second, we study countercyclical capital regulation by solving the problem of a planner who cannot commit.

We start with constant capital requirements. The welfare-maximizing constant requirement is 14%. It raises welfare by 4.3 basis points in consumption-equivalent terms relative to the unregulated economy. Welfare is strongly asymmetric around this optimum: overregulation is far more costly than underregulation. Given parameter uncertainty, this asymmetry argues for erring on the side of a less stringent requirement, that is, one below 14%. The moderate welfare gains at the optimum masks large offsetting effects. Regulation shifts

wealth toward bank owners: their welfare rises by 13.5 log points, while household welfare falls by 0.46 log points. The main benefit is that states with scarce bank-owner wealth become rare, which contributes about 0.10 log points. The main cost is concentrated ownership: bank owners hold more of their wealth in their own bank and lose more when it fails (-0.11 log points). Fewer failures destroy less capital, so the consumption-and-growth term is positive at the optimum, but it turns negative at tighter requirements as lower investment dominates.

We then turn to state-contingent requirements. In practice, the CCyB is set at the discretion of a committee: in some countries by the central bank, in others together with fiscal authorities. Because it does not follow a fixed rule, we model it as the choice of a planner who acts under discretion. Our method fully characterizes this planner's policy.

The discretionary planner is looser than the constant requirement, especially when banks are poorly capitalized. This keeps banks lending and allows them to continue diversifying idiosyncratic risk. The policy is not monotone, however. In an intermediate range of bank-owner wealth, the planner tightens sharply, which induces bank owners to hold more equity in their banks. In the most severe crisis states, when their wealth share is very low, the planner relaxes the requirement again.

The discretionary planner does not internalize a general equilibrium effect and takes the value of safe assets as given. Looser regulation lowers the value of safe assets and, with it, the benefits of self-insurance. This welfare loss outweighs the gain from higher investment when safe assets crowd out less physical capital.

The result is a paradox. From an ex-ante perspective, discretionary CCyB delivers lower welfare than the constant requirement of 14%. The shift in the stationary distribution also contributes to this welfare finding. However, conditional and starting from states in which bank owners' wealth share is low, welfare is higher under the discretionary CCyB. Starting from states in which it is high, the constant requirement is superior.

Related literature. Our first contribution relates to the quantitative literature on the level of bank capital requirements. Requirements reduce bank failures but may restrict intermediation; Van den Heuvel (2008) quantifies the welfare cost of limiting banks' liquidity creation. Begenau (2020), Begenau and Landvoigt (2022), Elenev et al. (2021), and Abad et al. (2024) characterize welfare-maximizing requirements, and Corbae and D'Erasmo (2021) study regulation under imperfect competition. Phelan (2016) compares constant leverage limits, and Di Tella (2019) implements optimal intermediary regulation through a tax on asset holdings. Dynamic single-bank models show how default risk and liability structure respond to requirements (Hugonnier and Morellec, 2017; Sundaresan and Wang, 2023). We share the trade-off between stability and intermediation but emphasize risk sharing and the value of safe assets. Households self-insure with outside money, whose value is forward-looking and rises in a flight to safety. Capital requirements therefore affect not only bank failures but also, through the demand for self-insurance, the value of money, the capital price, and investment.

Our second contribution relates to work on cyclical capital requirements. Jiménez et al. (2017) find that Spain's dynamic provisioning smoothed credit supply in downturns. Repullo and Suarez (2013) show that costly failures justify requirements that are higher and less cyclical than under Basel II, and Gersbach and Rochet (2017) show that a requirement activated only in booms implements the planner's allocation in a two-state economy. Quantitatively, Davydiuk (2019), Gertler et al. (2020a), and Elenev et al. (2021) find gains from countercyclical requirements, whereas Mendicino et al. (2018), Abad et al. (2024), and Canzoneri et al. (2026) find more limited benefits from cyclical adjustment. Malherbe (2020) derives tighter requirements in booms under period-by-period surplus maximization. Because the CCyB is set by committees, we instead model a regulator who cannot commit and chooses a time-consistent Markov policy (Klein et al., 2008). Unlike Bianchi and Mendoza (2018), where a collateral constraint creates a pecuniary externality, the interest rate is exogenous, and time-consistent state-contingent policy outperforms constant taxes, the value of the safe asset in our model is endogenous, and the best constant requirement domi-

nates discretion. Van der Ghote (2021) examines how state-contingent capital requirements interact with monetary policy.

In terms of modelling our framework is based on continuous-time macrofinance models with financial intermediaries (He and Krishnamurthy, 2013; Brunnermeier and Sannikov, 2014). As in Brunnermeier and Sannikov (2016)'s I Theory, households hold money to self-insure against idiosyncratic risk, while intermediaries diversify part of that risk. Shocks to idiosyncratic volatility generate aggregate fluctuations through portfolios and asset prices, as in Di Tella (2017), Brunnermeier et al. (2024), and Alexandrov and Brunnermeier (2026). Our decomposition of welfare into wealth shares, consumption and growth, and the risks each sector bears relates to, but is not identical to the welfare decomposition of Dávila and Schaab (2025).

Roadmap. The paper proceeds as follows. Section 2 presents the model: the setup with households, experts, and banks; the equilibrium, including the valuation of money and loan issuance; and the calibration. Section 3 studies constant capital requirements. It characterizes how a requirement changes allocations, prices, and the stationary distribution of expert wealth, decomposes welfare into its components, and traces the response to a volatility shock. Section 4 turns to state-contingent requirements chosen by a planner without commitment and compares the resulting policy with the best constant requirement. Section 5 concludes. Appendix A contains the model derivations and robustness exercises, Appendix B shows that reserve requirements leave the results unchanged, and Appendix C collects additional figures.

2 Model

In this section, we sketch the model and relegate the details to Appendix A. Time is continuous and infinite. The economy is populated by a continuum of households and experts. Households operate firms that borrow from banks up to a limit. Experts use their equity to operate banks that lend to household-operated firms. Banks face a capital requirement set

by the regulator. The government issues outside money. Figure 1 shows the balance sheets of households, and banks that are owned by experts.

2.1 Setup

2.1.1 Capital

There is one real asset, capital, in positive net supply. Its aggregate stock is K_t.[1] An individual household's capital follows

$$\frac{dk_t}{k_t} = \Big(\underbrace{\frac{1}{\phi}\log(1+\phi\iota_t) - \delta}_{g(\iota_t)} \Big) dt + \widetilde{\sigma}_t d\tilde{Z}_t,$$

where ι_t is the investment rate chosen by capital holders, $g(\iota_t)$ is the expected growth rate of capital, δ is the depreciation rate, and $\tilde{Z}_t$ is the idiosyncratic Brownian Motion that is independent across households. The volatility $\widetilde{\sigma}_t$ follows the exogenous stationary process:

$$d(\widetilde{\sigma}_t^2) = \psi\big((\widetilde{\sigma}^0)^2 - \widetilde{\sigma}_t^2\big)dt + \sigma(\widetilde{\sigma}_t)dZ_t, \tag{1}$$

where ψ is the mean-reversion rate, $\widetilde{\sigma}^0$ is the square root of the long-run mean variance, $\sigma(\widetilde{\sigma}_t)$ is the volatility, and Z_t is a standard Brownian Motion denoting aggregate shock. The common shock Z_t changes households' idiosyncratic risk and is the only source of aggregate uncertainty. Idiosyncratic capital shocks wash out in the aggregate. The aggregate capital stock evolves as follows:

$$\frac{dK_t}{K_t} = \left(g(\iota_t) - \delta_t\right) dt,$$

[1] We write k_t for the capital operated by an individual household and K_t for the aggregate stock.

where δ_t denotes capital destroyed by bank failures, explained later. The capital price evolves as

$$\frac{dq_t^K}{q_t^K} = \mu_t^{q^K} dt + \sigma_t^{q^K} dZ_t,$$

with drift and loading determined in the equilibrium. The government issues outside money in fixed nominal supply and pays no interest on it. Its aggregate real value is $q_t^{\mathcal{MB}} K_t$, where

$$\frac{dq_t^{\mathcal{MB}}}{q_t^{\mathcal{MB}}} = \mu_t^{q^{\mathcal{MB}}} dt + \sigma_t^{q^{\mathcal{MB}}} dZ_t.$$

The drift $\mu_t^{q^{\mathcal{MB}}}$ and loading $\sigma_t^{q^{\mathcal{MB}}}$ are determined in equilibrium. Since aggregate capital grows at rate $g(\iota_t) - \delta_t$, the drift satisfies

$$\mu_t^{q^{\mathcal{MB}}} = \mathbb{E}[r_t^{\mathcal{MB}}] - g(\iota_t) + \delta_t.$$

Government policy fixes the nominal quantity of money, while its real value adjusts to agents' demand for self-insurance.

2.1.2 Household problem

Households operate firms that hold capital k_t that produces output ak_t. Households finance part of their capital with risky claims (loans) from banks. They choose consumption c_t^h, the investment rate ι_t, and portfolio weights on capital holding θ_t^K, loans $\theta_t^{L,h}$, and deposits $\theta_t^{D,h}$. The returns are given by

$$\begin{aligned} dr_t^K &= \mathbb{E}[r_t^K]dt + \sigma_t^{q^K} dZ_t + \widetilde{\sigma}_t d\tilde{Z}_t \\ dr_t^{L,h} &= \mathbb{E}[r_t^L]dt + \sigma_t^{q^K} dZ_t + \widetilde{\sigma}_t d\tilde{Z}_t, \\ dr_t^D &= dr_t^{\mathcal{MB}} = \mathbb{E}[r_t^{\mathcal{MB}}]dt + \sigma_t^{q^{\mathcal{MB}}} dZ_t. \end{aligned} \tag{2}$$

where the drift and diffusion functions are determined in equilibrium. A loan carries

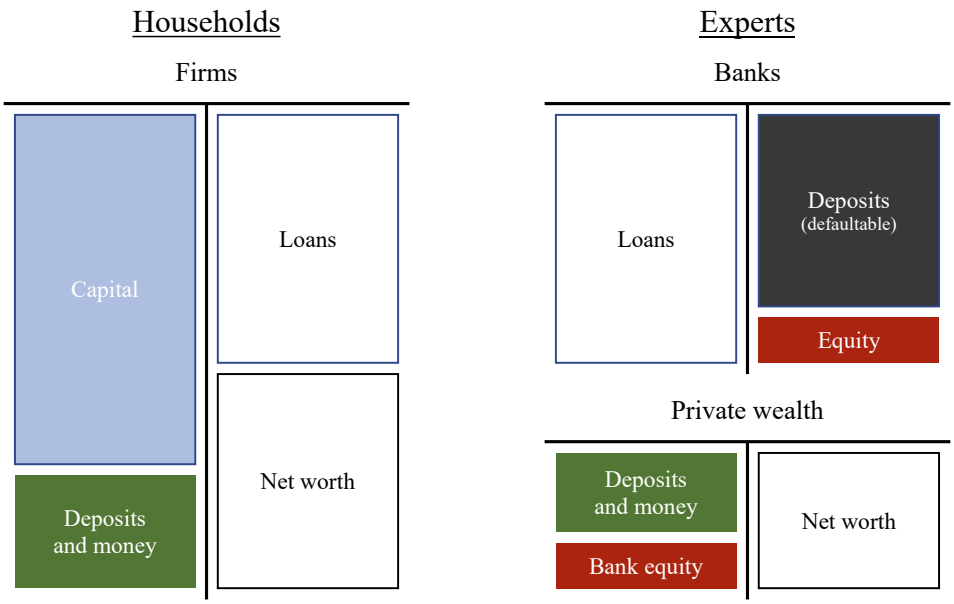


Figure 1: Balance sheets.

the aggregate and idiosyncratic risk of the capital, so borrowing sheds idiosyncratic risk. Deposits earn the same return as money. Capital pays the dividend yield $(a - \iota_t)/q_t^K$. Its expected return $E[r_t^K]$ also reflects capital price changes, accumulation, and spillover losses from bank failures, $s\tilde{\lambda}_j \chi_t \mathbb{E}[d_t]$. Here s is the spillover coefficient, $\tilde{\lambda}_j$ is the arrival rate of bank-specific jumps, χ_t is the share of capital financed by bank loans, and $d_t \leq 0$ is the resolution loss per unit of bank loans. The parameters s and $\tilde{\lambda}_j$ are fixed, while χ_t and the expected resolution loss depend on equilibrium allocations. Money pays no dividend, and its return is the growth of its aggregate real value $q_t^{\mathcal{MB}} K_t$ is given by

$$\mathbb{E}[r_t^K] = \frac{a - \iota_t}{q_t^K} + \mu_t^{q^K} + g(\iota_t) + s\tilde{\lambda}_j \chi_t \mathbb{E}[d_t], \qquad \mathbb{E}[r_t^{\mathcal{MB}}] = \mu_t^{q^{\mathcal{MB}}} + g(\iota_t) - \delta_t.$$

The expected loan return $\mathbb{E}[r_t^L]$ is determined in equilibrium. Given initial net worth n_0^h and discount rate ρ, household h solves

$$\max_{c^h, \iota, \theta^K, \theta^{D,h}, \theta^{L,h}} \mathbb{E}_0 \int_0^\infty e^{-\rho t} \log c_t^h dt \tag{3}$$

subject to

$$\frac{dn_t^h}{n_t^h} = -\frac{c_t^h}{n_t^h}dt + \theta_t^K dr_t^K + \theta_t^{D,h} dr_t^D + \theta_t^{L,h} dr_t^{L,h}$$

and

$$1 = \theta_t^K + \theta_t^{D,h} + \theta_t^{L,h}, \qquad \chi_t = -\frac{\theta_t^{L,h}}{\theta_t^K} \leq \bar{\chi},$$

where χ_t is the share of the household's capital financed by risky loans. The ceiling $\bar{\chi}$ limits how much idiosyncratic risk a household can shed.

Log utility gives $c_t^h = \rho n_t^h$. Investment rate ι_t satisfies Tobin's q, $\iota_t = (q_t^K - 1)/\phi$. Households issue risky loans with a constraint $\overline{\chi}$ on risky loans. The expected excess return on a loan equals the price of the aggregate and idiosyncratic risk they shed, unless the constraint binds.

2.1.3 Expert problem

Experts cannot operate capital. Each expert owns a bank that holds loans and issues deposits. Banks diversify the idiosyncratic Brownian risk of their loans, so $\tilde{Z}_t$ washes out. An expert invests the fraction θ_t^E of net worth n_t^e in the equity of its bank and the rest in nominal deposits. Given initial net worth n_0^e, an expert chooses consumption and the share of net worth it holds in its bank's equity:

$$\max_{c^e, \theta^E} \mathbb{E}_0 \int_0^\infty e^{-\rho t} \log c_t^e dt \tag{4}$$

subject to

$$\frac{dn_t^e}{n_t^e} = -\frac{c_t^e}{n_t^e}dt + \theta_t^E dr_t^E + (1 - \theta_t^E) dr_t^D.$$

Log utility gives $c_t^e = \rho n_t^e$.

Jumps and default. Each expert can hold equity only in the bank they operate, which faces idiosyncratic jump risk. Therefore, the bank-specific jump risk described below remains undiversified for the experts. Jumps arrive at the Poisson rate $\tilde{\lambda}_j$ through the bank's

jump process $\tilde{J}_t$, are independent across banks, and have size $\tilde{j} \sim F$ with support $[\underline{j}, 0]$, where $-1 < \underline{j} < 0$. Immediately after a jump, but before resolution costs and limited liability, bank net worth per unit of pre-jump equity is $1 + \theta_t^{L,b}\tilde{j}$, where $\theta_t^{L,b}$ denotes bank portfolio share, defined as the value of loans per unit of bank equity. The bank therefore defaults when $\tilde{j} < -1/\theta_t^{L,b}$. Default is determined before applying resolution costs. Leverage at or below $\theta_{ND}^{L,b} = -1/\underline{j}$ rules out default.

Resolution costs. Resolving a failed bank destroys capital. We write $\not{d}_t \leq 0$ for the capital destroyed per unit of bank's loans when a jump $\tilde{j}$ arrives, with $\not{d}_t = 0$ when $\tilde{j} \geq -1/\theta_t^{L,b}$. This loss is proportional to the pre-cost shortfall, as specified in (12), and is zero when $\tilde{j} \geq -1/\theta_t^{L,b}$. Aggregate destruction is

$$\delta_t = -(1+\mathit{s})\tilde{\lambda}_j \chi_t \mathbb{E}\left[\not{d}_t\right] \tag{5}$$

where $\mathit{s} \geq 0$ scales the additional destruction that bank failures impose on the rest of the capital stock.

Deposits. Depositors of a failed bank lose the pre-cost shortfall plus the direct resolution cost. We write $\tilde{j}_t^D \leq 0$ for this loss per unit of deposits.[2] Bank returns compensate depositors for expected default losses. A depositor who spreads deposits across a continuum of banks diversifies the bank-specific jump risk and therefore earns the money return $dr_t^{\mathcal{MB}}$.

2.1.4 The bank's problem.

Let ξ_t^e be the stochastic discount factor of the expert who owns the bank. Bank equity E_t^b evolves as

$$dE_t^b = E_t^b\big(dr_t^E - dD_t^b\big),$$

where D_t^b is cumulative payouts per unit of equity. Negative payouts are equity issuance. The bank's return on loans differs from the household's because idiosyncratic Brownian risk

[2] Appendix A.3 derives the deposit loss.

is diversified away, while banks face bank-specific jump risk and resolution costs:

$$dr_t^{L,b} = \big(\mathbb{E}[r_t^L] - \tilde{\lambda}_j \mathbb{E}[\tilde{j}]\big)dt + \sigma_t^{q^K} dZ_t + (\tilde{j} + \not{d}_t)d\tilde{J}_t,$$

where $-\tilde{\lambda}_j \mathbb{E}[\tilde{j}]dt$ offsets the expected portfolio jump before resolution costs. The equity return is

$$dr_t^E = \big(\mathbb{E}[r_t^E] - \tilde{\lambda}_j \mathbb{E}[j_t^E]\big)dt + \sigma_t^{r^E} dZ_t + j_t^E d\tilde{J}_t, \tag{6}$$

with

$$\begin{aligned}
\mathbb{E}[r_t^E] &= \theta_t^{L,b}\big(\mathbb{E}[r_t^L] + \tilde{\lambda}_j \mathbb{E}[\not{d}_t]\big) - (\theta_t^{L,b} - 1)\mathbb{E}[r_t^{\mathcal{MB}}], \\
\sigma_t^{r^E} &= \theta_t^{L,b}\sigma_t^{q^K} + (1 - \theta_t^{L,b})\sigma_t^{q^{\mathcal{MB}}}, \\
j_t^E &= \max(\theta_t^{L,b}\tilde{j}, -1).
\end{aligned}$$

Limited liability caps the loss on bank equity at its pre-jump value. Because depositors are compensated for their expected losses, the expected direct resolution cost remains a cost to equity holders. The bank chooses leverage to maximize the value of its payouts:

$$\max_{\theta^{L,b}} \mathbb{E}_0\left[\int_0^\infty \xi_t^e E_t^b \left(dD_t^b + \frac{d[\xi^e, D^b]_t}{\xi_t^e}\right)\right] \qquad \text{subject to} \qquad \varkappa_t \theta_t^{L,b} \leq 1, \tag{7}$$

where $[\xi^e, D^b]$ is the quadratic covariation of the two processes.[3] A payout dD_t^b arrives at $t + dt$, and the covariation term discounts it with ξ_{t+dt}^e instead of ξ_t^e. The expert decides how much of its net worth to hold in the bank, so the bank takes the process E_t^b as given. Leverage affects only dr_t^E, and payouts follow from the law of motion of equity.

[3] In discrete time with periods of length Δ, the objective is the present value of payouts,

$$\mathbb{E}_0\Big[\sum_{t=0,\Delta,2\Delta,\ldots} \xi_{t+\Delta}^e E_t^b\big(D_{t+\Delta}^b - D_t^b\big)\Big].$$

Equity E_t^b held at t pays $E_t^b(D_{t+\Delta}^b - D_t^b)$ at $t + \Delta$, and the expert values this payout with $\xi_{t+\Delta}^e$. Write $\xi_{t+\Delta}^e = \xi_t^e + (\xi_{t+\Delta}^e - \xi_t^e)$. As $\Delta \to 0$, the sum of the terms $\xi_t^e E_t^b(D_{t+\Delta}^b - D_t^b)$ converges to $\int_0^\infty \xi_t^e E_t^b dD_t^b$. The sum of the terms $E_t^b(\xi_{t+\Delta}^e - \xi_t^e)(D_{t+\Delta}^b - D_t^b)$ converges to $\int_0^\infty E_t^b d[\xi^e, D^b]_t$. Together they give the integral in (7).

The regulator sets the capital requirement $\varkappa_t$. For $\varkappa_t > 0$, equity must finance at least the fraction $\varkappa_t$ of loans, imposing the leverage cap $1/\varkappa_t$. The unregulated economy has $\varkappa_t = 0$. Given the expert's capitalization process and SDF, the bank's leverage choice reduces to a static problem:[4]

$$\max_{\theta_t^{L,b}} \frac{1}{dt}\mathbb{E}_t\left[dr_t^E + \frac{d[\xi^e, r^E]_t}{\xi_t^e}\right] \qquad \text{subject to} \qquad \varkappa_t \theta_t^{L,b} \leq 1. \tag{8}$$

At the equilibrium allocation, substituting the expert's SDF expresses this risk-adjusted expected return as

$$\mathbb{E}[r_t^E] - \varsigma_t^e \sigma_t^{r^E} - \tilde{\lambda}_j \theta_t^E \mathbb{E}\left[\frac{(j_t^E)^2}{1 + \theta_t^E j_t^E}\right],$$

where ς_t^e is the expert's price of aggregate risk. The last term is the jump risk premium. A bank jump changes the expert's wealth by the factor $1 + \theta_t^E j_t^E$. With log utility, the associated proportional increase in marginal utility is $-\theta_t^E j_t^E/(1 + \theta_t^E j_t^E)$. The premium is therefore the arrival rate times the expected product of this increase and the loss on bank equity, $-j_t^E$. The bank holds the expert's state-contingent marginal utility fixed when comparing leverage choices. The SDF expressions above are equilibrium identities, substituted after forming the bank's optimality conditions.

2.2 Equilibrium

Total net worth is the value of capital plus the value of money, $N_t = (q_t^K + q_t^{\mathcal{MB}})K_t$. Two shares summarize the economy. The (outside) money share of total net worth and the expert wealth share are

$$\vartheta_t = \frac{q_t^{\mathcal{MB}}}{q_t^K + q_t^{\mathcal{MB}}}, \qquad \eta_t = \frac{N_t^e}{N_t},$$

where N_t^e aggregates expert net worth and $N_t^h = N_t - N_t^e$. The share of the capital stock financed by loans is $\chi_t = \theta_t^E \theta_t^{L,b} N_t^e/(q_t^K K_t) \leq \bar{\chi}$, and households retain the fraction $1 - \chi_t$

[4] Appendix A.5 derives this reduction.

of idiosyncratic capital risk.[5] Market clearing for loans and for goods gives

$$\theta_t^E \theta_t^{L,b} = \frac{\chi_t}{\eta_t}(1-\vartheta_t), \qquad \rho N_t = (a-\iota_t)K_t. \tag{9}$$

The aggregate state is $\boldsymbol{x_t} = (\eta_t, \widetilde{\sigma}_t^2)$. Independent idiosyncratic shocks average out across the continuum of agents, so the expert wealth share has no aggregate jumps and follows

$$\frac{d\eta_t}{\eta_t} = \mu_t^\eta dt + \sigma_t^\eta dZ_t.$$

where the drift and diffusion functions are endogenously determined.

Definition 1 (Markov equilibrium)**.** *Given a capital requirement $\varkappa_t$, a Markov equilibrium consists of a money share $\vartheta(\boldsymbol{x})$, allocations $(\theta^{L,b}, \theta^E, \chi)(\boldsymbol{x})$, and state dynamics $(\mu^\eta, \sigma^\eta)(\boldsymbol{x})$ such that (i) households solve* (3)*, experts solve* (4)*, and banks solve* (7)*; (ii) the markets for loans, deposits, money, and goods clear; and (iii) $(\eta_t, \widetilde{\sigma}_t^2)$ follows the law implied by individual wealth dynamics and* (1)*.*

Appendix A.1 states the full equilibrium conditions.

Capital price. Goods market clearing implies $q_t^K/(1-\vartheta_t) = (a-\iota_t)/\rho$. Combining this condition with Tobin's q, $q_t^K = 1+\phi\iota_t$, gives

$$q_t^K = \frac{(1-\vartheta_t)(1+\phi a)}{1-\vartheta_t+\phi\rho}, \qquad \iota_t = \frac{q_t^K - 1}{\phi}. \tag{10}$$

Thus, the money share determines the capital price and investment. A higher money share lowers both: a flight to money reduces the valuation of capital and the incentive to invest.

Money valuation. Although money pays no dividend, it provides insurance via retrading against risks that agents cannot otherwise diversify. Its share of total wealth satisfies the

[5] Recall that θ_t^E is the fraction of expert wealth in bank equity, and $\theta_t^{L,b}$ is the bank's portfolio share of risky loans as a fraction of wealth.

forward-looking valuation condition

$$\vartheta_t = \mathbb{E}_t \left[\int_t^\infty e^{-\rho(s-t)} \Big(\eta_s \big((\sigma_s^\eta)^2 + \widetilde{\mathcal{J}}_s \big) + (1-\eta_s) \big((\sigma_s^{1-\eta})^2 + (\widetilde{\sigma}_s^{1-\eta})^2 \big) \Big) \vartheta_s \, ds \right] \tag{11}$$

Here σ_t^η and $\sigma_t^{1-\eta}$ are the aggregate-shock loadings of the two wealth shares, and $\widetilde{\sigma}_t^{1-\eta}$ is the idiosyncratic volatility households retain per unit of their wealth. The term $\widetilde{\mathcal{J}}_t$ captures experts' exposure to bank-specific idoisyncratic jumps.

Bank jump risk introduces an additional source of demand for money. Banks diversify the idiosyncratic Brownian risk of their loans, but each expert owns one bank and cannot diversify its jump risk. Although these jumps are independent across banks and average out in the aggregate, they remain a source of individual consumption risk. A bank failure wipes out its equity, leaving its owner with the safe assets held outside the bank. The expert retains the fraction $1 - \theta^E$ of pre-jump wealth. The larger the fraction invested in bank equity, the greater the rise in marginal utility following default and the greater the value of self-insurance. Money valuation therefore reflects both the capital risk that households retain and the bank jump risk that experts bear.

Failures also destroy capital through resolution costs and their spillovers. These losses enter the valuation of money through equilibrium returns, portfolio choices, and wealth dynamics, which determine the risks agents expect to bear in the future. This additional source of risk matters with leverage constraints, since a binding constraint can restrict lending and leave households bearing more idiosyncratic risk. Even when lending is unchanged, lower bank leverage can induce experts to invest a larger share of their wealth in bank equity. The probability of bank failure may then fall while the expert jump-risk term $\widetilde{\mathcal{J}}$ rises. The effect on money valuation depends on the risk borne by both sectors, rather than on bank leverage or default probability alone.

The backward valuation of money transmits these risks to capital prices and investment. Consider an increase in idiosyncratic volatility $\widetilde{\sigma}$. Households demand more money to self-insure against the additional risk they retain. The money share rises, lowering the capital

price and investment through (10). Experts are exposed to capital through their banks, so the fall in capital's value relative to money reduces their wealth share, $\sigma^\eta < 0$. When bank equity is scarce, this loss restricts lending and leaves households bearing still more risk. Their demand for money rises further, amplifying the flight to safety. Bank jump risk adds to the self-insurance demand underlying this mechanism, while failures and resolution costs affect the evolution of expert wealth and aggregate capital.

Loan issuance. Consider a household that increases loan financing without changing its capital holdings. It sells an additional claim on capital returns, and holds the proceeds in deposits. It pays the expected loan –deposit return spread. In exchange, it sheds idiosyncratic risk and replaces the loan's exposure to the aggregate shock with that of deposits. With log utility, the household's prices of aggregate and idiosyncratic risk equal its wealth loadings, $\sigma_t^{1-\eta}$ and $\widetilde{\sigma}_t^{1-\eta}$.

For positive issuance, the household's optimality condition is

$$\mathbb{E}[\hat{r}_t^L] - \mathbb{E}[\hat{r}_t^D] \leq \sigma_t^{1-\eta}\big(\hat{\sigma}_t^L - \hat{\sigma}_t^D\big) + \widetilde{\sigma}_t^{1-\eta}\widetilde{\sigma}_t, \qquad \text{with equality if } 0 < \chi_t < \bar{\chi},$$

where hats denote returns and loadings measured in units of total wealth N_t, i.e., in the total net worth numeraire. The left side is the expected cost of replacing loan financing with deposits; the right side is the value of the associated change in risk. At the issuance ceiling, households would prefer to borrow more because the risk-sharing benefit is at least as large as the cost.

On the bank side, the loan return must cover funding and expected resolution costs and compensate experts for aggregate Brownian and bank-specific jump risk. The loan market therefore balances households' demand to shed risk against experts' willingness and capacity to bear it. When experts are poorly capitalized, scarce bank equity limits lending and raises the return banks require. Households respond by issuing fewer loans. When experts are sufficiently well capitalized, households would borrow more than $\bar{\chi}$, and the issuance ceiling binds. In the baseline equilibrium, loan issuance rises with η until it reaches this ceiling.

2.3 Calibration

We set five parameters externally and calibrate the remaining nine jointly to nine moments at the baseline capital requirement $\varkappa = 0.08$. Table 1 groups the parameters and reports the calibration targets alongside their model counterparts. The target listed for each calibrated parameter indicates its main economic role; all nine parameters are chosen jointly. Model moments are evaluated under the stationary distribution of the baseline equilibrium.

Table 1: Parameters and calibration targets. Moments are annual and evaluated at the baseline requirement $\varkappa_t = 0.08$. The last two columns give the value of each target in the data and in the model.

	Parameter	Value	Target	Data	Model
Macroeconomic					
ρ	discount rate	0.0517	Risk-free rate	2.20%	2.05%
a	productivity	0.1911	Investment rate	11.0%	11.0%
δ	depreciation	0.0752	Output growth	2.00%	1.95%
ϕ	adjustment cost	3.03	Price elasticity of investment (0.25)		
Volatility					
$\widetilde{\sigma}^0$	long-run volatility	0.3125	Safe-asset share	15.0%	15.0%
ψ	variance mean reversion	0.67	Brunnermeier et al. (2024)		
σ	volatility of variance	0.15	CIV data, 1973–2018		
Banking					
$\bar{\chi}$	issuance ceiling	0.1772	Bank assets / net worth	15.0%	15.0%
$\not{d}_0$	resolution cost	0.7194	Mean bank leverage	10.00	10.00
p_L	large-loss probability	0.0069	Bank failure rate	0.50%	0.50%
$\underline{j}$	worst jump size	−0.3951	Loss given failure	25.0%	25.0%
j_h	routine jump size	−0.0077	Charge-offs	0.90%	0.90%
$\tilde{\lambda}_j$	jump arrival rate	1	Normalization		
s	spillover	1	Data (1.1)		
Untargeted					
Equity risk premium				6.30%	6.0%
Direct resolution cost / failed-bank assets				12.0%	10.5%
Standard deviation of bank leverage				2.2	1.5
Correlation of bank leverage with output				−0.21	−0.30
Correlation of bank failure rate with output				−0.59	−0.30
Autocorrelation of bank capital ratio (q)				0.94	0.95

Macroeconomic parameters. The discount rate ρ targets the stationary mean return on money, using the mean real safe rate of 2.2% reported by Elenev et al. (2021) as the empirical benchmark. Productivity a targets an investment rate of 11% through (10). In the data,

private nonresidential fixed investment averages 11.2% of the lagged net stock of private nonresidential fixed assets over 1948–2024 (BEA Fixed Assets Accounts). Depreciation δ targets average output growth of 2%, including capital destruction from bank failures. Real GDP per capita grew by 1.96% a year over 1948–2025 (BEA National Income and Product Accounts). We set the adjustment-cost parameter $\phi = 3.03$ to match the elasticity of the capital price with respect to investment. Since $q_t^K = 1 + \phi\iota_t$, this elasticity is

$$\frac{\partial \log q_t^K}{\partial \log \iota_t} = \frac{\phi\iota_t}{1 + \phi\iota_t}.$$

At the targeted investment rate of 11%, $\phi = 3.03$ gives an elasticity of 0.25, as in Gertler et al. (2020b).

Volatility parameters. The parameter $\widetilde{\sigma}^0$ determines the stationary mean of idiosyncratic variance, $(\widetilde{\sigma}^0)^2$, and targets a mean safe-asset share of wealth of 15%. Our empirical measure is Treasury securities held outside the Federal Reserve plus the monetary base, divided by the net worth of households and nonprofit organizations. Using the September 2026 Financial Accounts vintage, the quarterly ratio averages 7.9% over 1970–2007 and 15.8% over 2011–2026Q2. We choose 15% as a benchmark close to the latter average.[6]

We adopt the variance mean-reversion rate $\psi = 0.67$ from Brunnermeier et al. (2024). To discipline fluctuations in variance, we estimate the square-root process (1) by maximum likelihood using the common idiosyncratic volatility (CIV) series of Herskovic et al. (2016) over 1973–2018. The CIV series measures return variance. For the process (1), the stationary coefficient of variation of variance is $\sigma/(\widetilde{\sigma}^0\sqrt{2\psi})$. This coefficient is unchanged by a multiplicative rescaling of the variance series. We therefore match its relative variation while calibrating the level of variance separately.

Using quarterly observations, the estimated coefficient of variation is 0.45, with a standard error of 0.05. The estimated annualized mean-reversion rate is 0.70, close to our choice

[6]This broad measure includes foreign holdings of Treasury securities and currency. It provides a calibration benchmark rather than a direct measure of domestic households' safe-asset portfolio share.

of ψ. With $\widetilde{\sigma}^0 = 0.3125$ and $\psi = 0.67$, the estimated relative variation implies $\sigma = 0.16$, with a 95% confidence interval of $[0.13, 0.20]$. The corresponding estimates using monthly and annual observations are 0.16 and 0.15. We set $\sigma = 0.15$.

Banking parameters. The issuance ceiling $\bar{\chi}$ targets bank assets equal to 15% of aggregate private wealth. In the data, total commercial-bank assets average 15.2% of household and nonprofit net worth over 1973–2026 (Federal Reserve H.8 release and Financial Accounts of the United States). The empirical household sector includes bank owners, so its net worth corresponds to total model wealth N_t, including expert wealth.

Resolution destroys capital in proportion to the failed bank's shortfall:

$$\mathscr{d}_t = -\mathscr{d}_0 \Big(-\frac{1}{\theta_t^{L,b}} - \tilde{j} \Big)^+, \tag{12}$$

where $(-1/\theta_t^{L,b} - \tilde{j})^+$ is the negative part of bank equity after the asset jump but before resolution costs, expressed per unit of pre-jump loans. Measuring the shortfall before costs avoids a feedback loop between the shortfall and the resolution charge. The parameter $\mathscr{d}_0$ affects banks' leverage incentives and targets mean bank leverage of 10. FDIC-insured commercial banks hold 10.1 dollars of assets per dollar of equity on average over 1995–2025 (FDIC).

The jump distribution F combines rare, potentially large losses with frequent routine losses:

$$\tilde{j} \sim \begin{cases} U[\underline{j}, 0] & \text{with probability } p_L, \\ j_h & \text{with probability } 1 - p_L, \end{cases} \qquad -1 < \underline{j} < j_h < 0.$$

The probability p_L targets an annual bank failure rate of 0.5%. On average, 0.53% of FDIC-insured institutions fail each year over 1984–2025 (FDIC). The lower support point $\underline{j}$ targets a loss given failure of 25%. For banks that failed over 2008–2013, the unweighted mean FDIC loss is 24.6% of assets measured in the quarter before failure (Shibut and de Verges, 2020). We use this measure as a proxy for the model's losses to deposit claims,

which include the shortfall and the direct resolution cost.

The routine size j_h targets an annual charge-off rate of 0.9%. The net charge-off rate on all loans at commercial banks averages 0.86% over 1985–2026 (Federal Reserve, Call Reports).

We set the arrival intensity to $\tilde{\lambda}_j = 1$, implying one jump per bank per year on average. The failure and charge-off moments discipline the arrival rate of large-loss draws, $\tilde{\lambda}_j p_L$, and the expected asset-loss rate, $-\tilde{\lambda}_j \mathbb{E}[\tilde{j}]$.[7]

The spillover parameter s scales the capital that failures destroy outside the receivership, relative to the direct resolution cost inside it (5). At the targeted loss given failure, the direct resolution cost is approximately

$$\frac{d_0}{1 + d_0} \times 25\% = 10.5\%$$

of the failed bank's assets. Bennett and Unal (2015) reports average discounted receivership expenses of approximately 12% of assets for failures over 1986–2007. We set $s = 1$, so failures destroy as much capital outside the receivership as inside it.[8]

Untargeted moments. The last panel of Table 1 reports moments that the calibration does not target. The model implies an equity risk premium of 6.00%, compared to 6.3% in the data (Bansal and Yaron (2004)). The standard deviation of bank leverage is 1.5 in the model, compared to 2.2 over 1988–2020 in the data (FFIEC Call Reports). To measure cyclicality, we apply the Hodrick–Prescott filter with smoothing parameter 1600 to log output and to bank leverage, measured as debt over assets. The correlation of the two cycles is -0.30 in the model, with 5th and 95th percentiles across samples of -0.49 and -0.05. Begenau and Landvoigt (2022) report -0.21 for the market leverage of commercial

[7] In a sensitivity exercise, halving or doubling $\tilde{\lambda}_j$, while adjusting p_L and j_h to preserve these two quantities, changes the financial moments reported in Table 1 by less than 0.6% relative to their baseline values.

[8] In a panel of US counties over 1995–2024, a failure whose FDIC loss equals 1% of county income is followed by per-capita income that is 0.066% lower on average over horizons of zero to six years. In the model, this response implies $s = 1.1$, with a 95% confidence interval of $[-0.4, 2.6]$. The mapping assumes that the local response excludes the direct resolution cost and that local losses are not offset in other counties.

banks over 1999–2019. Bank leverage is countercyclical in the model because a volatility shock lowers expert wealth, and banks raise leverage up to the requirement to sustain lending as shown in Section 3.2. The bank failure rate is also countercyclical, because the probability that a jump wipes out a bank's equity rises with its leverage. Its correlation with output is -0.30 in the model. In the data, we divide the number of failures of FDIC-insured institutions in each quarter by the number of insured institutions (FDIC). Over 1999–2019, the correlation of its cycle with the cycle of log real GDP is -0.59. Bank capital is persistent. The quarterly autocorrelation of the bank capital ratio, equity over assets, is 0.95 in the model, with 5th and 95th percentiles of 0.89 and 0.99. For the market capital ratio of He et al. (2017) over 1970–2024, it is 0.94. These autocorrelations imply half-lives of 2.7 years in the data and 3.2 years in the model.

2.3.1 The baseline equilibrium

Figure 2 shows the equilibrium under the baseline capital requirement $\varkappa = 0.08$. Each panel plots an equilibrium object against the expert wealth share η at low, median, and high idiosyncratic volatility.

Consider first the case in which experts are poorly capitalized. Banks operate at the leverage cap $1/\varkappa = 12.5$, and experts invest nearly all their net worth in bank equity, $\theta^E \approx 1$. Even so, bank equity is insufficient to finance loans up to the issuance ceiling, so issuance χ rises with η. Households retain the idiosyncratic risk that banks cannot absorb and hold money to self-insure. The money share ϑ is therefore high when η is low, while the capital price and investment are low (10). Bank equity earns high returns in these states, and the expert wealth share has positive drift.

Issuance reaches its ceiling $\bar{\chi}$ around $\eta = 0.012$. Beyond this point, additional expert wealth does not increase the share of capital financed by banks. Bank leverage falls, reducing the probability that a jump wipes out bank equity. Experts invest a smaller share of their net worth in their banks, with θ^E falling to about 0.42, and hold the remainder in safe assets. As leverage falls, bank equity earns lower returns. The drift of η turns negative

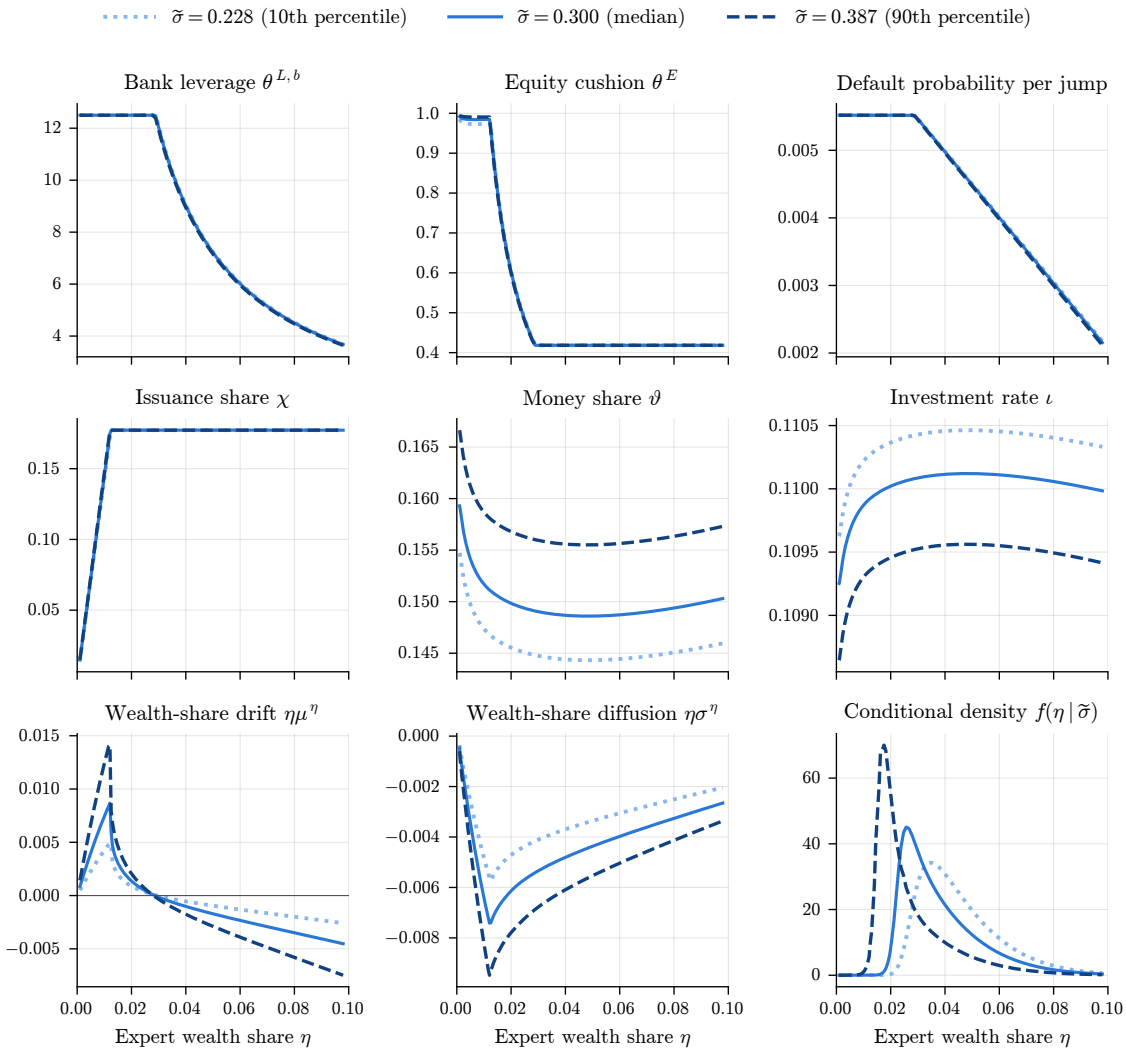


Figure 2: The equilibrium at the baseline requirement $\varkappa = 0.08$ against the expert wealth share $\eta \leq 0.10$, at the 10th percentile, the median, and the 90th percentile of the stationary distribution of $\widetilde{\sigma}$. The density $f(\eta \mid \widetilde{\sigma})$ is the stationary density of η conditional on $\widetilde{\sigma}$.

above approximately 0.028, and the stationary density concentrates near this region.

The figure also illustrates the flight to safety described in Section 2.2. A higher idiosyncratic volatility is associated with a higher money share and lower investment. A positive volatility shock reduces the expert wealth share, $\sigma^\eta < 0$. Its proportional response is strongest near $\eta = 0.012$, where banks operate at the leverage cap and issuance reaches its ceiling. High volatility is therefore associated with poorer expert capitalization, and the conditional stationary density shifts toward lower values of η.

3 Constant capital requirements

In this section, we vary banks' capital requirement and study its effects on equilibrium and welfare. Figure 3 compares the unregulated equilibrium with the baseline requirement $\varkappa = 0.08$ and a tighter capital requirement $\varkappa = 0.14$.[9]

The requirement binds when experts are poorly capitalized. Financing a given loan portfolio requires more equity, so banks lend less and issuance reaches its ceiling only at a higher expert wealth share. Households consequently retain more idiosyncratic risk. Experts also invest a larger fraction of their net worth in bank equity, leaving less wealth outside their banks to cushion a failure. Their jump-risk term $\widetilde{\mathcal{J}}$ rises despite the reduction in bank leverage. The requirement therefore reduces banks' ability to share risk between households and experts.

These effects change prices even where the requirement does not currently bind. Money valuation depends on the risks agents expect to bear in the future (11). Anticipating less risk sharing when expert wealth is scarce, agents value money more as a means of self-insurance. The money share rises, lowering the capital price and investment.

At the same time, the requirement weakens the feedback between the flight to safety and expert capitalization. A rise in volatility produces a smaller decline in the expert wealth share, limiting the subsequent contraction in lending. Bank failures also become less frequent. Together, these effects shift the stationary distribution away from states with

[9] $\varkappa = 0.14$ is the welfare-maximising capital requirement, as explained later.

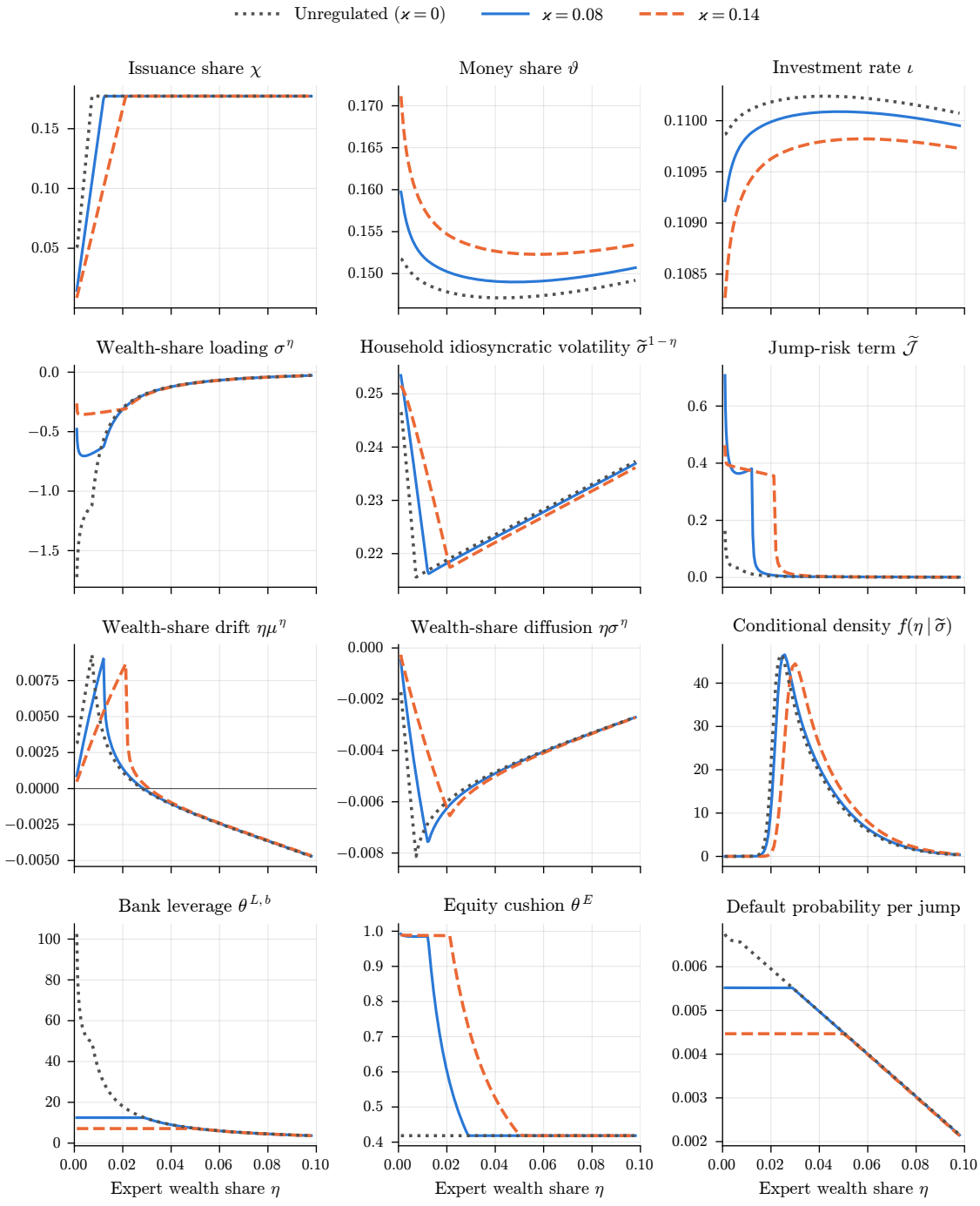


Figure 3: Equilibrium objects against the expert wealth share $\eta \leq 0.10$, at the stationary mean volatility of the unregulated equilibrium, $\widetilde{\sigma} = 0.306$. Each panel compares the unregulated equilibrium with the baseline requirement $\varkappa = 0.08$ and the constant requirement that maximizes aggregate welfare, $\varkappa = 0.14$. The density $f(\eta \mid \widetilde{\sigma})$ is the stationary density of η conditional on $\widetilde{\sigma}$.

scarce expert wealth. Under the constant requirement of 14%, the probability that η falls below 0.02 declines from 13.4% to 2.8%. The requirement thus trades weaker risk sharing and lower investment against fewer failures and more stable expert capitalization.

3.1 Welfare

We measure welfare as a weighted sum of expert and household welfare with a fixed Pareto weight $\omega \simeq 0.036$ on experts, equal to their mean wealth share in the unregulated equilibrium. The sector level welfare flows are $u_t^e + \log \eta_t$ for experts and $u_t^h + \log(1-\eta_t)$ for households, where

$$u^e = \log(a-\iota) + \frac{1}{\rho}\Big[g^K + \tilde{\lambda}_j\big\{\mathbb{E}[\log(1+\theta^E j^E)] - \theta^E \mathbb{E}[j^E]\big\}\Big],$$
$$u^h = \log(a-\iota) + \frac{1}{\rho}\Big[g^K - \tfrac{1}{2}(\widetilde{\sigma}^{1-\eta})^2\Big].$$

Both sectors value current consumption, $\log(a-\iota)$, and capital growth, $g^K = g(\iota) - \delta_t$. Experts additionally bear their banks' idiosyncratic jump risk, while households bear the idiosyncratic capital risk they retain. The expert correction subtracts the jump mean already included in aggregate wealth-share dynamics. The log wealth-share terms account for the allocation of aggregate wealth between the two sectors.

Welfare from state $(\eta_0, \widetilde{\sigma}_0^2)$ under a given policy is

$$W(\eta_0, \widetilde{\sigma}_0^2) = \mathbb{E}_0\left[\int_0^\infty \rho e^{-\rho t}\Big(\omega\big(u_t^e + \log\eta_t\big) + (1-\omega)\big(u_t^h + \log(1-\eta_t)\big)\Big)dt\right], \tag{13}$$

where expectations follow the equilibrium under the respective policy. Stationary welfare is the average of W in (13) under the stationary distribution of $(\eta, \widetilde{\sigma}^2)$ that the policy induces.

Figure 4 decomposes stationary aggregate welfare into the following terms: (i) the log wealth shares of experts and households, (ii) consumption and growth, (iii) the idiosyncratic risk households retain, and (iv) the jump risk experts bear. Changes are reported in log points, so the components add exactly. Each requirement is evaluated under its own

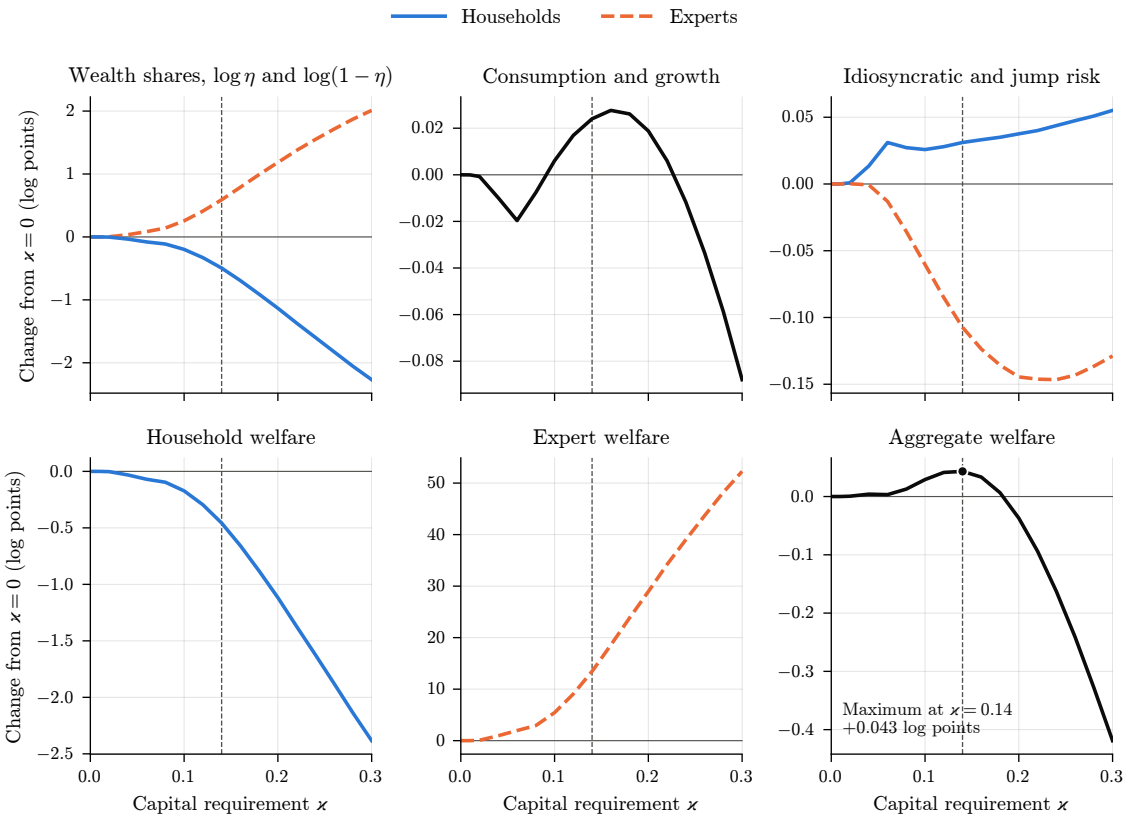


Figure 4: Stationary welfare across constant capital requirements $\varkappa \leq 0.30$. All changes are relative to $\varkappa = 0$ and expressed in log points. The dashed vertical line shows the capital requirement that maximizes aggregate welfare.

stationary distribution, with the Pareto weight held fixed. This comparison captures differences across stationary regimes; it does not include the transition following the introduction of regulation from a common initial state.

Aggregate welfare peaks at $\varkappa = 0.14$, with a consumption-equivalent gain of 0.043% relative to the unregulated equilibrium. This small net gain reflects substantial offsetting changes in the distribution of wealth and the risks each sector bears. Tighter capital requirement shifts wealth toward experts. At $\varkappa = 0.14$, expert welfare rises by 13.5 log points, while household welfare falls by 0.46 log points. The large expert gain receives a small weight in aggregate welfare because experts account for a small share of wealth in the unregulated economy. Household losses, although smaller individually, receive correspondingly greater weight.

The aggregate effect of this redistribution depends on both the mean and the distribution of the expert wealth share. With log utility, the wealth-share expression $\omega \log \eta + (1 - \omega) \log(1 - \eta)$ is maximized at $\eta = \omega$. Since the Pareto weight ω equals the mean expert wealth share in the unregulated economy, raising the mean above this level reduces the expression evaluated at the mean. Regulation also makes very low values of η less frequent. These states are particularly costly because expert log wealth falls sharply as η approaches zero. The improvement in the distribution outweighs the cost of shifting its mean: the combined wealth-share contribution rises by approximately 0.10 log points.[10]

The consumption and growth term captures a separate trade-off. Lower investment leaves more output available for current consumption but slows capital accumulation. Fewer bank failures reduce capital destruction and partly offset the slower growth. The combined contribution is positive at the welfare-maximizing requirement but turns negative when the requirement becomes sufficiently tight.

Households also bear slightly less idiosyncratic risk on average. This is an equilibrium average, combining changes in portfolios, prices, and the stationary distribution of states.

[10] We separate the wealth-share contribution into the expression evaluated at mean η and the difference between its expectation and its value at the mean. At $\varkappa = 0.14$, the first contribution falls by approximately 0.03 log points, while the second rises by 0.13 log points.

A requirement restricts risk transfer when expert wealth is scarce, but it also changes how often the economy visits those states. The exogenous variance process itself is unchanged across policies.

This household-risk contribution depends on aggregate volatility shocks. Without them, households bear the same idiosyncratic exposure across interior deterministic steady states.[11] With volatility shocks, regulation changes the joint distribution of expert wealth and risk exposures, allowing average household risk to differ across requirements.

The main offsetting cost is the jump risk borne by experts. A tighter requirement induces experts to invest a larger fraction of their personal wealth in bank equity. Their banks fail less frequently, but experts lose a larger fraction of their wealth when a failure occurs. The expert jump-risk contribution, net of compensation for expected losses, falls by approximately 0.11 log points at $\varkappa = 0.14$.

Beyond the welfare-maximizing requirement, the additional cost of concentrated expert risk increases, the consumption and growth contribution deteriorates, and the net wealth-share contribution declines. The optimum therefore balances the benefit of avoiding states with scarce expert wealth against the costs of weaker risk sharing, concentrated bank ownership, and lower investment.

3.2 A volatility shock

Figure 8 in Appendix C traces the response to an increase in variance $\widetilde{\sigma}^2$ equal to one standard deviation of its stationary distribution. It compares the unregulated equilibrium with the constant requirements $\varkappa = 0.08$ and $\varkappa = 0.14$. Each economy starts at its own stationary median state, and responses are measured relative to its corresponding unshocked path. The experiment therefore compares typical responses under each regime.

The shock triggers a flight to safety. Households demand more money to insure against higher idiosyncratic risk, raising the money share and lowering the capital price. Investment

[11] In an interior deterministic steady state, the wealth-share condition implies $\widetilde{\mathcal{J}} = (\widetilde{\sigma}^{1-\eta})^2$. Substituting this equality into the money-valuation condition gives $(\widetilde{\sigma}^{1-\eta})^2 = \rho$, independently of the capital requirement.

and capital growth fall. These price and investment responses are broadly similar across the three regimes and largely dissipate within five years.

Expert capitalization recovers more slowly. The initial revaluation reduces the expert wealth share by approximately 0.46 percentage points in each economy. Even after the responses of money valuation and investment have largely faded, expert wealth remains below its unshocked path. The shock thus leaves a persistent effect on financial intermediation through the distribution of wealth.

The capital requirement changes how banks adjust to this loss. Without regulation, banks increase leverage, cushioning the decline in lending. Banks constrained by the requirement cannot make the same adjustment, so more of the response falls on issuance. Under $\varkappa = 0.14$, the peak decline in issuance is approximately 0.05 percentage points, compared with 0.02 without regulation. A fixed requirement therefore makes lending more procyclical following the volatility shock.

Expert wealth nevertheless recovers somewhat faster under the tighter requirement. After five years, the expert wealth share is approximately 0.19 percentage points below its unshocked path under $\varkappa = 0.14$, compared with 0.22 without regulation. The difference is modest. These responses illustrate the trade-off underlying the stationary welfare results: stronger capitalization limits banks' ability to maintain lending after a shock, while improving the subsequent dynamics of expert wealth.

The similar initial responses at the median coexist with larger differences in the lower tail of the stationary distribution. A typical volatility shock and the sequences of shocks that leave experts severely undercapitalized need not produce the same policy comparison. Stationary welfare accounts for both.

The procyclical lending response motivates a state-contingent requirement that can be relaxed after a shock. Evaluating such a policy requires balancing the immediate benefit of relaxing the lending constraint against its effects on risk taking, asset prices, and the future distribution of expert wealth. The next section studies this choice when the regulator cannot commit.

4 Countercyclical capital requirements

In this section, we study a planner who chooses a state-contingent capital requirement without commitment. The planner accounts for the effects of current regulation on future welfare but takes the policies of future planners as given.

4.1 The planner's problem

Objective. The planner maximizes the welfare W in (13), with the same Pareto weight ω. Section 3.1 averages W over the stationary distribution of each constant requirement. The planner maximizes $W(\eta, \widetilde{\sigma}^2)$ from the current state $(\eta, \widetilde{\sigma}^2)$.

Instrument. The planner chooses bank leverage $\theta^{L,b}$ at each state $(\eta, \widetilde{\sigma}^2)$ and implements it with the requirement $\varkappa = 1/\theta^{L,b}$. The planner therefore chooses any leverage from the no-default leverage $\theta^{L,b}_{ND}$ up to the leverage that the bank chooses on its own.

No commitment. The planner cannot commit to future requirements, so it solves a sequence of problems, one at each date. When it sets leverage at one state, it takes prices and its own future choices as given. Prices reflect the requirements of all future dates, and a change in the requirement for one instant does not move them. The planner therefore takes the forward-looking money share ϑ, its derivatives, and hence investment ι at their equilibrium values as given.

Trade-off. On the one hand, lower leverage at a state $(\eta, \widetilde{\sigma}^2)$ changes the current flows. Fewer banks fail, so resolution destroys less capital and g^K rises for both sectors. The jump risk experts bear and the idiosyncratic risk households retain also change. On the other hand, lower leverage changes the drift and volatility of the expert wealth share, and with them the states the economy visits next. The value W measures welfare at those states. At each state, the planner chooses the leverage that maximizes the current aggregate flow plus the expected change in W. In equilibrium, prices and W follow from

the planner's requirements, and each requirement is the planner's best choice given prices and W. Appendix A.10 writes the problem as a partial differential equation for W.

Figure 5 compares the discretionary planner's policy with the unregulated equilibrium and the best constant requirement, $\varkappa = 0.14$. The top row shows bank leverage and loan issuance at median idiosyncratic volatility. The bottom row shows the stationary distribution of expert wealth conditional on median and high volatility. The comparison separates how regulation changes allocations at a given state from how it changes the frequency with which the economy visits different states.

When experts are poorly capitalized, the discretionary planner chooses leverage close to the privately optimal level. Issuance is below its ceiling because bank equity is scarce. Reducing leverage would restrict lending and leave households bearing more idiosyncratic risk. The constant requirement imposes this restriction: banks lend less at a given expert wealth share, and issuance reaches its ceiling only when experts have accumulated substantially more wealth.

The discretionary planner tightens regulation once expert wealth is sufficient to support issuance at its ceiling. In this intermediate region, it reduces bank leverage sharply while preserving lending. Experts finance the same loan holdings by investing a larger fraction of their wealth in bank equity, θ^E, approaching full investment at the tightest point. Lower bank leverage reduces the probability of default, but the larger equity position exposes experts to a greater loss of personal wealth when their bank fails. The planner balances these effects against the benefit of preserving risk sharing with households. At higher expert wealth shares, it again chooses leverage close to the privately optimal level, with a more modest reduction. Throughout, issuance remains close to its unregulated level.

These choices also explain the stationary distributions in the second row. The distribution depends on both the drift of expert wealth and its exposure to common shocks. Bank leverage alone does not determine this exposure. An expert's total loan position per unit of personal wealth is $\theta^E \theta^{L,b}$, which loan market clearing ties to issuance through (9). Under the planner, the increase in θ^E largely offsets the reduction in bank leverage. Issuance and

money valuation remain close to their unregulated levels, so common price changes continue to redistribute wealth between experts and households in much the same way.

The planner nevertheless changes how fast experts accumulate wealth in the intermediate region. Surprisingly, lower bank leverage makes the expert wealth share grow faster. Issuance stays at its ceiling, so experts hold the same loans with almost all of their wealth in the equity of their own bank. They cannot diversify its jump risk, and they earn compensation for bearing it. At median volatility, the drift of the expert wealth share is up to three times its unregulated level. This faster accumulation is what the planner gains from tightening. The current flow of welfare is lower, because experts bear concentrated risk. Above the intermediate region this cost exceeds the gain, and the planner returns to leverage close to the privately optimal level.

The planner tightens sharply in a narrow range of states, which the economy visits 1.4% of the time. The constant requirement binds 77% of the time and raises the drift of the expert wealth share wherever it binds. At $\eta = 0.025$ and median volatility, the expert wealth share grows at 4.7% per year under the constant requirement and at 1.6% without regulation. By restricting issuance when expert wealth is scarce, the constant requirement also reduces experts' total loan exposure and cushions their wealth against the flight to safety. Appendix Figure 9 shows these differences in drift and diffusion. Consequently, the planner's stationary densities remain close to those of the unregulated economy, with a modest shift toward higher expert wealth. The constant requirement produces a larger shift and places much less probability on states with poorly capitalized experts. At high volatility, all three economies place more probability on low expert wealth, consistent with the flight to safety: money appreciates relative to capital, reducing the wealth share of experts exposed to loans. The constant requirement cushions this redistribution more strongly. Its long-run effect therefore extends beyond reducing bank leverage at a given state: it makes states with scarce expert wealth less frequent.

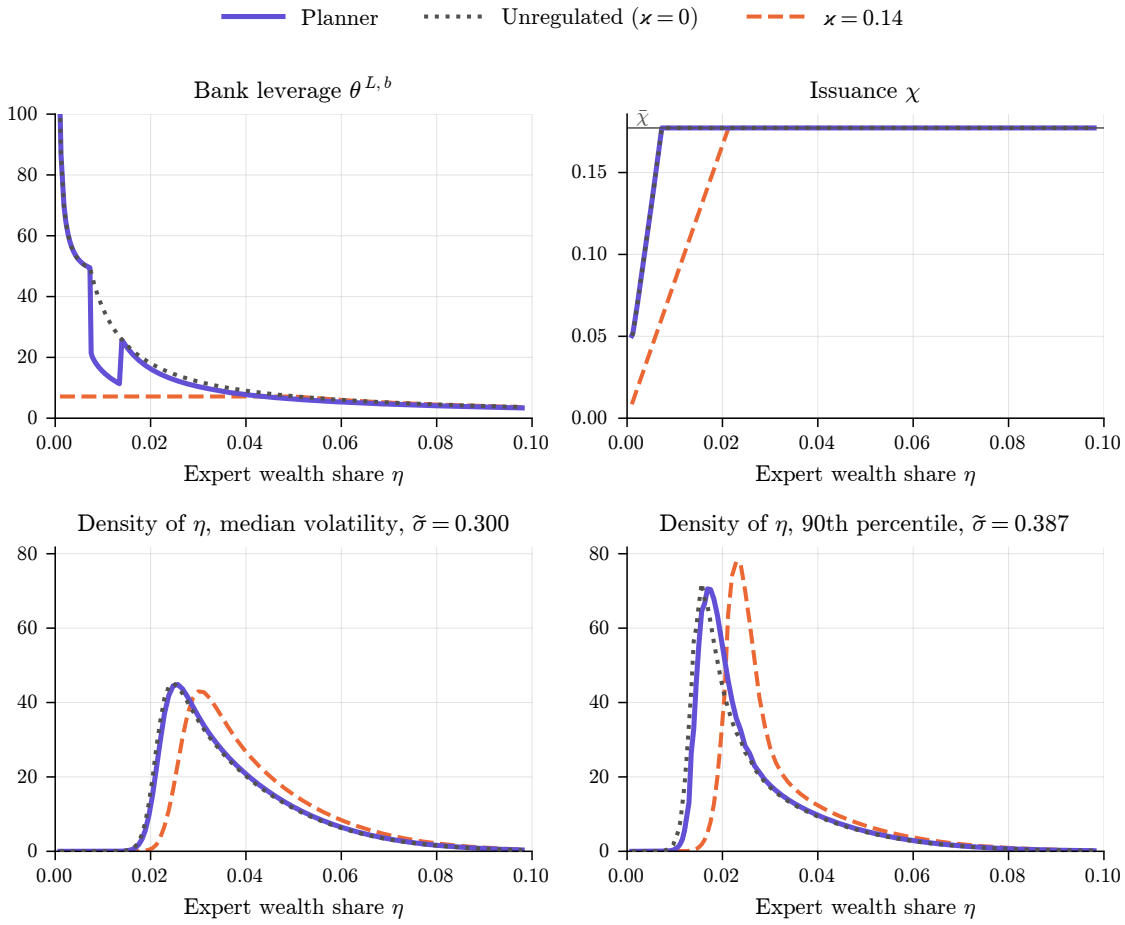


Figure 5: The planner's choice against the unregulated equilibrium and the constant requirement $\varkappa = 0.14$. Top: bank leverage and issuance, with its ceiling $\bar{\chi}$, at the median of the stationary distribution of $\widetilde{\sigma}$. Bottom: the stationary density of η conditional on $\widetilde{\sigma}$ in each economy, at the median and the 90th percentile of $\widetilde{\sigma}$.

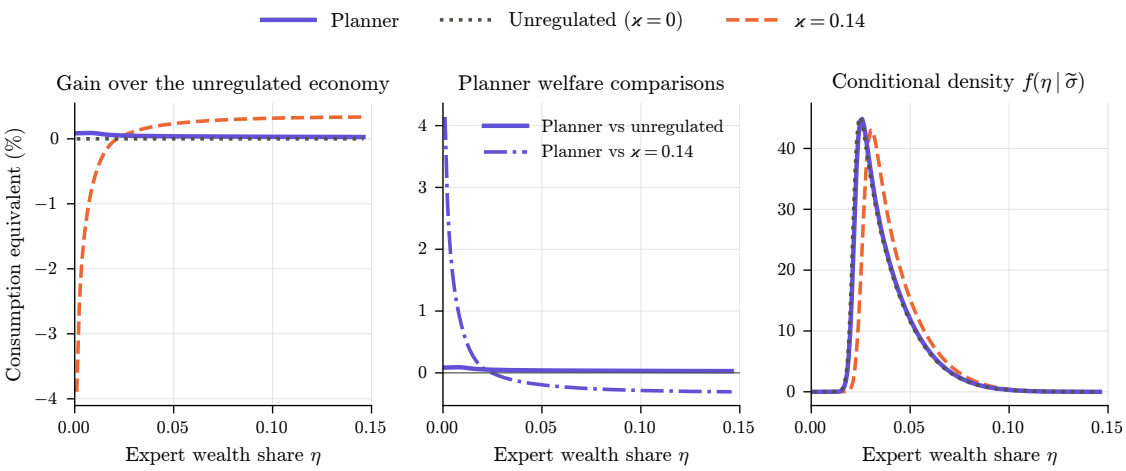


Figure 6: Aggregate welfare by initial state at median volatility, $\widetilde{\sigma} = 0.300$, in consumption-equivalent terms. Left: gains of the planner and of $\varkappa = 0.14$ over the unregulated equilibrium. Middle: the planner's gain over the unregulated equilibrium and over $\varkappa = 0.14$. Right: the stationary density of η conditional on $\widetilde{\sigma}$ in each economy.

Comparison with constant requirements. Figure 6 focuses on the comparison with the best constant requirement, $\varkappa = 0.14$. The planner delivers higher welfare when expert wealth is low, whereas the constant requirement performs better when experts are well capitalized. The planner preserves lending in fragile states and avoids the immediate cost of leaving households with more idiosyncratic risk. The constant requirement accepts this cost in exchange for lower leverage and less exposure of expert wealth to a flight to safety.

The frequency of these states matters for the long-run comparison. As Figure 5 shows, the constant requirement shifts the stationary distribution away from states with scarce expert wealth. The planner's largest advantage is therefore in states that the constant requirement makes relatively rare. Evaluated under each policy's own stationary distribution, the best constant requirement raises aggregate welfare by 0.043% relative to the unregulated equilibrium, compared with 0.034% under the planner. These stationary gains complement the comparisons from a common initial state: they account for the different distributions of states that the policies induce.

Why can a constant requirement outperform a planner who chooses regulation at every state? The planner's flexibility is subject to sequential optimality. It accounts for how

current leverage affects both current welfare and the future evolution of expert wealth, but it takes future planners' choices and the equilibrium price function as given. Choosing a constant requirement forever would change regulation at all future dates and, through expectations, money valuation and capital prices. Such a change is outside the current planner's choice.

This distinction matters most when experts are poorly capitalized. Given future policy and prices, the planner prefers to preserve lending rather than maintain a tight requirement for the current instant. A constant rule instead keeps the requirement in force in those states. The constant cap on leverage changes wealth dynamics and makes fragile states less frequent. Once a fragile state is reached, however, a future planner has an incentive to relax the requirement. The constant rule thus sustains a policy that would not remain optimal for successive planners.

A planner able to commit to an entire state-contingent rule could always reproduce the constant requirement. Here, each policy choice must also be optimal when the relevant state is reached. The welfare ranking reflects this restriction: discretion preserves lending in bad states, while commitment to a constant requirement does more to prevent the economy from reaching them.

5 Conclusion

This paper studies bank capital regulation in an economy in which banks diversify households' idiosyncratic risk and the value of safe assets is endogenous. Households self-insure with outside money, whose value is forward-looking: it reflects the risks agents expect to bear under current and future regulation. When idiosyncratic risk rises, a flight to safety raises the value of money, lowers the capital price and investment, and erodes the wealth of bank owners, which restricts lending further.

Capital requirements operate through this mechanism. In our baseline calibration, a constant requirement of 14% maximizes welfare, and overregulation is far more costly than

underregulation. Decomposing welfare reveals large offsetting effects behind the small net gain. Regulation shifts wealth toward bank owners and reduces the capital destroyed by bank failures, but it concentrates failure risk on bank owners and, at tight requirements, lowers investment. Much of the gain comes not from changes in allocations at a given state but from a shift in the stationary distribution away from states in which bank owners are poorly capitalized.

A discretionary planner setting the CCyB preserves lending when banks are poorly capitalized and, starting from such states, achieves higher welfare than the constant requirement. Since it cannot change the regulation that agents expect in the future, however, it takes the value of safe assets as given. A constant requirement commits to regulation in fragile states, which raises the value of money as a means of self-insurance and makes these states rare. From an ex-ante perspective, the constant requirement therefore delivers higher welfare than the discretionary CCyB.

Our welfare comparisons are across stationary distributions. In the long run, bank owners gain substantially from stricter regulation as their wealth share rises. Tightening regulation from today's state, however, may impose losses on them during a long transition before their wealth share has adjusted. Studying this transition is left for future research.

A Model derivations

This appendix states the equilibrium conditions, derives them from the individual problems, and defines the welfare measures.

A.1 Equilibrium conditions

Proposition 1 (Equilibrium characterization)**.** *A Markov equilibrium satisfies, at every state* $x = (\eta, \widetilde{\sigma}^2)$*:*

(i) Static conditions. *Loan market clearing* (9)*, the issuance condition* (A.4)*, the leverage condition* (A.3)*, and the complementarity conditions*

$$0 \le \chi \le \bar{\chi}, \quad \lambda^{\bar{\chi}} \ge 0, \quad \lambda^{\bar{\chi}}(\bar{\chi} - \chi) = 0, \qquad \lambda^{\varkappa} \ge 0, \quad \lambda^{\varkappa}\Big(\tfrac{1}{\varkappa} - \theta^{L,b}\Big) = 0.$$

(ii) Wealth-share dynamics. *The expert wealth share follows* $d\eta_t/\eta_t = \mu_t^\eta dt + \sigma_t^\eta dZ_t$ *with*

$$\mu^\eta = (1-\eta)\Big[(\sigma^\eta)^2 - (\sigma^{1-\eta})^2 - (\widetilde{\sigma}^{1-\eta})^2 + \widetilde{\mathcal{J}}\Big] - \sigma^\eta\sigma^\vartheta, \qquad \eta\sigma^\eta = \frac{(\eta-\chi)\sigma(\widetilde{\sigma})\partial_{\widetilde{\sigma}^2}\vartheta/\vartheta}{1 + (\chi-\eta)\partial_\eta\vartheta/\vartheta}, \tag{A.1}$$

where $\sigma^{1-\eta} = -\eta\sigma^\eta/(1-\eta)$ *is the loading of the household wealth share,* σ^ϑ *the loading of the money share,* $\widetilde{\mathcal{J}} \ge 0$ *the aggregate jump-risk term, and* $\widetilde{\sigma}^{1-\eta}$ *the idiosyncratic volatility households retain per unit of their wealth (Appendix A.7).*

(iii) Money valuation. *The money share solves*

$$\begin{aligned}\rho\vartheta = {} & \Big[\eta\big((\sigma^\eta)^2 + \widetilde{\mathcal{J}}\big) + (1-\eta)\big((\sigma^{1-\eta})^2 + (\widetilde{\sigma}^{1-\eta})^2\big)\Big]\vartheta \\ & + \partial_\eta\vartheta\ \eta\mu^\eta + \tfrac{1}{2}\partial_{\eta\eta}\vartheta\ \eta^2(\sigma^\eta)^2 + \psi\big((\widetilde{\sigma}^0)^2 - \widetilde{\sigma}^2\big)\partial_{\widetilde{\sigma}^2}\vartheta + \tfrac{1}{2}\sigma^2\widetilde{\sigma}^2\partial_{\widetilde{\sigma}^2\widetilde{\sigma}^2}\vartheta + \eta\sigma^\eta\sigma(\widetilde{\sigma})\partial_{\eta\widetilde{\sigma}^2}\vartheta.\end{aligned} \tag{A.2}$$

A.2 Returns and the wealth numeraire

The expected returns in (2) decompose as

$$\mathbb{E}[r_t^K] = \frac{a - \iota_t}{q_t^K} + \mu_t^{q^K} + \mu_t^K - \tilde{\lambda}_j\chi_t\mathbb{E}[\mathcal{d}_t], \qquad \mathbb{E}[r_t^{\mathcal{MB}}] = \mu_t^{q^{\mathcal{MB}}} + \mu_t^K, \qquad \mu_t^K = g(\iota_t) - \delta_t.$$

The capital return adds back the direct cost $-\tilde{\lambda}_j \chi_t \mathbb{E}[\not{d}_t]$, not the spillover. The spillover lowers the capital and money returns in common. It cancels from relative returns and remains in physical growth and welfare. The expected loan return $\mathbb{E}[r_t^L]$ clears the loan market. Hatted returns and loadings are measured in units of total wealth N_t. Because capital is the fraction $1-\vartheta_t$ of total wealth and money the fraction ϑ_t, the loadings of loans and deposits are

$$\hat{\sigma}_t^L = \sigma_t^{1-\vartheta}, \qquad \hat{\sigma}_t^D = \sigma_t^{\vartheta},$$

the loadings of $1-\vartheta_t$ and ϑ_t on Z_t.

A.3 Deposit losses

With the resolution cost (12) and $\theta_t^{L,b} > 1$, the contractual deposit loss per unit of deposits is

$$\tilde{j}_t^D = \begin{cases} \dfrac{(1+\not{d}_0)(1+\theta_t^{L,b}\tilde{j})}{\theta_t^{L,b}-1}, & \tilde{j} < -1/\theta_t^{L,b}, \\ 0, & \tilde{j} \geq -1/\theta_t^{L,b}. \end{cases}$$

The shortfall is computed from pre-cost equity, so the right side contains no unknown and there is no recovery-cost fixed point. Admissibility requires $-1 \leq \tilde{j}_t^D \leq 0$ on the jump size support, which the calibration satisfies through $(1+\not{d}_0)(-\underline{j}) < 1$. At $\theta_t^{L,b} = 1$ there are no deposits and $\tilde{j}_t^D = 0$. Depositors bear the loss and are compensated for its expected value, so the return on a deposit at one bank is

$$dr_t^{D,b} = dr_t^{\mathcal{MB}} - \tilde{\lambda}_j \mathbb{E}[\tilde{j}_t^D]dt + \tilde{j}_t^D d\tilde{J}_t.$$

Jumps are independent across banks, so a depositor who spreads deposits across many banks earns $dr_t^{\mathcal{MB}}$. In (6), the equity jump nets the loan jump, the resolution charge, and the full contractual deposit loss:

$$\theta_t^{L,b}\Big[\tilde{j} - \not{d}_0\Big(-\tfrac{1}{\theta_t^{L,b}} - \tilde{j}\Big)^+\Big] - (\theta_t^{L,b}-1)\tilde{j}_t^D = \theta_t^{L,b}\tilde{j} + (-1-\theta_t^{L,b}\tilde{j})^+ = \max(\theta_t^{L,b}\tilde{j}, -1) = j_t^E.$$

A.4 Household optimality

With log utility, $c_t^h = \rho n_t^h$, and a household's stochastic discount factor in the wealth numeraire is $d\hat{\xi}_t^h/\hat{\xi}_t^h = -\hat{r}_t^h dt - \varsigma_t^h dZ_t - \tilde{\varsigma}_t^h d\tilde{Z}_t$. Its prices of aggregate and idiosyncratic risk equal the household's wealth loadings, $\varsigma_t^h = \sigma_t^{1-\eta}$ and $\tilde{\varsigma}_t^h = \widetilde{\sigma}_t^{1-\eta}$. The first-order condition for issuance χ_t^h in (3), with multiplier $\lambda_t^{\bar{\chi}}$ on the ceiling, is

$$\mathbb{E}[\hat{r}_t^L] - \mathbb{E}[\hat{r}_t^D] = \varsigma_t^h\big(\hat{\sigma}_t^L - \hat{\sigma}_t^D\big) + \tilde{\varsigma}_t^h\widetilde{\sigma}_t - \lambda_t^{\bar{\chi}}, \qquad \lambda_t^{\bar{\chi}}(\bar{\chi} - \chi_t) = 0, \quad \lambda_t^{\bar{\chi}} \geq 0.$$

Borrowing through a loan replaces a deposit return with a loan return and sheds idiosyncratic exposure priced at $\tilde{\varsigma}_t^h\widetilde{\sigma}_t$.

A.5 Bank optimality

The law of motion of equity gives payouts $dD_t^b = dr_t^E - dE_t^b/E_t^b$. Substituting them into (7) splits the objective in two:

$$\begin{aligned}\mathbb{E}_0\left[\int_0^\infty \xi_t^e E_t^b\left(dD_t^b + \frac{d[\xi^e, D^b]_t}{\xi_t^e}\right)\right] = -\mathbb{E}_0\left[\int_0^\infty \xi_t^e\left(dE_t^b + \frac{d[\xi^e, E^b]_t}{\xi_t^e}\right)\right] \\ + \mathbb{E}_0\left[\int_0^\infty \xi_t^e E_t^b\left(dr_t^E + \frac{d[\xi^e, r^E]_t}{\xi_t^e}\right)\right].\end{aligned}$$

The expert chooses E_t^b, so the first term does not depend on the bank's choices. Leverage enters only dr_t^E, with no link across dates, and $\xi_t^e E_t^b > 0$. The bank therefore maximizes, at each date, $\mathbb{E}_t\big[dr_t^E + d[\xi^e, r^E]_t/\xi_t^e\big]/dt$ subject to $\varkappa_t\theta_t^{L,b} \leq 1$. With log utility, ξ_t^e is proportional to $e^{-\rho t}/n_t^e$. Its loading on Z_t is $-\varsigma_t^e$, and a bank jump changes it by the fraction $-\theta_t^E j_t^E/(1+\theta_t^E j_t^E)$. The covariation with the equity return (6) is therefore

$$\frac{d[\xi^e, r^E]_t}{\xi_t^e} = -\varsigma_t^e\sigma_t^{r^E}dt - \frac{\theta_t^E(j_t^E)^2}{1+\theta_t^E j_t^E}d\tilde{J}_t.$$

With $\mathbb{E}_t[dr_t^E] = \mathbb{E}[r_t^E]dt$, taking expectations gives (8).

A.6 Expert optimality

Expert wealth in the total-wealth numeraire evolves as

$$\frac{d\hat{n}_t^e}{\hat{n}_t^e} = \mu_t^{n^e} dt + \sigma_t^\eta dZ_t + \theta_t^E j_t^E d\tilde{J}_t,$$

with

$$\begin{aligned}
\mu_t^{n^e} &= -\rho + \mathbb{E}[\hat{r}_t^D] + \theta_t^E \Big[\theta_t^{L,b}\big(\mathbb{E}[\hat{r}_t^L] - \mathbb{E}[\hat{r}_t^D] - \tilde{\lambda}_j \mathbb{E}[\tilde{j}]\big) + \tilde{\lambda}_j(\theta_t^{L,b} - 1)\mathbb{E}[\tilde{j}_t^D]\Big], \\
\sigma_t^\eta &= \hat{\sigma}_t^D + \theta_t^E \theta_t^{L,b}(\hat{\sigma}_t^L - \hat{\sigma}_t^D).
\end{aligned}$$

Bank jumps do not load on Z_t, so the individual loading equals the loading of the sector share. The expert chooses θ_t^E to maximize $\mu_t^{n^e} - \frac{1}{2}(\sigma_t^\eta)^2 + \tilde{\lambda}_j \mathbb{E}[\log(1 + \theta_t^E j_t^E)]$. In this numeraire the bank's objective (8) changes only by terms independent of leverage, and the expert's price of aggregate risk is σ_t^η. With the expert's marginal utility held fixed, the derivative of (8) with respect to $\theta_t^{L,b}$ is then the derivative of the expert's objective, divided by θ_t^E. The first-order conditions are

$$\begin{aligned}
[\theta^E]: \quad 0 &= \theta_t^{L,b}\big(\mathbb{E}[\hat{r}_t^L] - \mathbb{E}[\hat{r}_t^D] - \tilde{\lambda}_j \mathbb{E}[\tilde{j}]\big) + \tilde{\lambda}_j(\theta_t^{L,b} - 1)\mathbb{E}[\tilde{j}_t^D] \\
&\quad - \theta_t^{L,b}(\hat{\sigma}_t^L - \hat{\sigma}_t^D)\sigma_t^\eta + \tilde{\lambda}_j \mathbb{E}\left[\frac{j_t^E}{1 + \theta_t^E j_t^E}\right], \\
[\theta^{L,b}]: \quad 0 &= \theta_t^E \Big[\mathbb{E}[\hat{r}_t^L] - \mathbb{E}[\hat{r}_t^D] - \tilde{\lambda}_j \mathbb{E}[\tilde{j}] + \tilde{\lambda}_j \mathbb{E}[\tilde{j}_t^D]\Big] + \tilde{\lambda}_j \theta_t^E (\theta_t^{L,b} - 1)\frac{d\mathbb{E}[\tilde{j}_t^D]}{d\theta_t^{L,b}} \\
&\quad - \theta_t^E(\hat{\sigma}_t^L - \hat{\sigma}_t^D)\sigma_t^\eta + \tilde{\lambda}_j \mathbb{E}\left[\frac{\theta_t^E \partial j_t^E / \partial \theta_t^{L,b}}{1 + \theta_t^E j_t^E}\right] - \lambda_t^{\varkappa}.
\end{aligned}$$

Taking $[\theta^{L,b}] - (\theta_t^E/\theta_t^{L,b})[\theta^E]$ eliminates prices and loadings. On the branch with a positive default probability it gives the leverage condition

$$\lambda_t^{\varkappa} = \tilde{\lambda}_j \frac{\theta_t^E \mathbb{P}_t\big(\tilde{j} < -1/\theta_t^{L,b}\big)}{\theta_t^{L,b}} \left[\frac{1}{1 - \theta_t^E} - (1 + d_0)\right], \qquad \lambda_t^{\varkappa} \geq 0, \quad \lambda_t^{\varkappa}\Big(\tfrac{1}{\varkappa} - \theta_t^{L,b}\Big) = 0. \quad \text{(A.3)}$$

With a slack requirement, $\lambda_t^{\varkappa} = 0$ delivers the equity cushion $\theta_t^E = \not{a}_0/(1+\not{a}_0)$. The no-default branch $\theta_t^{L,b} \le \theta_{ND}^{L,b}$ and the binding branch $\theta_t^{L,b} = 1/\varkappa$ have their own conditions. At every state, the selected branch maximizes the expert's objective over leverage at or below the cap, with θ^E reoptimized for each leverage.

Log utility sets the household's risk prices to its wealth loadings (Appendix A.4). Combining the household issuance condition with $[\theta^E]$ then eliminates the expected excess return and gives the equilibrium issuance condition

$$0 = (\sigma_t^{\eta} - \sigma_t^{1-\eta})(\hat{\sigma}_t^L - \hat{\sigma}_t^D) - \widetilde{\sigma}_t^{1-\eta}\widetilde{\sigma}_t + \lambda_t^{\bar{\chi}} + \tilde{\lambda}_j \left[\mathbb{E}[\tilde{j}] + \frac{1-\theta_t^{L,b}}{\theta_t^{L,b}} \mathbb{E}[\tilde{j}_t^D] - \frac{1}{\theta_t^{L,b}} \mathbb{E}\left(\frac{j_t^E}{1+\theta_t^E j_t^E} \right) \right], \tag{A.4}$$

with the complementarity in Proposition 1. Aggregate destruction δ_t does not appear, because it cancels from relative returns.

On the partial-default branch, $\theta_{ND}^{L,b} < \theta_t^{L,b} < -1/j_h$, only large losses cause default, and the mixture moments have closed forms:

$$\begin{aligned}
\mathbb{P}_t(\tilde{j} < -1/\theta_t^{L,b}) &= p_L \frac{1+\theta_t^{L,b}\underline{j}}{\theta_t^{L,b}\underline{j}}, \qquad \mathbb{E}\Big[\Big(-\tfrac{1}{\theta_t^{L,b}} - \tilde{j}\Big)^+\Big] = p_L \frac{(-1/\theta_t^{L,b} - \underline{j})^2}{-2\underline{j}}, \\
\mathbb{E}[\tilde{j}_t^D] &= -\frac{(1+\not{a}_0)\theta_t^{L,b}}{\theta_t^{L,b}-1} \mathbb{E}\Big[\Big(-\tfrac{1}{\theta_t^{L,b}} - \tilde{j}\Big)^+\Big], \\
\mathbb{E}[j_t^E] &= p_L \left(-1 - \frac{1}{2\underline{j}\theta_t^{L,b}} \right) + (1-p_L)\theta_t^{L,b} j_h, \\
\mathbb{E}[\log(1+\theta_t^E j_t^E)] &= p_L \left[\frac{1+\theta_t^{L,b}\underline{j}}{\theta_t^{L,b}\underline{j}} \log(1-\theta_t^E) + \frac{(1-\theta_t^E)\log(1-\theta_t^E) + \theta_t^E}{\underline{j}\theta_t^E\theta_t^{L,b}} \right] \\
&\quad + (1-p_L)\log(1+\theta_t^E\theta_t^{L,b} j_h), \\
\mathbb{E}\left[\frac{j_t^E}{1+\theta_t^E j_t^E} \right] &= p_L \left[-\frac{1+\theta_t^{L,b}\underline{j}}{\underline{j}\theta_t^{L,b}(1-\theta_t^E)} - \frac{\theta_t^E + \log(1-\theta_t^E)}{\underline{j}(\theta_t^E)^2\theta_t^{L,b}} \right] \\
&\quad + (1-p_L)\frac{\theta_t^{L,b} j_h}{1+\theta_t^E\theta_t^{L,b} j_h}.
\end{aligned}$$

Other branches use the corresponding expectations over the jump size distribution.

A.7 Wealth-share dynamics

Individual bank jumps average out of sector wealth. The drift of the expert share therefore adds the jump mean to the individual drift, $\mu_t^\eta = \mu_t^{n^e} + \tilde{\lambda}_j \theta_t^E \mathbb{E}[j_t^E]$, and the aggregate jump-risk term is

$$\mathcal{J}_t = \tilde{\lambda}_j (\theta_t^E)^2 \mathbb{E}\left[\frac{(j_t^E)^2}{1+\theta_t^E j_t^E}\right] = \tilde{\lambda}_j \theta_t^E \Big\{ \mathbb{E}[j_t^E] - \mathbb{E}\big[j_t^E/(1+\theta_t^E j_t^E)\big] \Big\} \geq 0.$$

Households retain idiosyncratic Brownian exposure

$$\widetilde{\sigma}_t^{1-\eta} = \frac{1-\vartheta_t}{1-\eta_t}(1-\chi_t)\widetilde{\sigma}_t$$

per unit of their wealth. The shares sum to one, so $\mu_t^{1-\eta} = -\eta_t \mu_t^\eta/(1-\eta_t)$ and $\sigma_t^{1-\eta} = -\eta_t \sigma_t^\eta/(1-\eta_t)$. Substituting the first-order conditions into $\mu_t^{n^e}$ delivers the drift in (A.1). Prices are functions of the state, $\vartheta_t = \vartheta(\eta_t, \widetilde{\sigma}_t^2)$. Applying Itô's formula to ϑ and matching dZ_t terms gives

$$\sigma_t^\vartheta \vartheta_t = \eta_t \sigma_t^\eta \partial_\eta \vartheta_t + \sigma(\widetilde{\sigma}_t^2)\partial_{\widetilde{\sigma}^2}\vartheta_t, \qquad \sigma_t^{1-\vartheta} = -\frac{\vartheta_t}{1-\vartheta_t}\sigma_t^\vartheta.$$

Substituting these loadings into σ_t^η from Appendix A.6 and using loan market clearing gives a linear equation in σ_t^η, whose solution is the loading in (A.1). Its denominator $1 + (\chi_t - \eta_t)\partial_\eta \vartheta_t/\vartheta_t$ must remain positive.

A.8 Money valuation

Deposits and money earn the same return, so $\mathbb{E}[\hat{r}_t^D] = \mu_t^\vartheta - \breve{\mu}_t^{\mathcal{MB}}$. The state covariances are

$$(d\eta_t)^2 = \eta_t^2(\sigma_t^\eta)^2 dt, \qquad (d\widetilde{\sigma}_t^2)^2 = \sigma(\widetilde{\sigma}_t^2)^2 dt, \qquad d\eta_t d\widetilde{\sigma}_t^2 = \eta_t \sigma_t^\eta \sigma(\widetilde{\sigma}_t^2) dt.$$

Applying Itô's formula to $\vartheta(\eta, \widetilde{\sigma}^2)$ and substituting the equilibrium expression for $\mathbb{E}[\hat{r}_t^D]$ from the household and expert first-order conditions yields (A.2). The mixed derivative

enters with coefficient one. A single common shock drives both states, so the money share depends on both and the mixed covariance is necessary.

At $\widetilde{\sigma} = 0$ the allocation $\chi = \theta^E = 0$ is an exact corner: the issuance condition holds with $\lambda^{\bar{\chi}} = 0$, all wealth-share loadings and $\mathcal{J}$ vanish, and $\mathbb{E}[\hat{r}^L] = \mathbb{E}[\hat{r}^D]$. For each fixed $\theta^{L,b}$, the marginal payoff of raising θ^E from zero is $-\tilde{\lambda}_j \theta^{L,b} \not{d}_0 \mathbb{E}[(-1/\theta^{L,b} - \tilde{j})^+] \leq 0$, so $\theta^E = 0$ is a private optimum. With no assets in the bank, leverage is set to $\min(\theta^{L,b}_{ND}, 1/\varkappa)$.

A.9 Welfare

Sector welfare uses the flows

$$u^e = \log(a - \iota) + \frac{1}{\rho}\Big[g^K + \tilde{\lambda}_j\big\{\mathbb{E}[\log(1 + \theta^E j^E)] - \theta^E \mathbb{E}[j^E]\big\}\Big],$$
$$u^h = \log(a - \iota) + \frac{1}{\rho}\Big[g^K - \tfrac{1}{2}(\widetilde{\sigma}^{1-\eta})^2\Big],$$

with $g^K = g(\iota) - \delta_t$ expected log capital growth. The expert flow subtracts the jump mean because the share drift already contains it. Household idiosyncratic risk does not enter the aggregate state, so it appears in u^h. Total destruction is already in g^K. Fix initial capital K_0 and the initial shares. The sector values $W^e = \rho V^e - \log K_0$ and $W^h = \rho V^h - \log K_0$, where V^e and V^h are the values of (4) and (3) for an agent whose initial wealth equals the whole sector's wealth, satisfy

$$\rho W^e = \rho[u^e + \log \eta] + \mathcal{L} W^e, \qquad \rho W^h = \rho[u^h + \log(1 - \eta)] + \mathcal{L} W^h, \tag{A.5}$$

with the generator

$$\mathcal{L} V = \eta \mu^\eta V_\eta + \tfrac{1}{2}\eta^2 (\sigma^\eta)^2 V_{\eta\eta} + \psi\big((\widetilde{\sigma}^0)^2 - \widetilde{\sigma}^2\big) V_{\widetilde{\sigma}^2} + \tfrac{1}{2}\sigma^2 \widetilde{\sigma}^2 V_{\widetilde{\sigma}^2 \widetilde{\sigma}^2} + \eta \sigma^\eta \sigma(\widetilde{\sigma}) V_{\eta \widetilde{\sigma}^2}.$$

Stationary welfare evaluates each policy, a constant requirement or the planner, under its own stationary distribution π of $(\eta, \widetilde{\sigma}^2)$. By (A.5), the stationary welfare of a sector is the stationary average of its flow: $\mathbb{E}_\pi[W^e] = \mathbb{E}_\pi[u^e + \log \eta]$ and $\mathbb{E}_\pi[W^h] = \mathbb{E}_\pi[u^h + \log(1 - \eta)]$.

Sector s gains $\exp(\mathbb{E}_\pi[W^s] - \mathbb{E}_{\pi_0}[W^s]) - 1$ in consumption-equivalent terms, where π_0 is the stationary distribution of the unregulated equilibrium. The aggregate uses $\omega W^e + (1-\omega)W^h$ in place of W^s. Its five terms are $\omega \log \eta$, $(1-\omega)\log(1-\eta)$, consumption and growth $\log(a-\iota) + g^K/\rho$, household idiosyncratic risk $-(1-\omega)(\widetilde{\sigma}^{1-\eta})^2/(2\rho)$, and expert jump risk $\omega\tilde{\lambda}_j\{\mathbb{E}[\log(1+\theta^E \jmath^E)] - \theta^E \mathbb{E}[\jmath^E]\}/\rho$. Figure 4 reports the differences $\mathbb{E}_\pi[\,\cdot\,] - \mathbb{E}_{\pi_0}[\,\cdot\,]$ multiplied by 100, in log points. Figure 4, Section 4.1, and Table 2 use this comparison. The sector gains include the wealth-share terms $\log \eta$ and $\log(1-\eta)$. Without them, the gain per unit of sector wealth is $\exp(\mathbb{E}_\pi[u^s] - \mathbb{E}_{\pi_0}[u^s]) - 1$.

A.10 The planner

The value (13) solves the partial differential equation

$$\begin{aligned}\rho W = \max_{\theta^{L,b}} \Big\{ &\rho\big[\omega(u^e + \log\eta) + (1-\omega)(u^h + \log(1-\eta))\big] + \eta\mu^\eta W_\eta + \tfrac{1}{2}\eta^2(\sigma^\eta)^2 W_{\eta\eta} \\ &+ \psi\big((\widetilde{\sigma}^0)^2 - \widetilde{\sigma}^2\big)W_{\widetilde{\sigma}^2} + \tfrac{1}{2}\sigma^2\widetilde{\sigma}^2 W_{\widetilde{\sigma}^2\widetilde{\sigma}^2} + \eta\sigma^\eta\sigma(\widetilde{\sigma})W_{\eta\widetilde{\sigma}^2}\Big\},\end{aligned} \tag{A.6}$$

with the maximum over leverage from $\theta^{L,b}_{ND}$ to the bank's own choice. The first term is the aggregate flow. The other five are the expected change in W per unit of time, the generator $\mathcal{L}$ of (A.5) at the chosen leverage, so $W = \omega W^e + (1-\omega)W^h$. Write $u(\theta)$ for the first term and $\mathcal{L}(\theta)W$ for the other five when banks hold leverage θ. The weight $\omega = 0.0359$ is the mean of η in the unregulated equilibrium. During a local deviation, the price function, its first derivatives, and the continuation values are held fixed. Issuance, the private leverage choice, destruction, and the generator are recomputed. The economy is then repriced under the selected requirements until policy, prices, and values form a joint fixed point.

The planner's leverage in Figure 5 jumps where the Hamiltonian in (A.6) has two local maxima of equal height (Figure 7). The first is the lowest leverage at which issuance reaches its ceiling $\bar{\chi}$. The second is at or just below the leverage banks choose on their own. Between the two, issuance stays at $\bar{\chi}$. Households retain the same idiosyncratic risk, and the expert wealth share has the same exposure to the aggregate shock. Only the share of wealth that

experts hold in bank equity differs: $\theta^E = 0.99$ at the first maximum and $\theta^E \leq 0.43$ at the second.

At the first maximum, experts bear more of their bank's jump risk and earn more compensation for it. The risk lowers the current flow. The compensation makes the expert wealth share grow faster, which raises the expected change in W. At the four expert wealth shares in the figure, moving from the first maximum to the second raises the current flow by 5.6 to 6.0, in the figure's units of 10^{-4}. It lowers the expected change in W by 7.5 at $\eta = 0.0125$, 6.0 at $\eta = 0.0135$, 5.3 at $\eta = 0.0140$, and 3.8 at $\eta = 0.0151$. This loss shrinks because W_η falls as η rises. The first maximum is higher at $\eta = 0.0125$ and $\eta = 0.0135$, and the second at $\eta = 0.0140$ and $\eta = 0.0151$. Between $\eta = 0.0135$ and $\eta = 0.0140$, the planner's leverage jumps from 11.3 to 25.7. The downward jump, between $\eta = 0.0073$ and $\eta = 0.0075$, has the same two maxima.

At a few states the problem (A.6) cycles between two requirements with equal value. There the planner randomizes publicly between the two, the limit of arbitrarily fast switching. The solution randomizes at three states that carry 0.0003% of the stationary mass. At these states, the planner switches between two implementable leverages $\theta_0^{L,b}$ and $\theta_1^{L,b}$, with probability p on the second. Allocations, flows, and generators are computed for each action and averaged,

$$\overline{\mathcal{L}} = (1-p)\mathcal{L}(\theta_0^{L,b}) + p\mathcal{L}(\theta_1^{L,b}), \qquad \bar{u} = (1-p)u(\theta_0^{L,b}) + pu(\theta_1^{L,b}),$$

and the values and the money share solve the averaged equations. Evaluating the economy at an average leverage is not equivalent. Let $H_a = u(\theta_a^{L,b}) + \mathcal{L}(\theta_a^{L,b})W$. The mixing probability satisfies $H_1 \leq H_0$ at $p = 0$, $H_1 = H_0$ at interior p, and $H_1 \geq H_0$ at $p = 1$, and every supported action maximizes the Hamiltonian over the whole feasible action set. The money equation holds to 4×10^{-12} at every state.

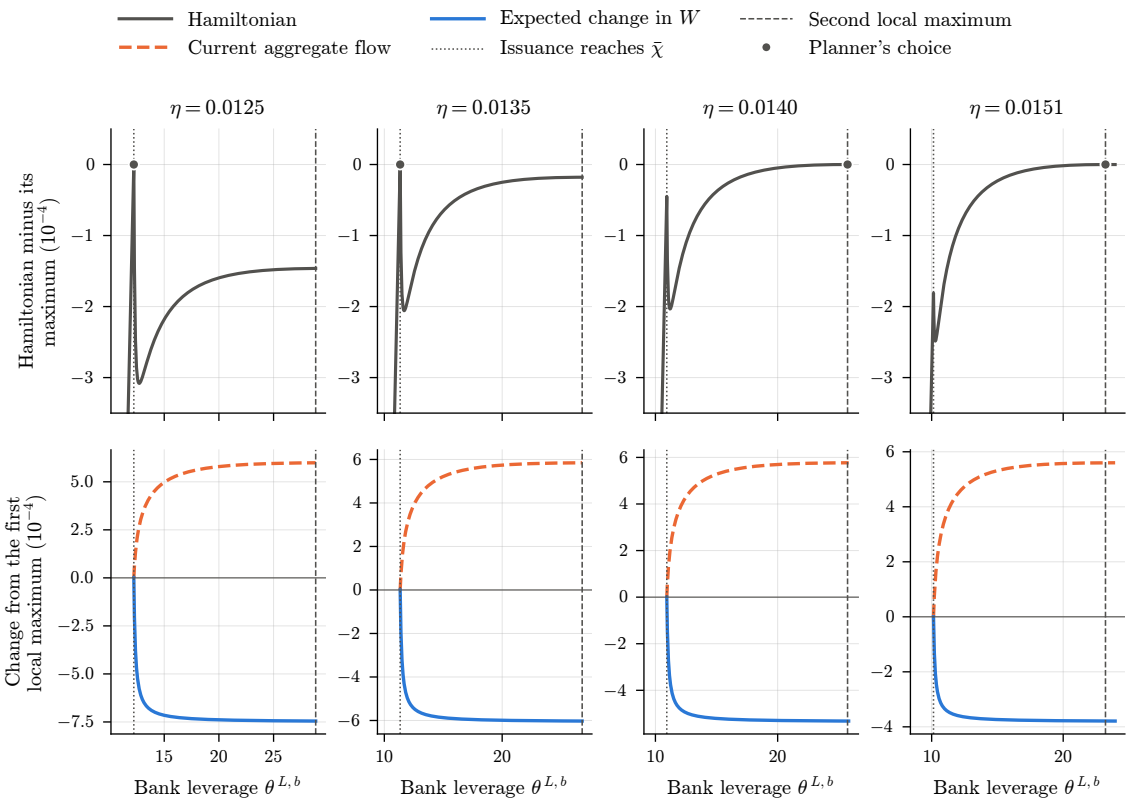


Figure 7: The planner's Hamiltonian against bank leverage at four expert wealth shares around the upward jump in Figure 5, at median volatility $\widetilde{\sigma} = 0.300$, with the planner's prices and value W held fixed. Top: the Hamiltonian minus its maximum. Bottom: its two parts, the current aggregate flow and the expected change in W, as changes from the first local maximum, where issuance reaches $\bar{\chi}$ (dotted line). Dashed line: the second local maximum. Dots: the planner's choice. Units are 10^{-4} of log consumption equivalents per year.

A.11 Robustness

Table 2 changes one fixed parameter or one target at a time. For each alternative we re-estimate the nine parameters of Table 1 and re-solve the constant requirements and the planner. The first panel changes the spillover multiplier s, the mean reversion of the variance ψ, and the price elasticity of investment that fixes ϕ. The second panel changes the targets, each of which moves one estimated parameter most directly, as listed in Table 1. Gains are aggregate consumption equivalents over the unregulated equilibrium, with each policy evaluated under its own stationary distribution (Appendix A.9). The best constant requirement maximizes this gain. The planner's gain exceeds that of the best constant requirement for $s = 0$, $\psi = 0.5$, mean leverage 11, and safe-asset share 18%.

Table 2: Welfare gains (%) under alternative parameters and targets.

	Best constant requirement		
	$\varkappa$	Gain	Planner
Baseline[†]	0.14	0.043	0.034
Fixed parameters			
$s = 0$	0.04	0.002	0.017
$s = 2$	0.16	0.113	0.088
$\psi = 0.5$	0.16	0.002	0.026
$\psi = 0.85$	0.12	0.098	0.047
Price elasticity 0.20	0.14	0.039	0.034
Price elasticity 0.33	0.14	0.050	0.034
Targets			
Mean leverage 9	0.16	0.076	0.041
Mean leverage 11	0.12	0.024	0.029
Safe-asset share 12%	0.14	0.057	0.031
Safe-asset share 18%	0.12	0.032	0.037
Bank assets 13%	0.14	0.043	0.028
Bank assets 17%	0.14	0.044	0.040
Failure rate 0.3%	0.14	0.050	0.038
Failure rate 0.7%	0.14	0.042	0.032
Loss given failure 20%	0.14	0.046	0.034
Loss given failure 30%	0.14	0.041	0.034

[†]Baseline economy. Parameters are given in Table 1.

Table 3 instead moves one parameter by 25% in each direction and keeps every other parameter at its value in Table 1, as in Begenau and Landvoigt (2022). These economies no

longer match the targets of Table 1. We re-solve the constant requirements and the planner for each, and report the same gains. The planner's gain exceeds that of the best constant requirement when $\widetilde{\sigma}^0$ rises and when $\not{d}_0$, ρ, or ψ falls.

Table 3: Welfare gains (%) under perturbed parameters.

	Parameter $\times 0.75$			Parameter $\times 1.25$		
	Best $\varkappa$	Gain	Planner	Best $\varkappa$	Gain	Planner
Baseline[†]	0.14	0.043	0.034	0.14	0.043	0.034
$\widetilde{\sigma}^0$	no monetary equilibrium[‡]			0.00	0.000	0.033
$\not{d}_0$	0.12	0.025	0.029	0.14	0.064	0.038
$\bar{\chi}$	0.12	0.028	0.023	0.14	0.061	0.043
a	0.14	0.043	0.034	0.14	0.043	0.034
δ	0.14	0.043	0.034	0.14	0.043	0.034
ρ	0.10	0.006	0.042	0.16	0.093	0.028
p_L	0.14	0.043	0.035	0.14	0.045	0.034
$\underline{j}$	0.14	0.046	0.033	0.14	0.042	0.034
$\bar{j}_h$	0.12	0.028	0.027	0.14	0.064	0.043
ψ	0.18	0.029	0.036	0.10	0.065	0.037
$1+s$	0.12	0.020	0.019	0.14	0.074	0.058
ϕ	0.14	0.039	0.034	0.14	0.047	0.034

[†]Baseline economy. Parameters are given in Table 1. [‡]With $\widetilde{\sigma}^0$ lower by 25%, the model has no equilibrium in which money has positive value.

B Reserve requirements

Proposition 2. *Fix the capital requirement $\varkappa$ and the resolution cost $\not{d}_0$ per unit of pre-cost shortfall. Let deposits and money earn the same safe return, and let experts hold signed outside safe positions. Suppose the regulator requires bank reserves equal to a fraction of gross deposits strictly below one. Every zero-reserve equilibrium then has a counterpart with the same prices, allocations, state dynamics, welfare, and planner policies.*

Proof. Measure reserves and gross deposits per unit of bank equity. The balance sheet and post-jump pre-cost equity satisfy

$$\theta_t^{L,b} + \text{reserves} = 1 + \text{gross deposits}, \qquad \theta_t^{L,b}(1+\tilde{j}) + \text{reserves} - \text{gross deposits} = 1 + \theta_t^{L,b}\tilde{j}.$$

The default event $\tilde{j} < -1/\theta_t^{L,b}$, the shortfall $(-1-\theta_t^{L,b}\tilde{j})^+$, and the destruction $\not{d}_0(-1-\theta_t^{L,b}\tilde{j})^+$ therefore do not depend on reserves. The total deposit loss satisfies $-\text{gross deposits}\cdot\tilde{j}_t^D = (1+\not{d}_0)(-1-\theta_t^{L,b}\tilde{j})^+$. Extra deposits dilute the percentage loss and leave the total loss unchanged, and the total compensation $-\text{gross deposits}\cdot\tilde{\lambda}_j\mathbb{E}[\tilde{j}_t^D] = \tilde{\lambda}_j(1+\not{d}_0)\mathbb{E}[(-1-\theta_t^{L,b}\tilde{j})^+]$ is also unchanged. Reserves earn $dr_t^{\mathcal{MB}}$, so reserves and deposits contribute

$$\begin{aligned}&\text{reserves}\, dr_t^{\mathcal{MB}} - \text{gross deposits}\big[dr_t^{\mathcal{MB}} - \tilde{\lambda}_j\mathbb{E}[\tilde{j}_t^D]dt + \tilde{j}_t^D d\tilde{J}_t\big]\\ &\quad = -(\theta_t^{L,b}-1)dr_t^{\mathcal{MB}} - \text{gross deposits}\big[-\tilde{\lambda}_j\mathbb{E}[\tilde{j}_t^D]dt + \tilde{j}_t^D d\tilde{J}_t\big]\end{aligned}$$

to bank equity. By the two cancellations above, the right side does not depend on the reserve requirement. Move the required money into bank reserves, issue matching deposits, and lower the owners' direct safe position by the same amount. Money-market clearing is preserved, and households swap money for deposits that earn the same return. All returns, destruction, the state generator, money valuation, and both sectors' flows coincide with the zero-reserve equilibrium, and hence so do welfare and the planner's policies. □

C Additional figures

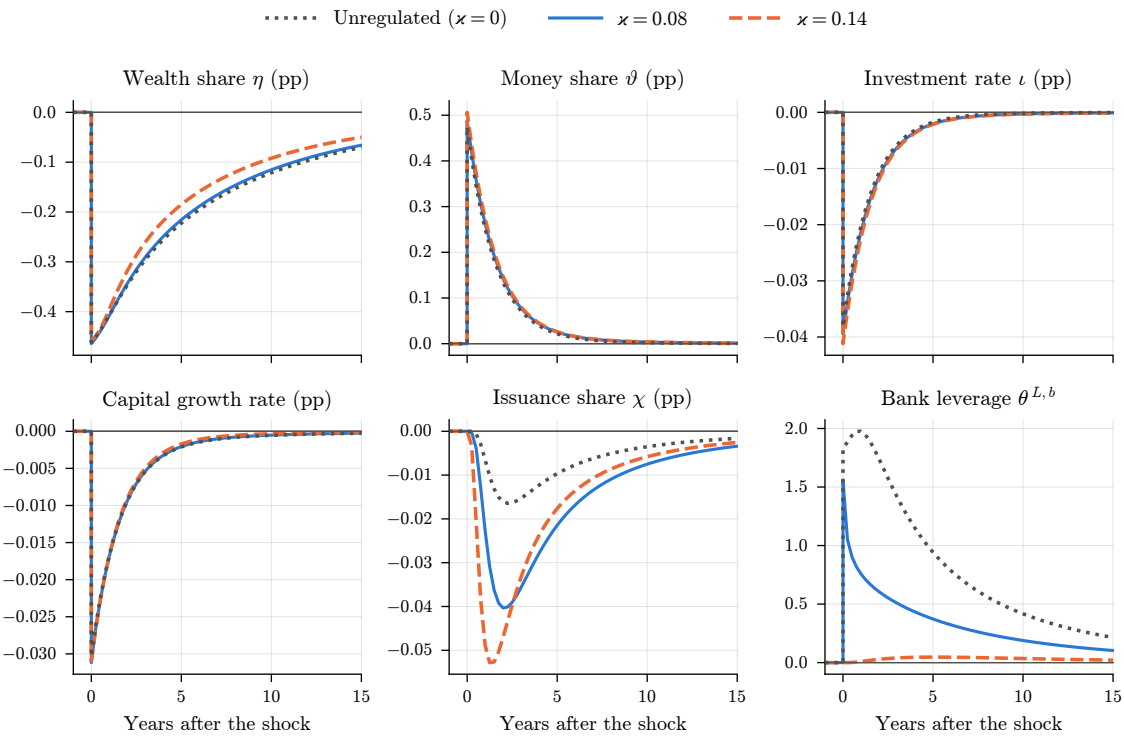


Figure 8: Impulse responses to a one-standard-deviation increase in the variance $\widetilde{\sigma}^2$ under the unregulated equilibrium and the constant requirements $\varkappa = 0.08$ and $\varkappa = 0.14$. Each economy starts at the medians of its own stationary distribution of η and $\widetilde{\sigma}^2$. The impulse is the Brownian shock that raises $\widetilde{\sigma}^2$ by one stationary standard deviation, and it moves η by its loading on the same shock. Responses are shocked minus unshocked conditional expectations under each policy's own equilibrium.

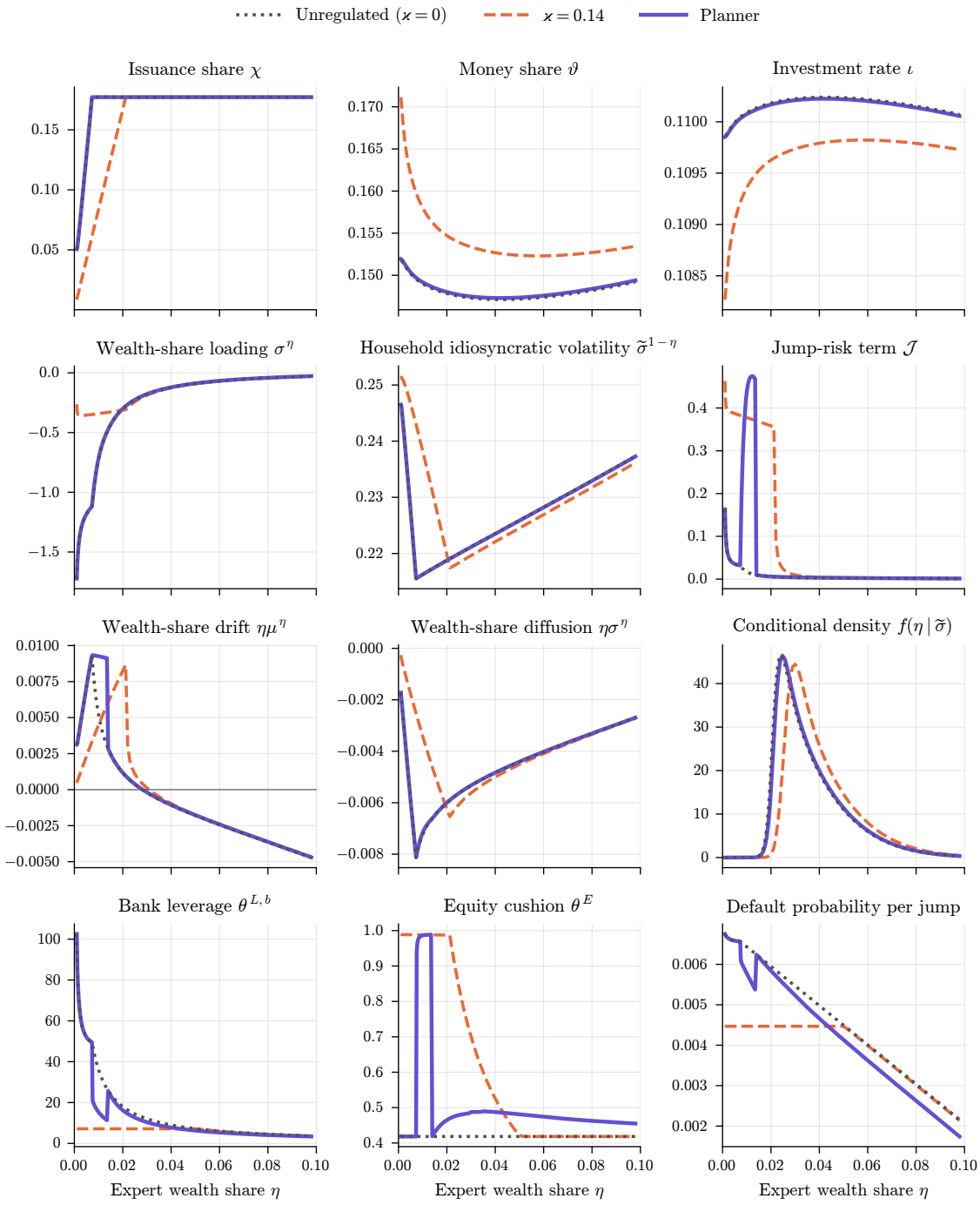


Figure 9: Equilibrium objects under the planner, the unregulated equilibrium, and the constant requirement $\varkappa = 0.14$, against the expert wealth share $\eta \leq 0.10$ at the stationary mean volatility of the unregulated equilibrium, $\widetilde{\sigma} = 0.306$. The panels are those of Figure 3.

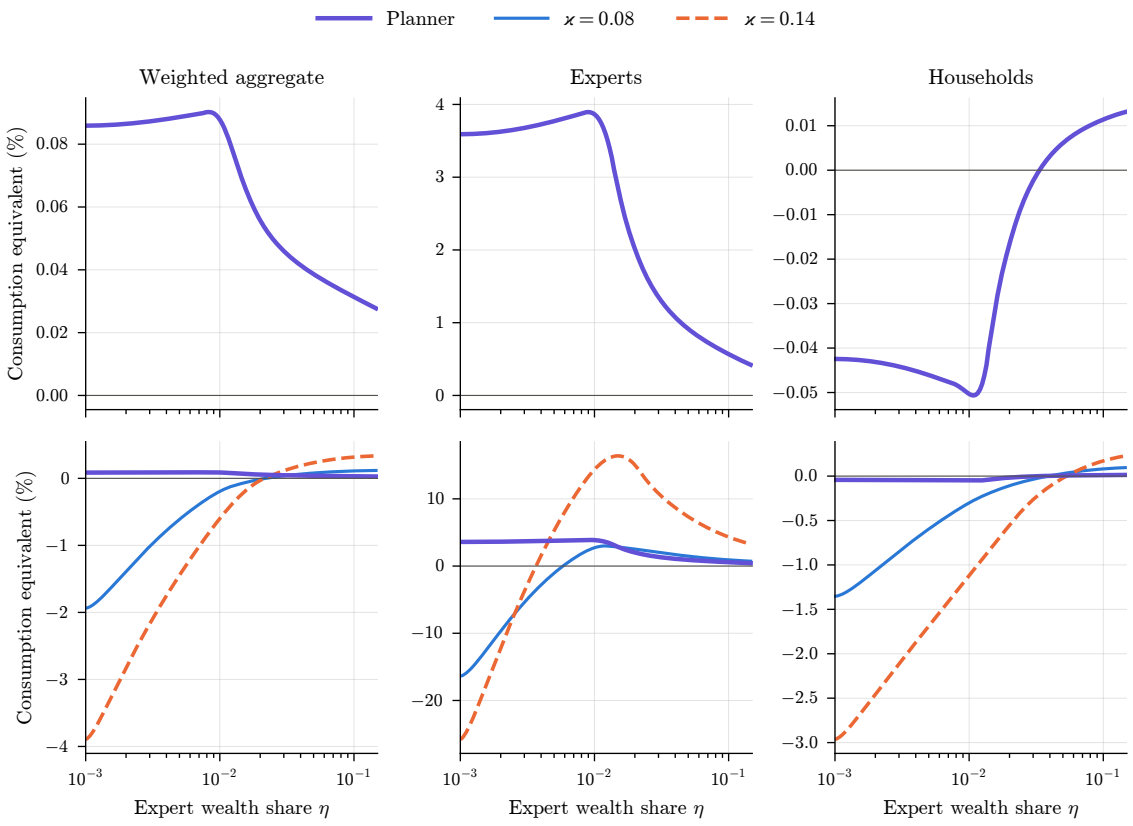


Figure 10: Welfare gains over the unregulated equilibrium by initial state, at median volatility $\widetilde{\sigma} = 0.300$, in consumption-equivalent terms. Each gain holds the initial state fixed and evaluates each policy in its own equilibrium. Top row: the planner. Bottom row: the planner and the constant requirements $\varkappa = 0.08$ and $\varkappa = 0.14$, on a wider scale.

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