Convenience Yields and Financial Repression

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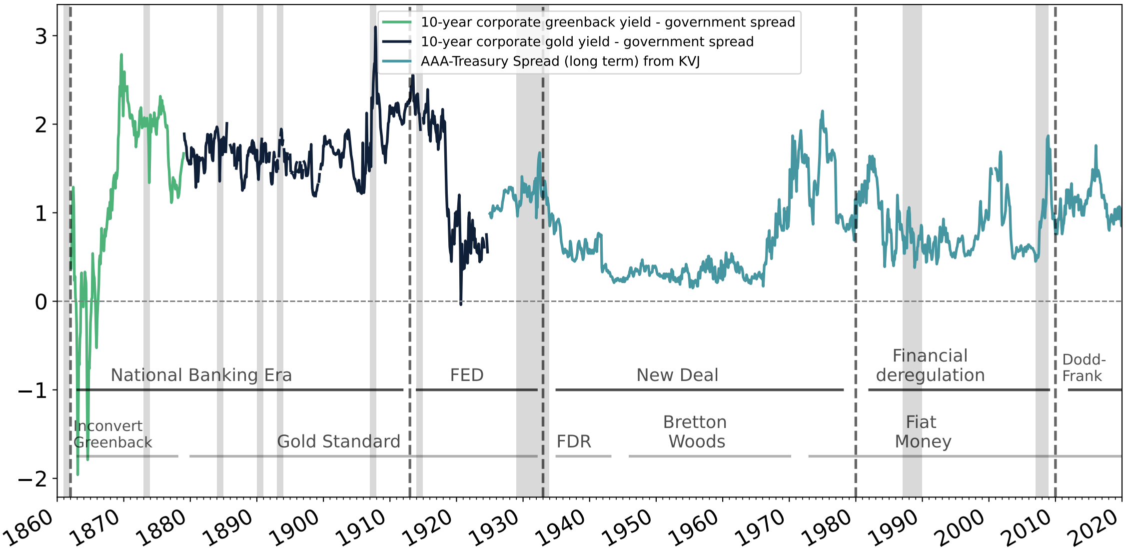
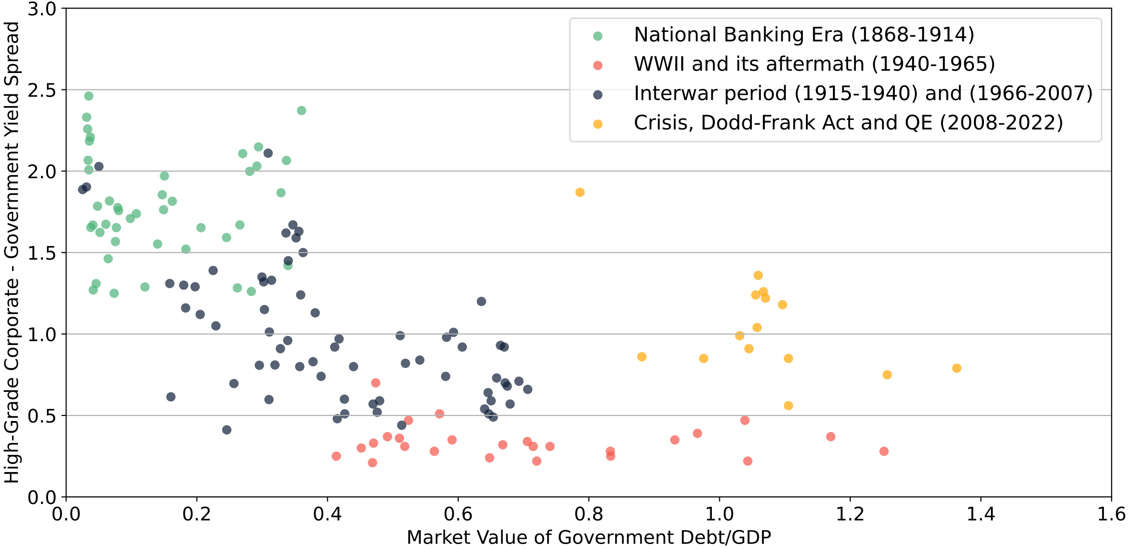
US government has enjoyed a large funding advantage since 1860



Convenience Yields vs Debt/GDP — exploitable "demand function"?



This Paper: Endogenizes the Convenience Yield

- We build a model where the convenience yield emerges through financial regulation.
  - Government debt is not inherently special, but financial repression can make it so
  - Convenience premium comes from hedging aggregate risk (Acharya and Laarits, 2023)
- Environment has a risky financial sector:
  - Banks create on-demand assets + intermediation between savers and borrowers
  - ... but prone to costly default and "fire sale" dynamics $\Rightarrow$ hedging is valuable
- We study a government that wants to finance spending:
  - Cannot change taxes (has a pre-specified "fiscal rule" from the political process)
  - But can impose restrictions on bank portfolios ("regulation" or "repression")

Results

1. Portfolio restrictions make government debt a hedge with "convenience-yield".
   - Restrictions bind more in bad times and so bank demand increases in bad times.
   - Regulatory parameters relate to "exogenous" bond demand elasticities.

2. High convenience yields come at the "cost" of financial instability (and crowding out)

3. Fiscal irresponsibility erodes the convenience yield.

4. Exogenous bond demand (bond-in-utility, bond-in-advance, . . .) miss 2 & 3.

Takeaway: Convenience yield is a choice, *not* invariant to regulation or fiscal policy

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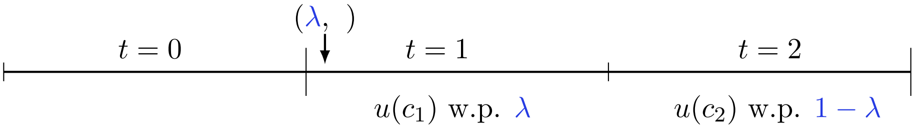
Preferences ("Diamond-Dybvig" Style)



- Continuum of islands each with unit measures of households and banks
- One consumption good; households are endowed with one unit at $t = 0$
- Two "layers" of idiosyncratic preference shocks at the start of $t = 1$:
  - *household-specific:* households value $t = 1$ consumption with prob. λ
  - *island-specific:* probability $\lambda \sim F$ is random across islands.
- Banks issue on-demand deposits d_0 and equity e_0 to households on the same island
  - Deposits can be withdrawn for 1 good at $t \in \{1, 2\}$, unless bank defaults $\Rightarrow \delta^d < 1$

Household Problem

- Taking prices as given, household solves:

$$\max_{d_0, e_0, \mathbf{c}} \quad \mathbb{E}\Big[\int \lambda u(c_1(\lambda)) + (1-\lambda) u(c_2(\lambda)) dF(\lambda) \Big] \quad s.t.$$

$$q_0^d d_0 + q_0^e e_0 \leq 1$$

and the $t = 1$ "deposit-in-advance" constraint for early consumers:

$$c_1(\lambda) \leq \delta^d(\lambda) d_0, \qquad \text{where } \delta^d(\lambda) = 1, \text{ if bank solvent}$$

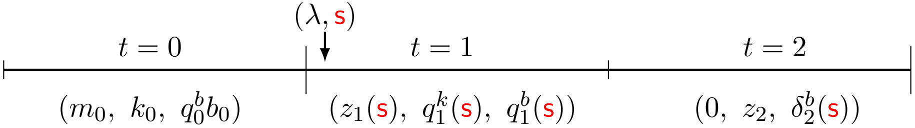
and the $t = 2$ budget constraint for late consumers:

$$c_2(\lambda) \leq \delta_2^e(\lambda) e_0 + \delta^d(\lambda) d_0 - T_2$$

Liquidity premium on bank deposit:

only on-demand assets can be used for consumption at $t = 1$

Technology and Markets



- Time 0: Three investment opportunities exposed to aggregate risk $\mathsf{s} \in \{\mathsf{s}_L, \mathsf{s}_H\}$:
  - *Short asset* (m_0), transforms one good at $t = 0$ to $z_1(\mathsf{s})$ goods at $t = 1$
  - *Capital* (k_0), transforms one good at $t = 0$ to $z_2 > z_1(\mathsf{s})$ goods at $t = 2$
  - *Bond* (b_0), for price q_0^b (primary market), it promises to pay $\delta_2^b(\mathsf{s})b_0$ at $t = 2$
- Time 1: Secondary markets for bonds (at q_1^b) and capital (at q_1^k):

"Fire sale pricing" in inter-bank asset markets at $t = 1$:
No bank equity issuance and no short selling $\quad \Rightarrow \quad q_1^k(\mathsf{s}) < z_2,\ \ q_1^b(\mathsf{s}) < \delta_2^b(\mathsf{s})$

Bank Problem

- Taking prices and household SDF $\{\xi(\lambda)\}_\lambda$ as given, the bank maximizes its value:

$$\max_{m_0,\mathsf{k},\mathsf{b},\mathsf{d},\delta^e} \Big\{\mathbb{E}\Big[\int \xi(\lambda)\max\Big\{0;\ \delta_2^e(\lambda)\Big\}dF(\lambda)\Big] + q_0^d d_0 - m_0 - k_0 - q_0^b b_0\Big\}\ s.t.$$

$$\underbrace{\delta_1^d(\lambda)\lambda d_0 + \varsigma d_0 \mathbb{1}^d}_{\text{Withdrawals}} \le \underbrace{z_1 m_0 + q_1^k(k_0 - k_1(\lambda)) + q_1^b(b_0 - b_1(\lambda))}_{\text{Short asset + sale of long term assets}}$$

$$\delta_2^e(\lambda) + \delta_2^d(\lambda)(1-\lambda)d_0 \le z_2 k_1(\lambda) + \delta_2^b b_1(\lambda)$$

$$0 \le b_1(\lambda),\ k_1(\lambda),$$

Costly bank default:
Deposit contracts are not fully state contingent on (λ, s) + limited liability

Government

- Ranks equilibria by: $\theta G + \mathbb{E}[\int (\lambda u(c_1(\lambda)) + (1-\lambda)u(c_2(\lambda)))dF(\lambda)]$ where spending G at $t=0$ is financed with debt b_0 that is repaid using taxes at $t=2$:

$$G = q_0^b b_0, \qquad \delta_2^b(\mathsf{s})b_0 = T_2(\mathsf{s})$$

Exogenous fiscal rule: $T_2(\mathsf{s})$ determined outside the model (political process)

- Sets restrictions on bank portfolios:

$$\frac{\varrho}{2}(q_0^d d_0 - m_0) \leq \kappa q_0^b b_0 + (1-\kappa)k_0,$$
$$\frac{\varrho}{2} d_1 \leq \kappa q_1^b b_1 + (1-\kappa)q_1^k k_1$$

Regulation: ϱ is overall leverage constraint; $\kappa \in [1/2, 1]$ incentivizes debt holding
$\ldots \kappa = 1/2$ "neutral" regulation; $\kappa = 1$ is "pure" repression; $(\varrho, \kappa) \approx$ "risk-weights"

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Inter-bank Market Equilibrium (Conditional on $t = 0$ choices)

- Equilibrium in inter-bank asset markets require:

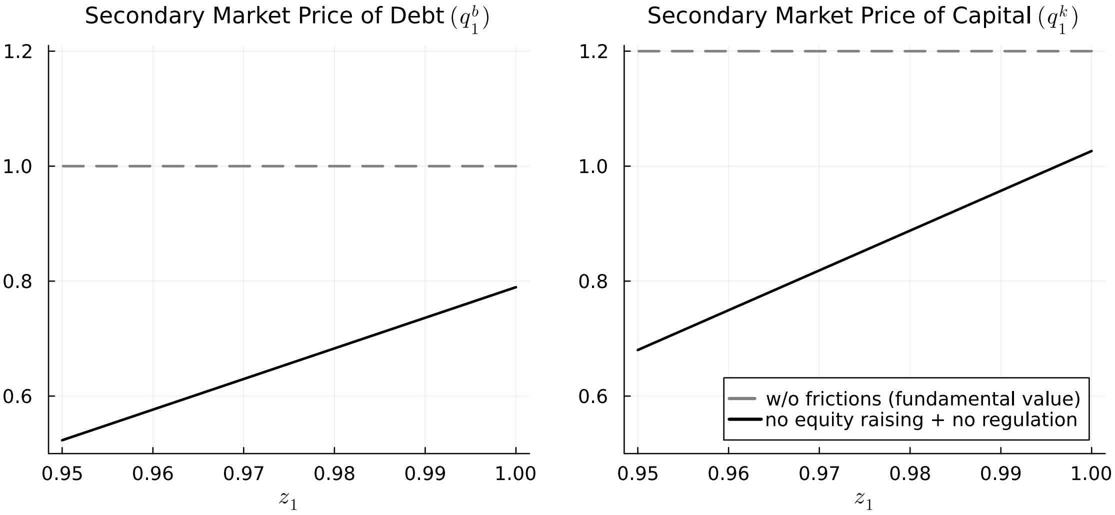
$$q_1^k(\mathsf{s}) = \frac{z_2(\mathsf{s})}{1 + \mu_1^e(\mathsf{s}) - (1-\kappa)\mu_1^r(\mathsf{s})} \qquad q_1^b(\mathsf{s}) = \frac{\delta_2^b(\mathsf{s})}{1 + \mu_1^e(\mathsf{s}) - \kappa\mu_1^r(\mathsf{s})}$$

  - μ_1^e is the Lagrange multiplier on the (time 1) equity raising constraint
  - μ_1^r is the Lagrange multiplier on the (time 1) regulatory constraint

- If $\kappa = 1/2$ ("neutral regulation"), then banks are indifferent between b_1 and k_1:

$$R_{1,2}^k(\mathsf{s}) = R_{1,2}^b(\mathsf{s})$$

Inter-bank Asset Prices Move with "Market Liquidity"



Parameters

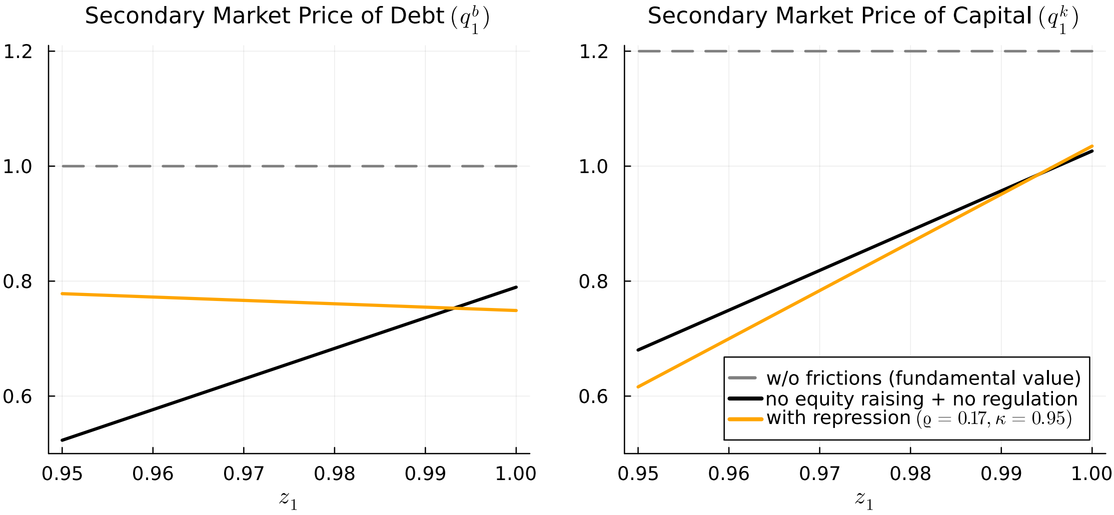
Inter-bank Market Equilibrium (Conditional on $t = 0$ choices)

- If $\kappa > 1/2$ ("repression"), asset demand is tilted toward debt:

$$R^k_{1,2}(\mathsf{s}) - R^b_{1,2}(\mathsf{s}) = (2\kappa - 1)\mu^r_1(\mathsf{s}) > 0$$

  - In the bad state, s_L, there are fewer resources and so $\uparrow \mu^r_1(\mathsf{s}_L)$ and $\uparrow q^b_1(\mathsf{s})/q^k_1(\mathsf{s})$
    (i.e. regulation makes banks a "captive market" for government debt in bad times)

Repression Makes Government Debt a Hedge Against Aggregate Risk



Parameters

Convenience Yield Increases Fiscal Capacity (benefit)

- Bank demand for government debt at $t = 0$:

$$q_0^b = \mathbb{E}\Bigg[\xi \;\underbrace{\Omega(\mu_1^e, \mu_1^r)}_{\text{default}}\; \underbrace{\left(\frac{(1-\kappa\mu_0^r)^{-1}}{1+\mu_1^e-\kappa\mu_1^r}\right)}_{\text{regulation}}\; \delta_2^b\Bigg] \quad > \quad q_0^{\mathsf{s}} := \mathbb{E}\big[\xi\big]$$

  - μ_0^r, direct effect of repression: forcing the bank to hold debt in the primary market
  - μ_1^r, indirect effect through captive demand in the secondary market (and default)

Convenience Yield: (often) defined as $\quad \chi := \log\left(q_0^b\right) - \log\left(q_0^{\mathsf{s}}\right)$

Decreasing "Risk-Aversion" Increases Financial Instability (cost)

- Equilibrium in inter-bank asset markets requires:

$$q_1^k(\mathsf{s}) = \frac{z_2(\mathsf{s})}{1 + \mu_1^e(\mathsf{s}) - (1-\kappa)\mu_1^r(\mathsf{s})} \qquad q_1^b(\mathsf{s}) = \frac{\delta_2^b(\mathsf{s})}{1 + \mu_1^e(\mathsf{s}) - \kappa\mu_1^r(\mathsf{s})}$$

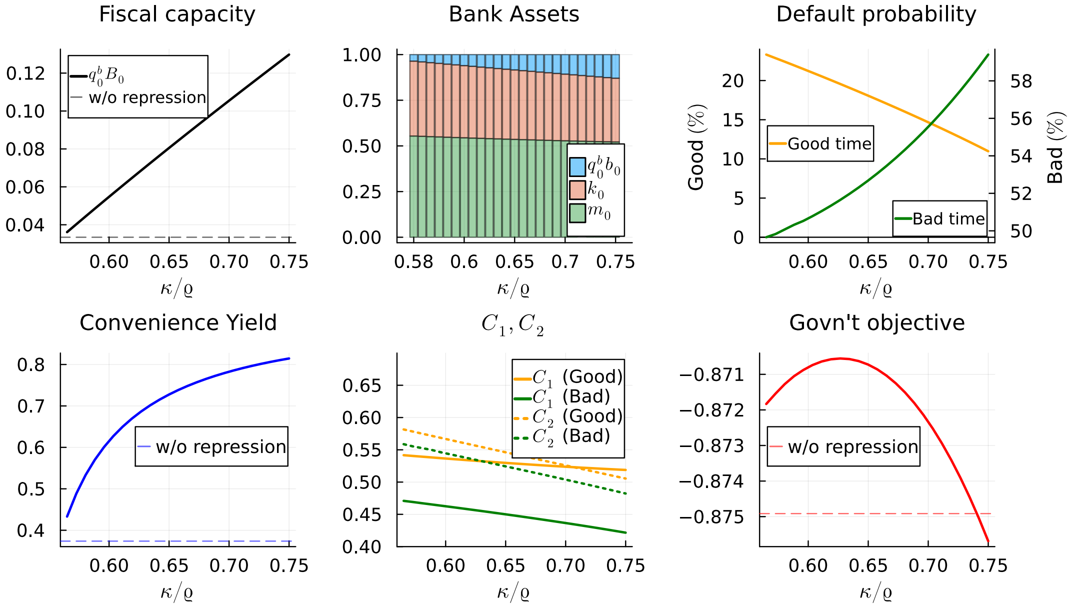
  - High $\mu_1^e(\mathsf{s}_L)$ makes banks more "risk-averse" (by increasing endogenous default cost)
  - High $\mu_1^r(\mathsf{s}_L)$ alleviates excess risk-aversion (by giving banks a hedging asset)

  $\Rightarrow$ Banks choose less short asset m_0 at $t = 0$ exposing them to increased default risk

Financial instability: repression leads to more (less) default in bad (good) times

National Banking Era (1862-1913): high repression ($\kappa \approx 0.9$), frequent bank crises

Optimal κ balances fiscal capacity, financial stability, and investment



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Role of a Fiscal Rule — Risky Government Debt

- For risky $\delta_2^d(\mathsf{s})$ we need "risk-adjusted convenience yield" (measure of specialness):

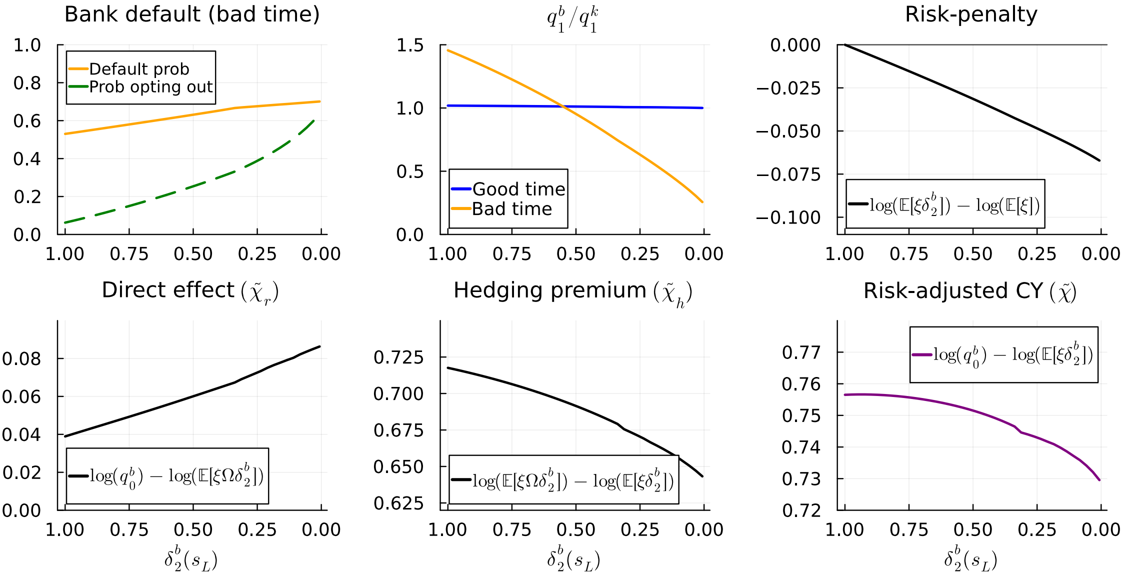
$$\chi = \underbrace{\log\left(q_0^b\right) - \log\left(\mathbb{E}[\xi\delta_2^b]\right)}_{\text{risk-adjusted convenience yield}} + \underbrace{\log\left(\mathbb{E}[\xi\delta_2^b]\right) - \log\left(\mathbb{E}[\xi]\right)}_{\text{risk penalty}}$$

...that can be further decomposed into

$$\widetilde{\chi} = \underbrace{\log\left(q_0^b\right) - \log\left(\mathbb{E}[\xi\Omega\delta_2^b]\right)}_{\text{direct effect of regulation}} + \underbrace{\log\left(\mathbb{E}[\xi\Omega\delta_2^b]\right) - \log\left(\mathbb{E}[\xi\delta_2^b]\right)}_{\text{indirect hedging premium}}$$

- **Experiment:** compare equilibria indexed by $T_2(s_L) \searrow 0 \quad \Rightarrow \quad \delta_2^b(s_L) \searrow 0$
  - Extension: banks can pay a fixed fee at $t = 1$ and escape regulatory constraint

Fiscal Irresponsibility Erodes the Convenience Yield



Two Alternative Environments with "Exogeneous Demand"

1. *Bond-in-utility (BIU):* private sector solves:

$$\max_{b_0,k_0,c_1} \left\{ v(q_0^b b_0) + \beta \mathbb{E}[u(c_2)] \right\} \quad s.t.$$

$$q_0^b b_0 + k_0 \leq 1$$

$$c_2 \leq z_2 k_0 + \delta_2^b b_0 - \tau$$

2. *Bond-in-advance with uninsurable idiosyncratic risk (BIA):* private sector solves:

$$\max_{b_0,m_0,k_0,b_1,\mathbf{c}} \mathbb{E}[\lambda u(c_1) + (1-\lambda) u(c_2)] \quad s.t.$$

$$q_0^b b_0 + m_0 + k_0 \leq 1$$

$$c_1 \leq q_1^b b_0$$

$$c_2 \leq z_2 k_0 + \delta_2^b \left(\frac{z m_0 + q_1^b b_0 - c_1}{q_1^b} \right) - \tau$$

Three Bond Demand Equations

Bond-in-utility:

$$q_0^b = \mathbb{E}[\xi \delta_2^b] \left(1 - \frac{\upsilon'(q_0^b b_0)}{\mu_0^c} \right)^{-1}$$

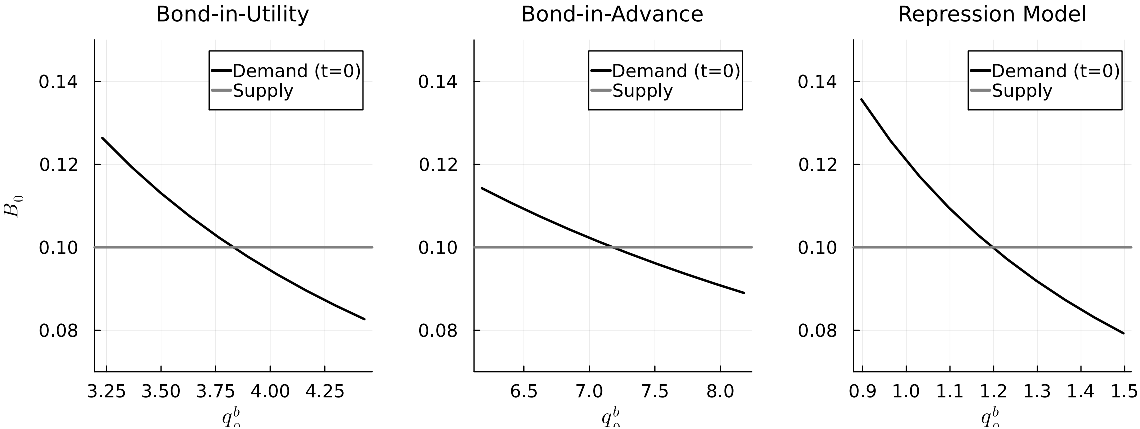
Bond-in-Advance:

$$q_0^b = \mathbb{E}\left[\xi \delta_2^b \left(1 - \frac{\mu_1^b}{\lambda u'(c_1)} \right)^{-1} \right]$$

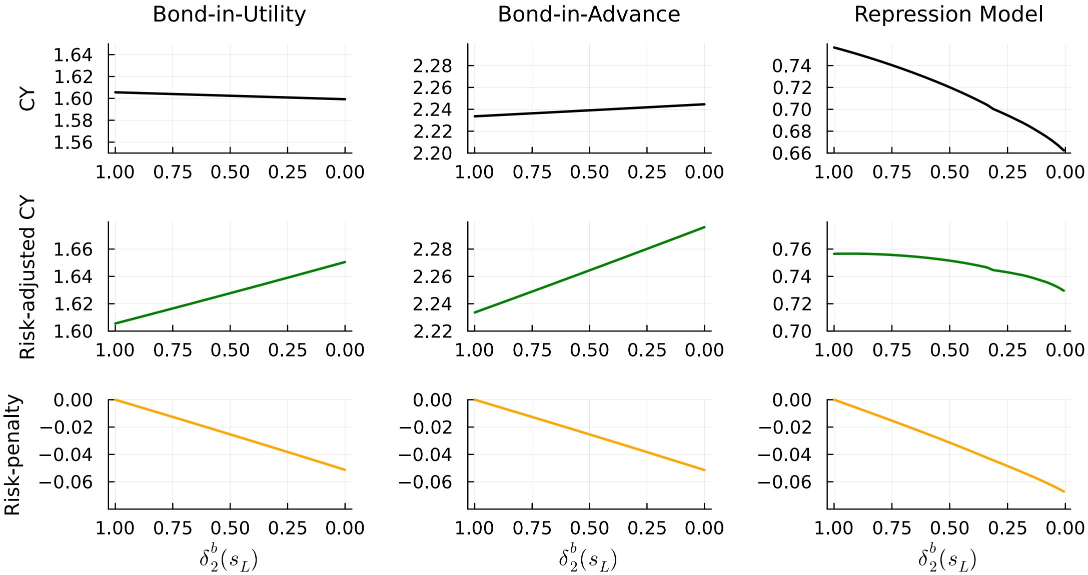
Repression Model:

$$q_0^b = \mathbb{E}\left[\xi \delta_2^b \; \Omega(\mu_1^e, \mu_1^r) \; \left(1 + \mu_1^e - \kappa \mu_1^r \right)^{-1} \right] \left(1 - \kappa^b \mu_0^r \right)^{-1}$$

Similar Bond Demand Functions For a Fixed Fiscal Rule



But Very Different Responses When Fiscal Irresponsibility Increases



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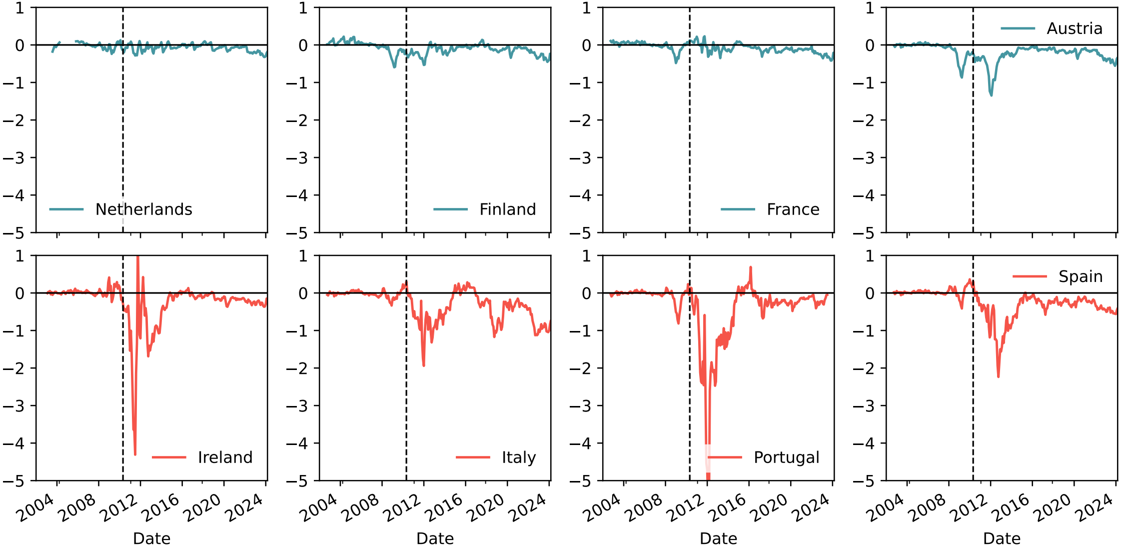
Do Fiscal Troubles Erode the Convenience Yield in the Data?

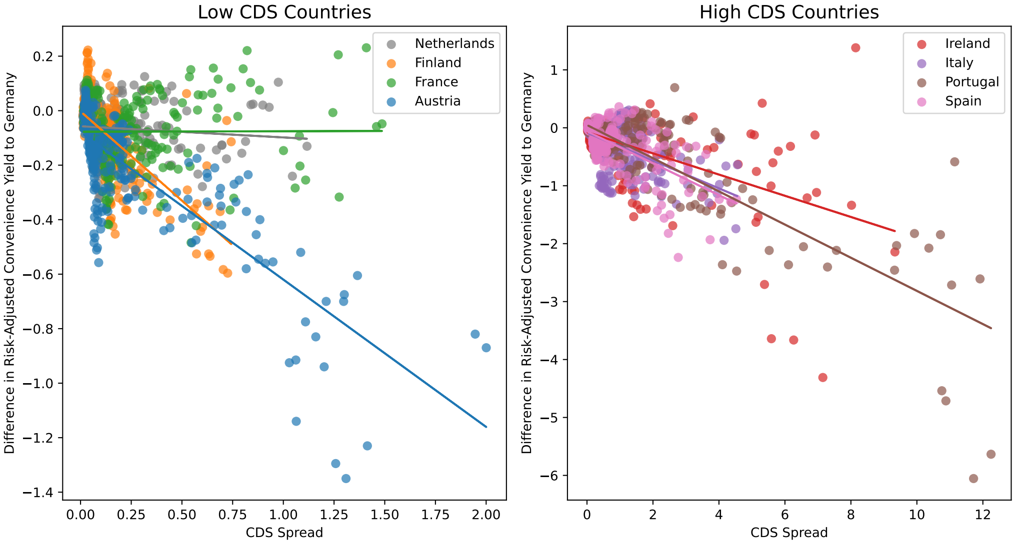
- We use data on Eurozone debts during the Sovereign Debt Crisis as a laboratory

  ... following closely Jiang, Lustig, van Nieuwerburgh, and Xiaolan (2024)
- Risk-adjusted convenience yield *differentials* (2004-2024)
  - relative to Germany to control for the common risk-free rate
  - use CDS spreads to control for compensation for default risk
  - 5-year tenor (most liquid)

Fiscal Troubles Tend To Erode the Convenience Yield



Fiscal Troubles Tend To Erode the Convenience Yield



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Conclusion

- Historical yield curves suggest government can exert high influence on government bond demand through financial sector regulation.
- We build a model to understand the trade-offs.
- **Q.** Can the government choose the convenience yield with financial repression? Yes!
- **Q.** Should the government create a large convenience yield? Maybe!
- **Q.** Is the convenience yield invariant to fiscal policy? No!
- **Work in progress:** infinite horizon model with (i) long-term government debt, (ii) mean-reverting aggregate shocks, and (iii) an empirically plausible fiscal rule

Thank You!

Literature: Integration of Public Finance and Macro-Finance

- Macroeconomic models of financial sector and government safe asset creation
  Holmstrom and Tirole (1997), Holmström and Tirole (1998), Gorton and Ordonez (2013), Gorton (2017), He et al. (2016), He et al. (2019), Caballero et al. (2008), Caballero et al. (2017), Caballero and Farhi (2018)
  - **This paper:** Taxation distortions and "shadow costs" of financial sector regulation.

- Historical asset pricing, market segmentation, and inelastic demand
  Krishnamurthy and Vissing-Jorgensen (2012), Daglish & Moore (2018), Choi et al. (2022), Payne et al. (2022), Jiang et al. (2022a), Chen et al. (2022), Jiang et al. (2022b), Jiang et al. (2021b), Jiang et al. (2021a), Koijen and Yogo (2019)
  - **This paper:** Government strategically chooses inelastic demand.

- Ramsey planners and government policy
  Calvo (1978), Bhandari et al. (2017b), Bhandari et al. (2017a), Chari et al. (2020), Bassetto and Cui (2021), Sims (2019), Brunnermeier et al. (2022), Angeletos (2002), Buera and Nicolini (2004), Lustig et al. (2008)
  - **This paper:** Focuses on regulation in risky economy rather than debt issuance decision.

Competitive Equilibrium

Given a fiscal rule T_2, regulation (ϱ, κ), and a budget-feasible government policy (G, b_0, δ_2^b), a competitive equilibrium is a set of prices $\left(q_0^d, q_0^e, q_0^b, q_1^k, q_1^b\right)$ and policies $\left(d_0^h, e_0^h, c_1(\lambda), c_1(\lambda)\right)$ and $\left(d_0, m_0, k_0, b_0, \lambda^*, k_1(\lambda), b_1(\lambda)\right)$ s.t.

1. Households and banks optimize
2. Markets clear:

$$d_0^h = d_0^f, \qquad e_0^h = 1, \qquad b_0^f = b_0, \qquad G + m_0 + k_0 = 1,$$

$$\int b_1(\lambda)dF = b_0, \qquad \int k_1(\lambda)dF = k_0, \qquad \int \lambda c_1(\lambda)dF = z_1 m_0 - \varsigma\left(\lambda^*\right) d_0$$

$$\int (1-\lambda)c_2(\lambda)dF = z_2 k_0 - \int \lambda \delta^e(\lambda)dF$$

Quantitative Illustration

- Aggregate shock is a (common) TFP shock to the two types of capital:

$$z_{AM}(\mathsf{s}) = z_{AM}\mathsf{s}, \quad z_{PM}(\mathsf{s}) = z_{PM}\mathsf{s} \quad \text{with} \quad \mathsf{s} \in \{1,\ 0.95\} \ \text{ s.t. } \ \mathbb{P}[\mathsf{s} = 0.95] = 0.05$$

Parameter	Value	Description
γ	2	Risk aversion
θ	0.75	Weight on fiscal capacity
z_{AM}	1	TFP in the AM (good state)
z_{PM}	1.5	TFP in the PM (good state)
T_{PM}	0.15	Tax in the PM
(α, β)	$(4, 4)$	Withdrawal distribution, $\lambda \sim Beta(\alpha, \beta)$
ς	$1 - F(\lambda^*)$	Deadweight default cost

Why do other papers get a different result?

- We have default prone banks that play two roles in our model:
  1. Liquidity provision, and
  2. Investment into capital
- Financial repression can help liquidity provision because it creates a "safe-asset". (connection to Gorton and Ordonez (2013), Gorton (2017))
- But financial repression also hurts the economy:
  - Crowds out investment into capital (Chari et al. (2020))
  - Worsens frictions in the inter-bank market at time 1.
  - Ultimately, increases bank default in the bad times.

US Financial Eras: with Varying "Restrictions" on Financial Sector

- *1791-1862:* State banks: Federal gov. issued coins; state banks issued paper money
- *1862-1913:* National Banking System: of federally regulated one branch banks
  - National banks issued bank notes backed by long term US Federal bonds.
  - Looks very similar to our model with $(\kappa^k, \kappa^b) = (0, \kappa)$
- *1913+:* Federal Reserve System established as lender of last resort.
- *1934+:* Federal Deposit Insurance, Banks make LT mortgages & Glass-Steagall Act
- *1942-1951:* Yield curve control: treasury and Fed fix long rate at 2.5%
- *1944-1971:* Bretton Woods: exchange rates fixed to dollar; dollar convertible to gold
- *1972-2007:* Financial deregulation: interstate banking, repeal of Glass-Steagall Act
- *2010-2023:* Basel III accord, Dodd-Frank Act, and QE.

Estimation: Corporate Bond Yields

- **Data:** new database of price & cash-flows for US corporate bonds (1850-1940)
  (Companion to our database for US Federal bonds (1790-1940))
  - Sources: NYT, CFC, Merchant's Magazine, US Treasury Circulars, Bayley (1882), Sylla (2006), Razaghian (2002), Macaulay (1838).
- **Statistics:** Deploy methodology from Payne-Szoke-Hall-Sargent (2024):
  - Similar challenge: long time series but sparse cross-section at many dates.
    Response: statistical model with drifting parameters that interpolates gaps.
  - New challenge: no corporate bond ratings pre-1900.
    Response: Extract pre-1900 "AAA" bonds using Macaulay (1838) + pricing errors.
- **Output:**
  - Zero-coupon yield curve on "AAA" US corporate bonds for 1860-1940.
  - Convenience yield = "AAA" US corporate yield - US Federal yield for 1860-2022
  - We interpret convenience yield as measuring "funding advantage" of government

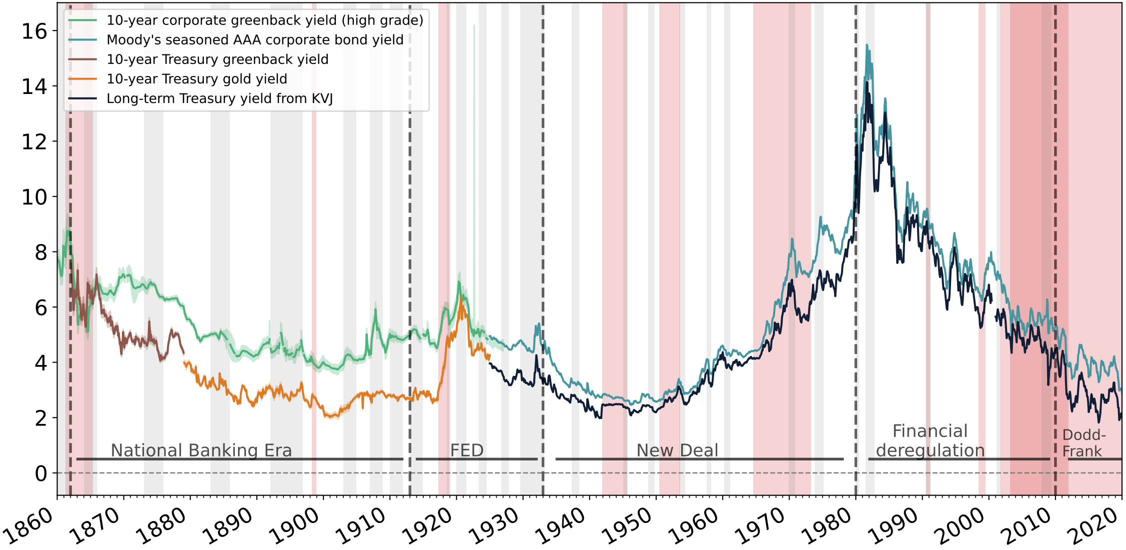
An exploitable demand function?

- Previous plot has sometimes been interpreted as exploitable stable demand function.
- Many macro models capture this using an exogenous bond demand function.
- But our model suggests that:
  - This curve reflects many regulatory shifts/skews in the bond demand function,
  - There are complicated costs with changing the shape of the demand function,
  - Ultimately reflects and equilibrium path of debt issuance in response to shocks.
- We integrate our illustrate model into dynamic macroeconomic model to study this.

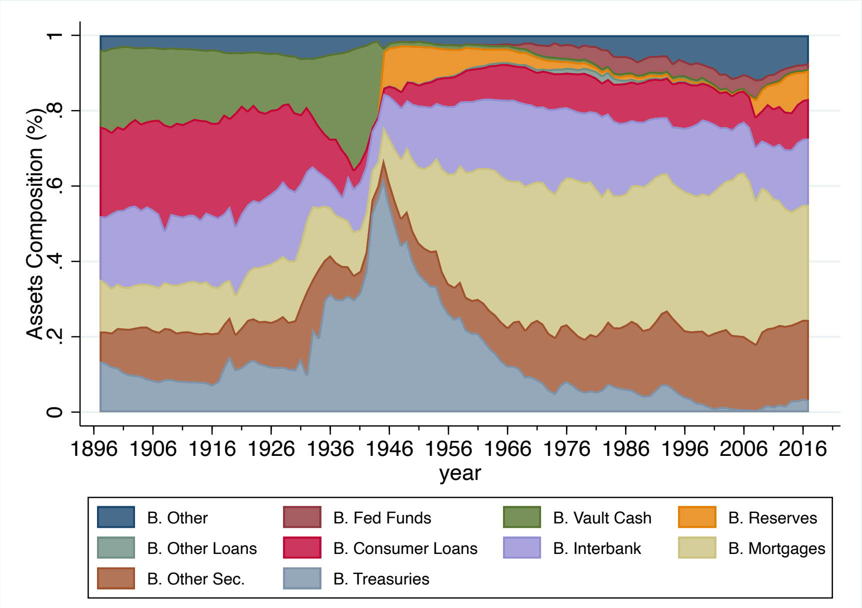
Why do BIU and BIA Get Different Results?

- Bond-in-Utility (BIU) and Bond-in-Advance (BIA) have the features:
  - "Specialness" of government debt is exogenous and
  - ... its marginal usefulness increases as market value of government debt decreases
  - So, as the government devalues its debt it becomes more "useful".
    (the agents "like" to fund the government even more).
- In our Repression Model:
  - Government debt is not exogenously special
  - Government debt's "safe-asset" role emerges from how regulation changes price process.
  - Repression ties the solvency of the banking sector to the solvency of the government.
  - $\Rightarrow \uparrow$ default (ultimately) leads to $\downarrow$ convenience yield

Low Frequency Movements in Convenience Yield



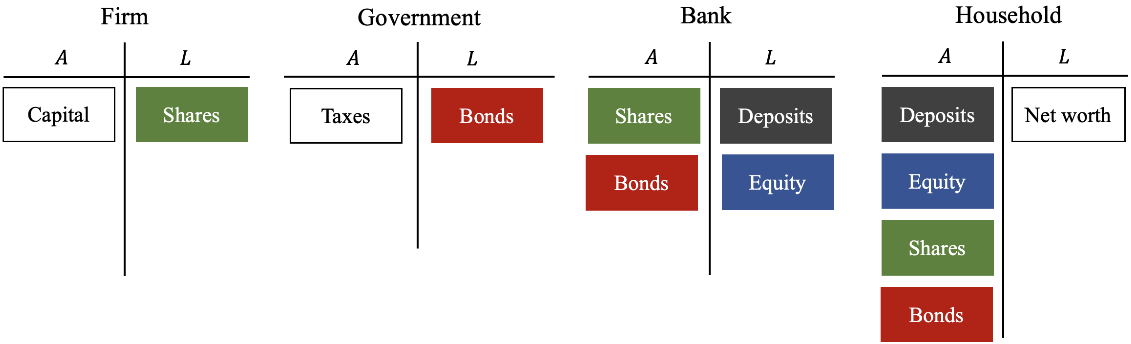
Bank Asset Holdings



Setting, Agents, and Production

- Discrete time, infinite horizon, one consumption good.
- Representative *firm* produces goods by $y = z_t k_t^{\alpha} l_t^{1-\alpha}$, where l_t is labor,
  - z_t is productivity; has evolution $\log(z_t) = (1-\eta)\log(\bar{z}) + \eta\log(z_{t-1}) + \epsilon_t$,
  - k_t is firm's capital stock; has evolution $k_{t+1} = (1-\delta)k_t + \Phi(\iota_t)k_t$,
- Representative *bank* with financial technology:
  - Assets: purchases firm equity, s_t^f and government bonds, b_t^f.
  - Liabilities: deposits, d_t^f, pay 1 good at $t+1$, and equity, e_t^f, pay δ_{t+1}^e at $t+1$.
  - Friction: faces recapitalization "cost" if net-worth, $\mathcal{A}_t^f$, goes negative.
- Representative *household*; utility $u(c_t, d_t^h) = (1-\nu)\frac{c_t^{1-\varphi_c}}{1-\varphi_c} + \nu\frac{(d_t^h - \underline{d})^{1-\varphi_d}}{1-\varphi_d}$.
- Competitive deposit, firm, equity, capital markets with prices $q_t^d, q_t^b, q_t^s, q_t^e, q_t^k$.

Agents and Balance Sheets



Government

- Finances spending, g, using output tax, $\hat{\tau}$, and debt, b_t s.t. budget constraint:

$$g + \zeta b_{t-1} \leq \hat{\tau}_t y_t + q_t^b (b_t - (1-\zeta) b_{t-1})$$

  - b_t is long-term debt that repays a fraction $\zeta \in [0,1]$ of principal each period
  - Budget feasible tax policy: (following Bohn (98), Leeper (15), Bianchi et al. (23))

$$\frac{\hat{\tau}_{t+1}}{\hat{\tau}^*} = \left(\frac{y_t}{y_{t+1}}\right)^{\gamma_y} \left(\frac{\hat{b}_t}{\hat{b}^*}\right)^{\gamma_b} \left(\frac{z_t}{z^*}\right)^{\gamma_z}, \qquad \hat{x}_t := \frac{x_t}{y_t}, \quad \gamma_y, \gamma_b, \gamma_g \geq 0$$

- Sets restrictions on bank portfolio (modeled as a penalty):

$$\varrho d_{t-1}^f \leq \left(\kappa^b (\zeta + (1-\zeta) q_t^b) b_{t-1}^f + \kappa^s (\delta_t^s + q_t^s) s_{t-1}^f\right) \quad \Leftrightarrow \quad \mu_t^b = \frac{1}{\mu}\left(\frac{\varrho^b d_{t-1}^f}{\kappa^b(\cdot) + \kappa^s(\cdot)}\right)^{\mu},$$

  - ϱ is constraint on risk taking; (κ^b, κ^s) incentivise holding particular assets.
  - National banking sets $\kappa_t^s = 0$ to get "collateral need": $d_{t-1}^f \leq \kappa^b (\zeta + (1-\zeta) q_t^b) b_{t-1}^f$
  - Basel III (approximately) sets κ_t^b and κ_t^s as "risk-weights"

Household Problem

- Household choose paths for consumption $\{c\}$ and deposits, bank equity, firm shares $\{d^h, e^h, s^h\}$, to solve:

$$\max \left\{ \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t, d_t^h) \right\} \quad s.t. \quad s_t^h \geq 0, \quad d_t^h \geq 0, \quad l_t = 1,$$

$$c_t + q_t^e e_t^h + q_t^d d_t^h + q_t^s s_t^h$$

$$\leq (\delta_t^s + q_t^s) s_{t-1}^h + (\delta_t^e + q_t^e) e_{t-1}^h + d_{t-1}^h$$

Environment friction: "transaction utility" $u(\cdot, d_t^h)$ enhanced by holding deposits.

Bank Problem

- **Morning:** Value of bank assets, $\mathcal{A}_t^f := (\zeta + (1-\zeta)q_t^b)b_{t-1}^f + (\delta_t^s + q_t^s)s_{t-1}^f$:
  - Bank incurs recapitalization cost if $\mathcal{A}_t^f < d_t^f$ (modeled as penalty $\Psi(d_t^f, \mathcal{A}_t^f)$)

- **Afternoon:** Asset markets open. Bank chooses dividends and portfolio $\{\delta_t^e, d_t^f, b_t^f, s_t^f\}_{t\geq 0}$ to maximize bank market value:

$$
\begin{aligned}
V_t(a_t^f) = & \max_{\delta_t^e, b_t^f, s_t^f, d_t^f} \left\{ \delta_t^e + \mathbb{E}_t \left[\xi_{t,t+1} V_{t+1}(a_{t+1}^f) \right] \right\}, \quad \xi_{t,t+1} \text{ is household SDF} \\
\text{s.t.} \quad & \delta_t^e + q_t^s s_t^f + q_t^b b_t^f - q_t^d d_t^f \leq a_t^f \\
& a_{t+1}^f = \mathcal{A}_{t+1}^f - d_t^f - \Psi\left(d_t^f, \mathcal{A}_{t+1}^f\right) \\
& \varrho d_t^f \leq \left(\kappa^b (\zeta + (1-\zeta) q_{t+1}^b) b_t^f + \kappa^s (\delta_{t+1}^s + q_{t+1}^s) s_t^f \right), \quad 0 \leq b_t^f, \ 0 \leq s_t^f
\end{aligned}
$$

Environment friction: Banks face resource cost $\Psi(d_t^f, \mathcal{A}_t^f)$ when “insolvent”.

Key Features of Environment

- **"Role of banking"** is to create a safe deposits
- **"Cost of banking"** banks face costly recapitalization, $\Psi(\cdot)$, when low net-worth
  (The cost of financial instability in our model)
- Distortions break Modigliani & Miller and make safe deposit creation difficult:
  - Creating safe deposits exposes banks to costly recapitalization.
  - Generates key distortion that household SDF differs from bank SDF.
- Clear welfare criteria because households are residual owners of banks and firms.

Equilibrium

Given a government fiscal rule and initial capital, k_0, a competitive equilibrium is a sequence of prices $\{q_t^d, q_t^e, q_t^b, q_t^s\}_{t\geq 0}$, household and bank choices s.t.:

1. Households, banks, and firms solve optimize given prices.
2. Markets clear:

$$d_t^h = d_t^f, \qquad e_t^h = 1, \qquad b_t^h + b_t^f = b_t, \qquad s_t^h + s_t^f = 1,$$

$$y_t - \Psi_t = c_t + \iota_t k_{t-1} + g_t,$$

3. Government budget constraint is satisfied.

Asset Pricing Equations: Deposit Market

- Deposit market:

$$q_t^d = \mathbb{E}_t\Big[\xi_{t,t+1}\underbrace{\Big(1 + \frac{\partial_d u_{t+1}}{\partial_c u_{t+1}}\Big)}_{\text{Safe asset benefit}}\Big], \qquad \text{Household demand}$$

$$q_t^d = \mathbb{E}_t\Big[\xi_{t,t+1}\underbrace{\Big(1 - \partial_d \Psi_{t+1} + \varrho\mu_{t+1}\Big)}_{\substack{\text{Distortion from solvency} \\ \text{costs and regulation}}}\Big] \qquad \text{Bank supply}$$

  - where μ_{t+1} is the penalty on regulation constraint
  - If $\nu \equiv 0$, then banks issue d_t only if $\partial_a \Psi_t = 0$
  - If $\Psi \equiv 0$ (and bank competition), then banks $\uparrow d_t$ until $\nu'(d) = 0$ and so $q_t^d = \mathbb{E}[\xi_{t,t+1}]$
  - Otherwise, $\partial \Psi_t$ distorts risk pricing of bank and $q_t^d > \mathbb{E}[\xi_{t,t+1}]$
  - Ψ generates key distortion that household SDF differs from bank SDF.

Asset Pricing Equations: Government Debt Market

- Government debt market:

$$q_t^b \geq \mathbb{E}[\xi_{t,t+1}(\zeta + q_{t+1}^b(1-\zeta))], \qquad \text{Household demand}$$

$$q_t^b = \mathbb{E}_t\left[\xi_{t,t+1}\underbrace{\left(1 - \partial_{\mathcal{A}}\Psi_{t+1} + \kappa^b\mu_{t+1}\right)}_{\substack{\text{distortion from solvency} \\ \text{costs and regulation}}}(\zeta + q_{t+1}^b(1-\zeta))\right] \qquad \text{Bank demand}$$

  - If regulation penalty μ_{t+1} is large during negative aggregate shocks, then government debt acts as a good hedge $\Rightarrow q_t^b$ is high (and convenience yield appears).
  - Banks potentially value government bonds more than households because they allow banks to hedge the cost of equity issuance when z_t is low.

Parameter Values

- State variables: $(z_t, k_t, b_{t-1}, d_{t-1}, b^f_{t-1}, s^f_{t-1})$
- We solve the model globally for following parameters (NOT a calibration):

Parameter	Value	Description
β	0.99	Discount factor
δ	0.025	Rate of depreciation
ζ	0.025	Maturity of government debt (10 years)
(b^*, γ_z)	$(45, -0.1)$	Debt policy parameters
$(\rho_z, \underline{\sigma_z})$	$(0.97,\ 0.05,\ 0.1)$	Parameters of log(z) (AR(1))
$(\psi, \bar{\psi})$	$(2,\ 0.01)$	Distortion cost
$(\mu, \bar{\mu}, \kappa^b, \kappa^s, \varrho)$	$(2,\ 0.01,\ \kappa,\ 0,\ 1)$	Regulation penalty

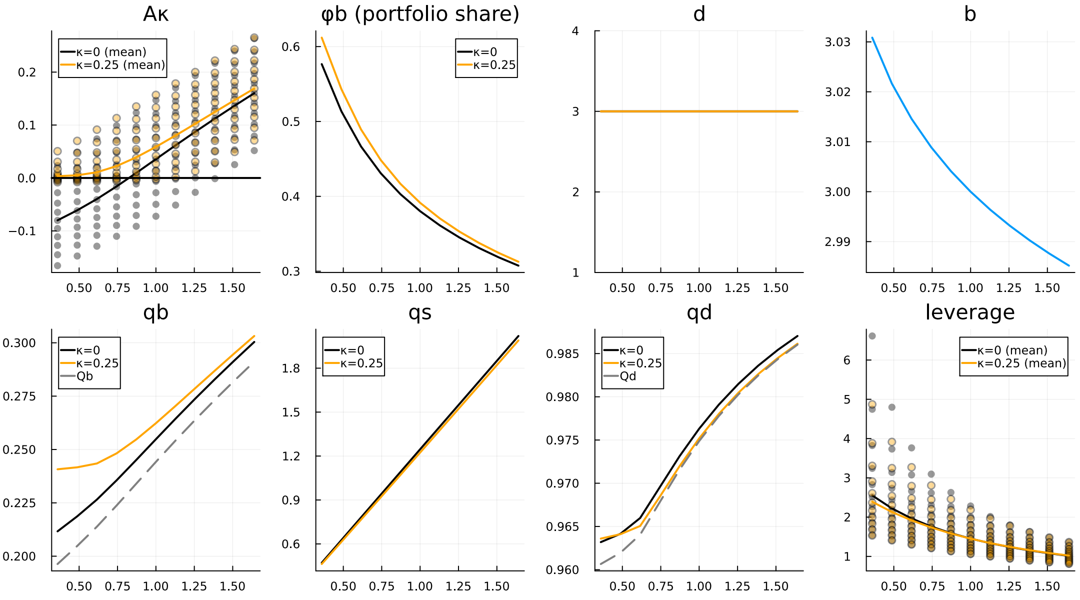
- We plot policies as function of z at stochastic steady state for other variables.

Impact of Regulation Depends on Bank Adjustment

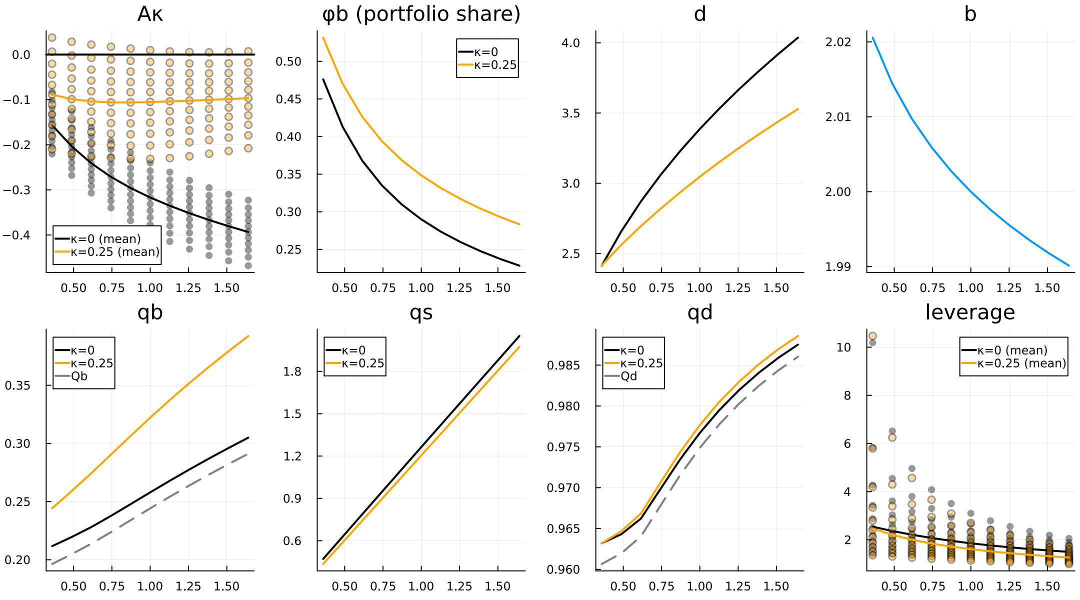
- Decrease in output $z_t \Rightarrow$ decrease in government debt and equity prices.
- Decrease in prices $\Rightarrow$ tighter regulatory constraint! Banks can respond by:
  - Decreasing deposit creation (i.e. shrinking balance sheet), or
  - Buying more bonds (to better back their deposits)
- How bank responds is governed by tradeoff:
  - $\downarrow$ deposits means giving up profits from providing liquidity services (governed by curvature in transaction utility $u(\cdot, d_t^h)$ from deposits)
  - $\downarrow$ deposits leads to $\downarrow$ leverage, which helps decrease solvency and regulatory costs (governed by curvature in resource cost $\Psi(d_t^f, \mathcal{A}_t^f)$ when insolvent)
- If banks respond by re-balancing from firm equity to bonds, then $\uparrow q_t^b/q_t^s$

The more stable deposit demand in recession $\Rightarrow$ the larger increase in q_t^b/q_t^s

Inelastic Deposit Demand: κ makes z-shock gov. debt demand shock



Elastic Deposit Demand: κ makes q^b more procyclical



Convenience Yields and Borrowing Cost Smoothing

- Government funding advantage in our model:

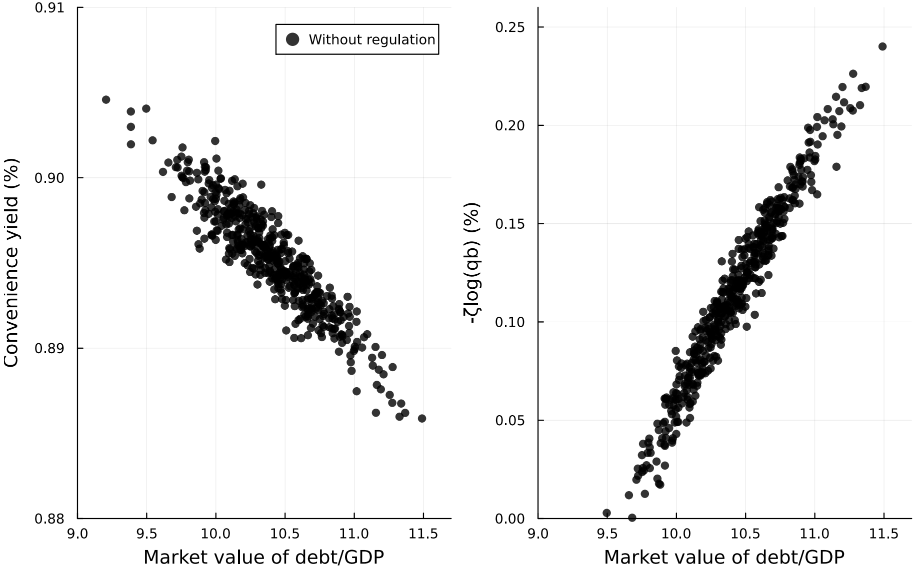
$$\text{“Convenience yield”} = \mathbb{E}_t[\xi_{t,t+1/\zeta}]^{-1} - \zeta \log(1/q_t^b)$$

- In our model, “convenience yield” on long-term government debt comes from:
  - Regulation (the constraint ϱ_b) leading banks to buy more debt in recessions.
  - ~~Government reducing bond supply in recessions~~ (fiscal policy doesn’t do this).
- To understand how this plays out in equilibrium, we:
  - Simulate economy under different regulatory policies and plot:

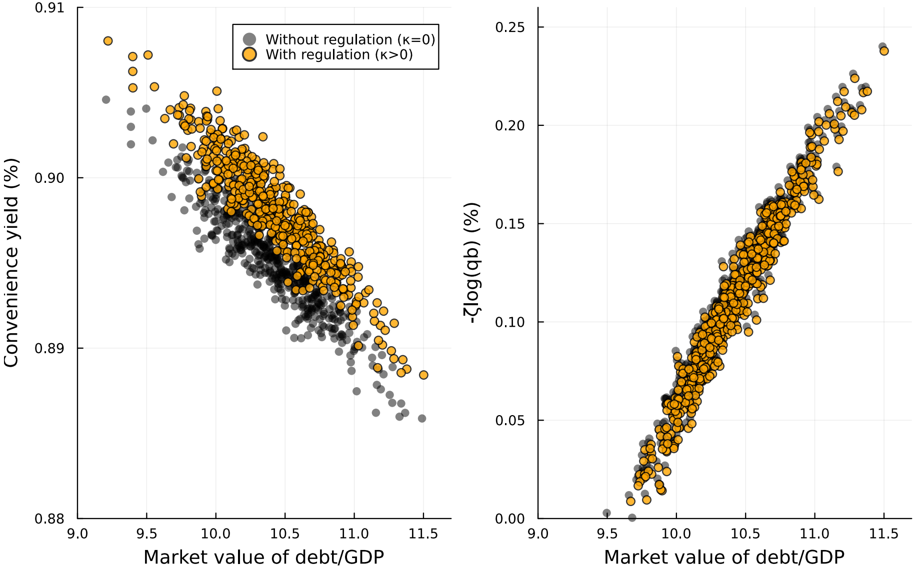
$$\underbrace{\mathbb{E}_t[\xi_{t,t+1/\zeta}]^{-1} - \zeta \log(1/q_t^b)}_{\text{Convenience yield / “funding advantage”}} \quad \sim \quad \underbrace{q_t^b b_{t+1}/y_t}_{\text{Market Value of Debt to GDP}}$$

  - Show how convenience yield moves along the equilibrium path.

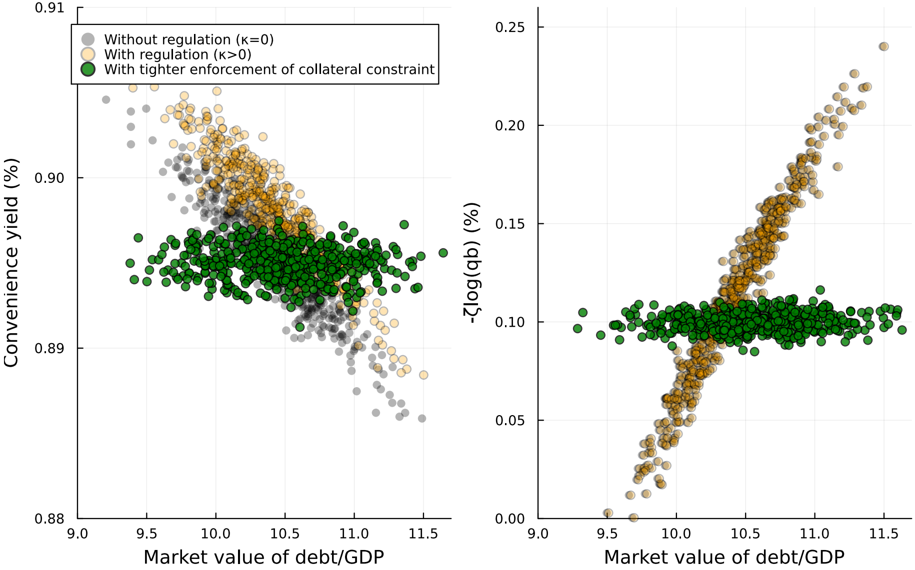
No Regulation



Loose Regulation, Elastic Demand For Deposits



Tight Regulation, Inelastic Demand For Deposits



Intuition

- The government increases debt/GDP when $\downarrow z$.
- But, $\downarrow z$ causes regulatory constraint to bind and and so $\uparrow$ bank demand for government debt.
- So, government can $\uparrow$ debt/GDP without facing an $\uparrow$ interest rate.

Household Welfare

- Household welfare in equilibrium:

$$\max \left\{ \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t, d_t^h) \right\}$$

$$c_t = y_t - \Psi(d_t, \mathcal{A}_t) - \iota_t k_{t-1} - g_t$$

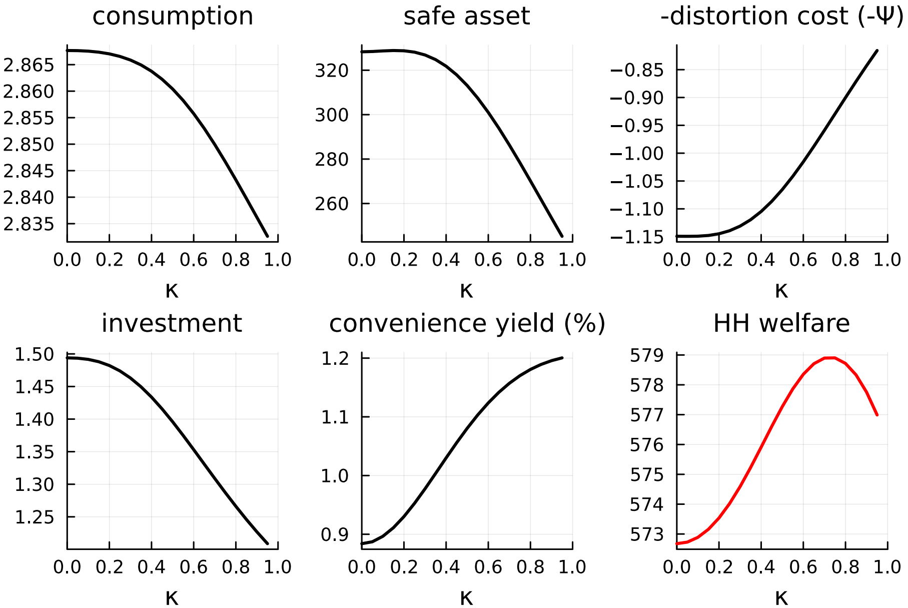
$$\hat{\tau}_t y_t = g_t + \zeta b_{t-1} - q_t^b (b_t - (1-\zeta) b_t)$$

$$k_t \Phi(\iota_t) [\Phi'(\iota_t)]^{-1} = q_t^s, \quad q_t^b, q_t^s, q_t^d \quad \text{satisfy equilibrium conditions}$$

Financial regulation to increase risk weight on government debt κ^b implies:

- $\downarrow \mathbb{E}_0[\hat{\tau}_t y_t]$ because government faces higher q^b when issuing debt.
- ? $\mathbb{E}_0[\iota_t]$ because lower bank demand for equity $\downarrow q_t^s$ but lower taxes $\uparrow q_t^s$.
- $\downarrow \mathbb{E}_0[\Psi(d_t, \mathcal{A}_t)]$ because risk taking penalized and banks can better use government debt to hedge risk.

Optimal κ^b balances tax smoothing, stability, and investment



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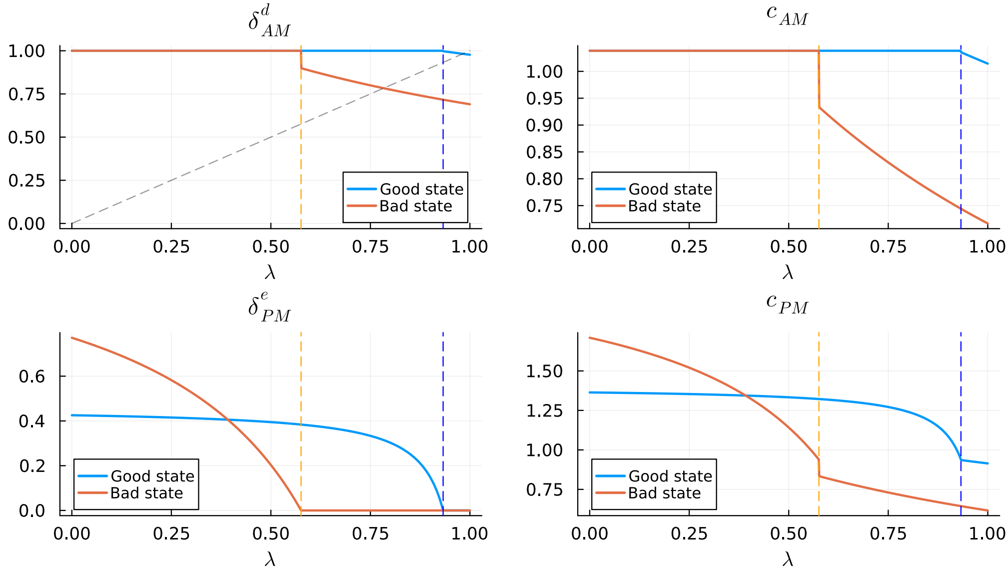
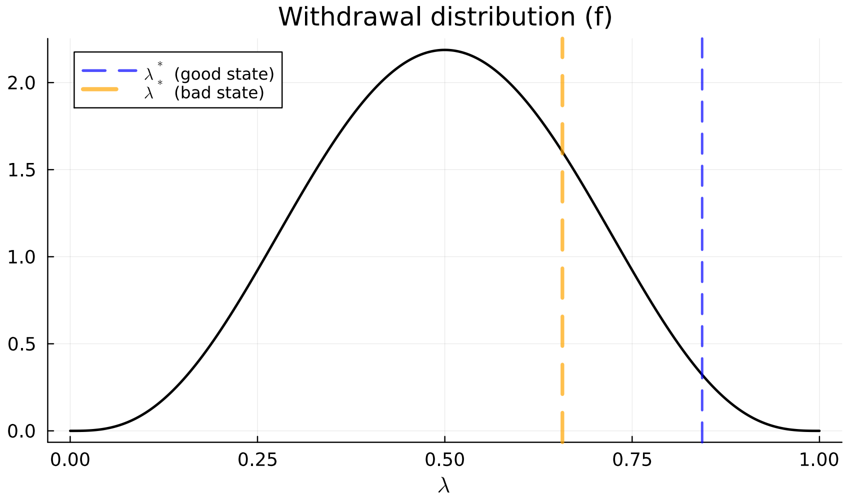
Payoffs and Individual Consumption



Withdrawal distribution



SDF Formulas

$$\xi(\lambda) := \frac{(1-\lambda)u'(c_{PM}(\lambda))}{\mu_0^c}$$

$$\nu(\lambda) := \frac{\lambda u'(c_{AM}(\lambda))}{(1-\lambda)u'(c_{PM}(\lambda))}$$

$$\Omega(\lambda) := \begin{cases} \frac{1+\nu(\lambda)}{(R^k-1)\lambda+1} + \Delta(\lambda) & \lambda > \lambda^* \\ (1-\lambda)^{-1} + \Delta(\lambda) & \lambda \leq \lambda^* \end{cases}$$

$$\Delta(\lambda) := \frac{\xi(\lambda^*)\Big(1+\nu(\lambda^*)\Big)}{\xi(\lambda)\Big((R^k-1)\lambda^*+1\Big)}\left[\varsigma \frac{z_{PM}k_0}{d_0}\right] f(\lambda^*)$$

$$\Gamma(\lambda) := \Bigg(R^k\lambda + \Big(1+\kappa(R^k-R^b)\Big)(1-\lambda)\Bigg)$$

Deposit Market at $t = 0$ [JP: Move to APPENDIX]

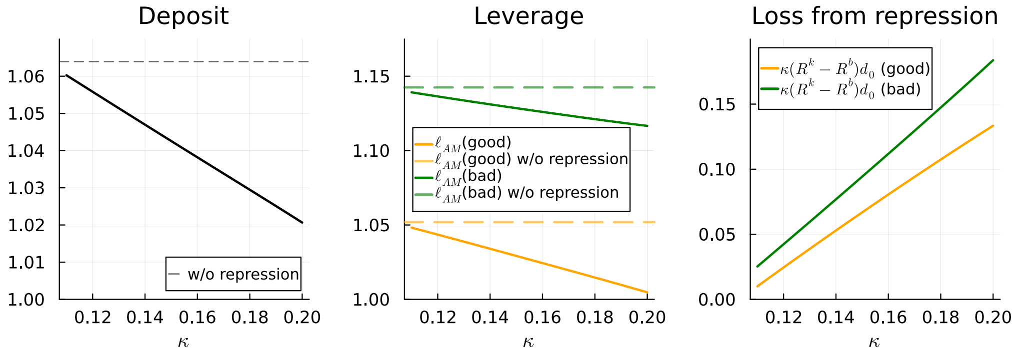
$$q_0^d = \mathbb{E}\left[\xi(\lambda) \quad \underbrace{(1+\nu(\lambda))}_{\text{on-demand benefit}} \quad \delta^d(\lambda)\right], \qquad \text{Household demand}$$

$$q_0^d = \mathbb{E}\left[\xi(\lambda) \ \underbrace{\Omega(\lambda)}_{\text{default}} \quad \underbrace{\Gamma(\lambda)}_{\text{regulation}} \ \delta^d(\lambda)\right] \qquad \text{Bank supply}$$

- If $\nu \equiv 0$, then banks issue d_0 only if $\Omega = 1$
- If $\Omega \equiv 0$, then banks $\uparrow d_0$ until $\nu = 0$
- Otherwise, positive equilibrium liquidity premium on deposits $q_0^d > \mathbb{E}[\xi]$
- $\left(1 + \frac{\lambda u'(c_{AM}(\lambda))}{(1-\lambda)\mu^c_{AM}(\lambda)}\right) =: 1 + \nu(\lambda)$
- where

$$\Omega(\lambda) := \begin{cases} \frac{(1+\nu(\lambda))\delta^d(\lambda)}{(\ell_{AM}-\varsigma)} + \mu_{AM} \frac{\xi(\lambda^*)(1+\nu(\lambda^*))}{\xi(\lambda)\mathcal{R}} \frac{\varsigma}{\ell_{AM}} \frac{f(\lambda^*)}{(1-F(\lambda^*))} & \lambda > \lambda^* \\ \mu_{AM} & \lambda \leq \lambda^* \end{cases}$$

Increasing κ reduces leverage and bank profit



Shareholder value:

$$V_{AM} = R^k \underbrace{\left(\ell_{AM}^{-1} - \lambda\right) d_0}_{\text{net worth}} - \underbrace{(1-\lambda)d_0}_{\text{late deposit}} - \underbrace{\kappa\left(R^k - R^b\right)(1-\lambda)d_0}_{\text{loss from repression}} \qquad \lambda^* = \frac{R^k \ell_{AM}^{-1} - \left(1 + \kappa(R^k - R^b)\right)}{R^k - \left(1 + \kappa(R^k - R^b)\right)}$$

where $R^k := z_{PM}/q_{AM}^k$, $\quad R^b := 1/q_{AM}^b$, $\quad$ and $\quad \ell_{AM} := d_0/(z_{AM}m_0 + q_{AM}^k k_0 + q_{AM}^b b_0)$