Intermediaries in Macro Finance

Xiang Fang

The University of Hong Kong

March, 2024

Outline

1. A canonical macroeconomic model with intermediary frictions
2. Nonlinear models
3. Intermediary asset pricing theory
4. Empirical advances in intermediary asset pricing
5. Monetary policy transmission through banks

1. A canonical macroeconomic model with intermediary frictions

Gertler and Karadi (2011, JME)

Households

- Preference

$$E_t \sum_{i=0}^{\infty} \beta^i \ln(C_{t+i} - hC_{t+i-1}) - \frac{\chi}{1+\varphi} L_{t+i}^{1+\varphi}$$

- Each household is a big family with perfect consumption insurance. There are two types of agents in each household, workers $1-f$ and bankers f
  - Workers supply labor and return wages to household
  - Each banker manages a financial intermediary (bank) and transfers "dividends" back to households
- Households do not hold capital directly; deposit funds in banks at risk-free rate
  - Very large equity frictions: no holding of capital, no holding of firm's claims, **passive** holding of banks' claims

Households' Optimization Problem

- Households solve

$$\max_{C_{t+i}, D_{t+i+1}} E_t \sum_{i=0}^{\infty} \beta^i \ln(C_{t+i} - \gamma C_{t+i-1}) - \frac{\chi}{1+\varepsilon} L_{t+i}^{1+\varepsilon}$$

$$s.t.: C_t = W_t L_t + \Pi_t + D_{t-1} R_t - D_t + T_t$$

  where C_t consumption, $W_t L_t$ wage payment, Π_t net payout from intermediaries, $D_{t-1} R_t$ proceeds from yesterday's deposit, D_t today's deposit, T_t lump-sum subsidy

- Optimality conditions

$$E_t u_{Ct} W_t = \chi L_t^{\varphi}$$

$$E_t M_{t+1} R_{t+1} = 1$$

Households Own and Operate Banks

- Each household sends bankers to operate its banks
- Workers deposit savings in other households' banks
  - Create moral hazard frictions, specified later
- Turnover of workers and bankers
  - Bankers become workers and pay out the net worth of banks to households. Meanwhile, the same amount of workers become bankers and start new banks
  - Otherwise, banks have incentives to accumulate enough net worth to grow out of the constraint

Banks

- Raise funds in the national financial market
- No friction in transfering funds from banks to firms (consolidate banks and firms)
- Banks' balance sheet
  - Claim to firms' capital s_t at price Q_t (interpreted as loans)
  - Financed with net worth n_t and deposit d_t

$$Q_t s_t = d_t + n_t$$

  - Dynamics of net worth

$$n_t = Q_{t-1} s_{t-1} R_{kt} - d_{t-1} R_t$$

Banks' Frictions

- Moral hazard problem: the bankers are able to divert away θ fraction of the assets at the end of each period
- To prevent this from happening, it must be that

$$V_t \geq \lambda Q_t s_t$$

  If the franchise value of the bank exceeds the private benefit, bankers will not divert assets
- As you will see later, this friction effectively imposes an endogenous leverage constraint

Banks' Problem

$$V(n_t; N_t, Z_t) = \max_{d_t, s_t} E_t M_{t+1} \left[(1-\sigma) n_{t+1} + \sigma V(n_{t+1}; N_{t+1}, Z_{t+1}) \right]$$

$$s.t. : n_{t+1} = n_t R_{k,t+1} + d_t (R_{k,t+1} - R_{t+1})$$

$$V_t \geq \lambda Q_t s_t$$

Conjecture: $V(n_t; N_t, Z_t) = \Omega(N_t, Z_t) n_t$ and define leverage $\phi_t = \frac{Q_t s_t}{n_t}$, the problem is written as

$$\Omega_t = \max_{\phi_t} E_t M_{t+1} (1 - \sigma + \sigma \Omega_{t+1}) \left[\phi_t (R_{k,t+1} - R_{t+1}) + R_{t+1} \right]$$

$$s.t. : \Omega_t \geq \lambda \phi_t$$

Banks' Optimality Condition

Define $M^J_{t+1} = M_{t+1}\frac{1-\sigma+\sigma\Omega_{t+1}}{\Omega_t}$, the optimality condition is

$$E_t M^J_{t+1}(R_{k,t+1} - R_{t+1}) - \frac{\lambda\kappa_t}{\Omega_t} = 0$$

- M^J_{t+1} the ratio of marginal value of cash today and tomorrow
- κ_t is the Lagrangerian multiplier to the constraint
- If $\kappa_t > 0$, $E_t M^J_{t+1}(R_{k,t+1} - R_{t+1}) > 0$
- Banks still would like to take deposits and invest in capital as there is "arbitrage gap", but the constraint does not allow

Envelope Condition

- The envelope condition with respect to n

$$E_t M^J_{t+1} R_{t+1} = 1 - \kappa_t$$

- The value of deposit tomorrow is smaller than the frictionless case if $\kappa_t > 0$. Absent constraint, the bank borrows more.

The Model Without Constraint

- If $\kappa_t = 0$

$$E_t M^J_{t+1}(R_{k,t+1} - R_{t+1}) = 0$$

$$E_t M^J_{t+1} R_{t+1} = 1$$

Recall that $M^J_{t+1} = M_{t+1}\frac{1-\sigma+\sigma\Omega_{t+1}}{\Omega_t}$ and $E_t M_{t+1} R_{t+1} = 1$, we can derive $\Omega_t = 1$

- Ω_t: the marginal value of net worth (Tobin's q). Absent frictions, the market value of one dollar should be one dollar
- Without frictions, we need two Euler equations (using households' SDF) to price the risk-free rate and the price of capital - the composition of financing does not matter for the value of the intermediaries with given n (Modigliani-Miller)

The Economics: Leverage Constraint and Financial Wedge

- With constraint, $\kappa_t > 0$, there exists a wedge between the return to capital and the risk-free rate
$$E_t M^J_{t+1}(R_{k,t+1} - R_{t+1}) > 0$$
  - Borrowing one more dollar to invest in capital is profitable, but is prohibited
  - Why prohibited? One more dollar of borrowing increases the franchise value as well as the divertable asset. If the increase in the divertable asset is greater than the contribution to the franchise value, the constraint binds

Aggregation of Bank Net Worth

- Only σ fraction of banks are still in the market next period
- To keep the measure of banks unchanged, the same measure of workers are appointed as bankers, and new banks are started with net worth N_{nt}
- The aggregate law of motion of bank net worth

$$N_{t+1} = \sigma[N_t R_{k,t+1} + D_t(R_{k,t+1} - R_{t+1})] + N_{nt}$$

where $N_{nt} = \omega Q_t S_{t-1}$

The Role of Net Worth

- Note that whether constraint binds or not depends on the **aggregate** net worth of the banking sector, not the individual banks
- Whether the constraint binds depends on the marginal contribution of one more unit of borrowing to the franchise value

$$E_t M_{t+1}(1-\sigma+\sigma\Omega_{t+1})(R_{k,t+1}-R_{t+1})$$

  All variables in this equations are determined by aggregate variables, not individual bank variables

- If bank net worth is ample, in aggregate banks are take advantage of the investment opportunities in the market through deposits and eliminate “arbitrage” opportunities
- Otherwise, bank net worth is scarce, the amount of deposit, or the capacity of purchasing capital, will be constrained. In this case, capital price is excessively low, and expected return of capaital is high (**funding illiquidity**)

Persistence and Amplification

- Emphasized in the early literature: Carlstrom and Fuerst (1997 AER), Kiyotaki and Moore (1997 JPE), see Bernanke, Gertler and Gilchrist (1999)
- The effect on capital investment disruption creates persistence
- The leverage constraint leads to a dynamic amplification
  - When the constraint binds, negative shock lowers asset price, which further reduces net worth through leverage effect, and further tightens the constraint - a spiral
  - Dynamically, if funding is scarce, investment is low, future capital and future output is low, which is reflected in a lower capital price today - another spiral

Credit Policy

- Denote S_{pt} the shares held by the private sector and S_{gt} the shares held by the government

$$S_t = S_{pt} + S_{gt}$$

- Credit policy: central bank issues government debt to households at R_{t+1} and lends to nonfinancial firms at $R_{k,t+1}$
  - Government lending is less efficient with a cost of τ per unit
  - Government always repays their debt to households

$$S_{gt} = \psi_t S_t$$

- Denote ϕ_{ct} the total leverage including public and private intermediation, we have

$$\phi_{ct} = \frac{\phi_t}{1 - \psi_t}$$

ψ_t is a general policy rule, e.g., combatting financial crisis

Intermediate Goods Firms

- Nonfinancial firms: produce intermediate goods and sell to retail firms
- Production function

$$Y_t = A_t \left(U_t \xi_t K_t\right)^{\alpha} L_t^{1-\alpha}$$

  - U_t is the capital utilization and it affects depreciation $\delta(U_t)$
  - ξ_t is the capital quality shock, $\xi_t K_t$ is the effective quantity of capital
- Optimality conditions

$$\alpha P_{mt} \frac{Y_t}{U_t} = \delta'(U_t) \xi_t K_t$$

$$(1-\alpha) P_{mt} \frac{Y_t}{L_t} = W_t$$

- Capital return

$$R_{k,t+1} = \frac{\alpha P_{m,t+1} \frac{Y_{t+1}}{\xi_{t+1} K_{t+1}} + Q_{t+1} - \delta(U_{t+1})}{Q_t} \xi_{t+1}$$

Capital Producing Firms

- At the end of each period, capital producing firms buy capital from intermediate goods producers, repair depreciated capital and build new capital, then sell both the new and re-furbished capital
- Assume the cost of replacing worn out capital is unity (no adjustment cost)
- Let I_t be gross capital created, $I_{nt} \equiv I_t - \delta(U_t)\xi_t K_t$ the net capital created, and I_{ss} the steady state investment
- The problem of capital producer

$$\max_{I_{n\tau}} E_t \sum_{\tau=t}^{\infty} M_{t,\tau} \left\{ (Q_\tau - 1) I_{n\tau} - f\left(\frac{I_{n\tau} + I_{ss}}{I_{n,\tau-1} + I_{ss}} \right) (I_{n\tau} + I_{ss}) \right\}$$

- The q-relation

$$Q_t = 1 + f(.) + \frac{I_{nt} + I_{ss}}{I_{n,t-1} + I_{ss}} f'(.) - E_t M_{t,t+1} \left(\frac{I_{n,t+1} + I_{ss}}{I_{nt} + I_{ss}} \right)^2 f'(.)$$

Retail Firms

- The final output is a CES composite of a continuum of differentiated intermediate goods
$$Y_t = \left[\int_0^1 Y_{ft}^{(\varepsilon-1)/\varepsilon} df \right]^{\varepsilon/(\varepsilon-1)}$$
where Y_{ft} is the output by retailer f. Derive the demand for retailer f's production
$$Y_{ft} = \left(\frac{P_{ft}}{P_t} \right)^{-\varepsilon} Y_t$$
Price index
$$P_t = \left[\int_0^1 P_{ft}^{1-\varepsilon} df \right]^{1/(1-\varepsilon)}$$

Price Rigidty and Retail Firms

- Retail firms face price rigidity: $1-\gamma$ probability can adjust price
- In between these periods, the firm is able to index its price to lagged inflation

$$\max_{P_t^*} E_t \sum_{i=0}^{\infty} \gamma^i M_{t,t+i} \left[\frac{P_t^*}{P_{t+i}} \prod_{k=1}^{i} (1+\pi_{t+k-1})^{\gamma_p} - P_{m,t+i} \right] Y_{f,t+i}$$

$$s.t.: Y_{f,t+i} = \left(\frac{P^*}{P_{t+i}} \right)^{-\varepsilon} Y_t$$

where π_t is the inflation from $t-i$ to t.

- The optimality condition

$$\sum_{i=0}^{\infty} \gamma^i M_{t,t+i} \left[\frac{P_t^*}{P_{t+i}} \prod_{k=1}^{i} (1+\pi_{t+k-1})^{\gamma_p} - \mu P_{m,t+i} \right] Y_{f,t+i} = 0$$

- The price level is

$$P_t = \left[(1-\gamma)(P_t^*)^{1-\varepsilon} + \gamma \left(\Pi_{t-1}^{\gamma_p} P_{t-1} \right)^{1-\varepsilon} \right]^{1/(1-\varepsilon)}$$

Resource Constraints and Government Policy

- Resource constraints

$$Y_t = C_t + I_t + f\left(\frac{I_{nt} + I_{ss}}{I_{nt} + I_{ss}}(I_{nt} + I_{ss}) + G + \tau\psi_t Q_t K_{t+1}\right)$$

- Capital evaluation

$$K_{t+1} = \xi_t K_t + I_{nt}$$

- Government budget

$$G + \tau\psi_t Q_t K_{t+1} = T_t + (R_{kt} - R_t)B_{g,t-1}$$

- Monetary policy rule

$$i_t = (1-\rho)\left[i + \kappa_\pi \pi_t + \kappa_y(\log Y_t - \log Y_t^*)\right] + \rho i_{t-1} + \varepsilon_t$$

- Fisher relation

$$1 + i_t = R_{t+1}\frac{E_t P_{t+1}}{P_t}$$

- Credit policy

$$\psi_t = \psi + \nu E_t\left[(\log R_{k,t+1} - \log R_{t+1}) - (\log R_k - \log R)\right]$$

Individual State Variables and Aggregate State Variables

- Individual state: the information decision maker needs to know to make decisions
- Aggregate state: drive aggregate variables
- The link between the two largely determines the tractability of macro models
- Intermediary's the individual state: n, or d_{-1}, s_{-1}
- Aggregate states: aggregate intermediary net worth N, aggregate capital K, lagged consumption C_{-1}, lagged investment I_{-1}, lagged interest rate i_{-1}, all exogenous states A, ξ and interest rate shock
- Aggregation of n to N is simple, (almost) homogeneous intermediaries
- Dynare solution: cast the model into VAR form, with all one-period lag variables and current shocks as state variables
- A solution to a model includes (i) individual decision as a function of aggregate and individual state; (ii) aggregate endogenous variables as a function of aggregate states; (iii) the evoluation of states
- Recursive formulation: Dirk Krueger's lecture notes on macroeconomics

Solution Method

- Dynare: if the constraint always binds
- OccBin (Guerrieri and Iacoviello, 2015, JME)
  - Can handle the occasionally-binding feature of the constraint up to the first order
  - Dynare code available
  - Requirement: exist two steady states with binding and nonbinding constraint
  - Limitations: cannot deal with higher-order effect, i.e., if the fear of future constraint to be binding has a substantial real impact today, the toolkit is inaccurate
  - Example of higher-order effect: Bocola (2016, JPE)

Calibration

Table 1
Parameters.

Households		
β	0.990	Discount rate
h	0.815	Habit parameter
χ	3.409	Relative utility weight of labor
φ	0.276	Inverse Frisch elasticity of labor supply
Financial Intermediaries		
λ	0.381	Fraction of capital that can be diverted
ω	0.002	Proportional transfer to the entering bankers
θ	0.972	Survival rate of the bankers
Intermediate good firms		
α	0.330	Effective capital share
U	1.000	Steady state capital utilization rate
$\delta(U)$	0.025	Steady state depreciation rate
ζ	7.200	Elasticity of marginal depreciation with respect to utilization rate
Capital Producing Firms		
η_i	1.728	Inverse elasticity of net investment to the price of capital
Retail firms		
ε	4.167	Elasticity of substitution
γ	0.779	Probability of keeping prices fixed
γ_P	0.241	Measure of price indexation
Government		
κ_π	1.5	Inflation coefficient of the Taylor rule
κ_y	0.50/4	Output gap coefficient of the Taylor rule
ρ_i	0.8	Smoothing parameter of the Taylor rule
$\frac{G}{\overline{Y}}$	0.200	Steady state proportion of government expenditures

Calibration: Parameters New to this Model

- Intermediary block: λ, ω, θ
- Three targeted moments: average spread, leverage ratio, average horizon of bank
- The calibration step is critical in a quantitative work
- Identification: which moments identify which parameters? Usually impossible to establish one-to-one mapping, but there is a rough relation through the underlying economics
- To show the rough mapping, changing one parameter at a time can display which moments are sensitive

Impulse Responses: TFP, Monetary and Net Worth Shock

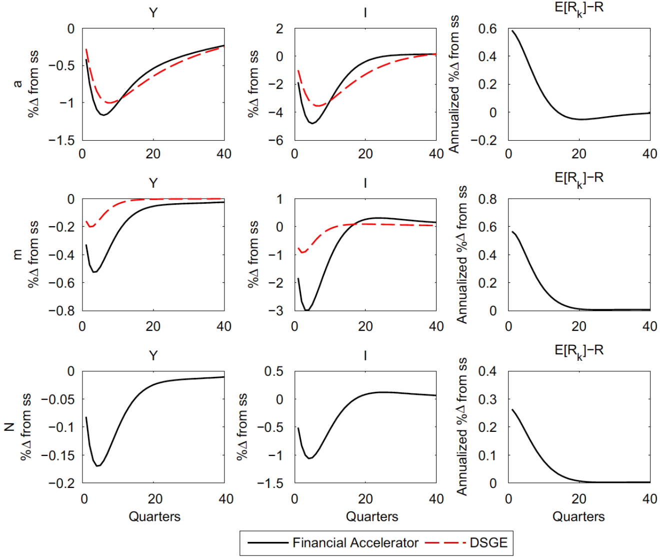
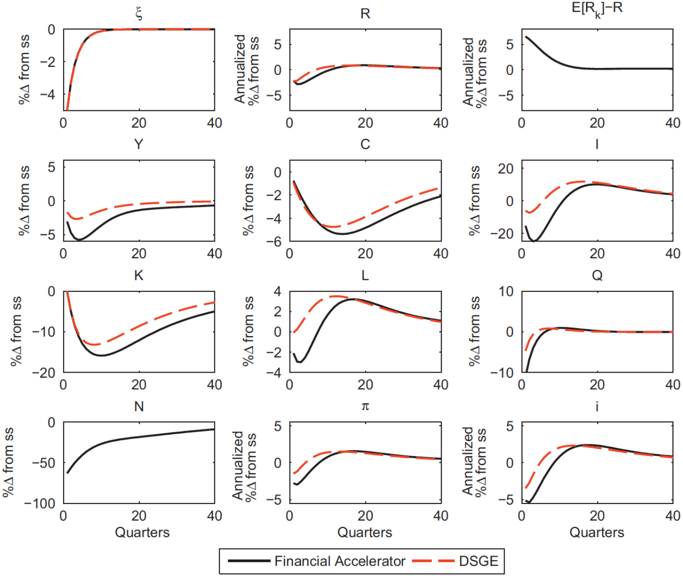


Fig. 1. Responses to Technology (a), Monetary (m) and Wealth (w) Shocks.

Impulse Responses (2): Capital Quality Shock



The Economics

- The intermediary friction, through the financial accelerator (net worth - constraint - asset price spiral), amplifies the drop in output, capital, consumption, labor, investment, inflation and asset price (deeper response)
- The main mechanism: limited lending reduces capital price, which in turn discourages investment
- Monetary policy shock/intermediary net worth shock reduces aggregate demand, which induces lower labor demand and lower capital utilization

Credit Policy

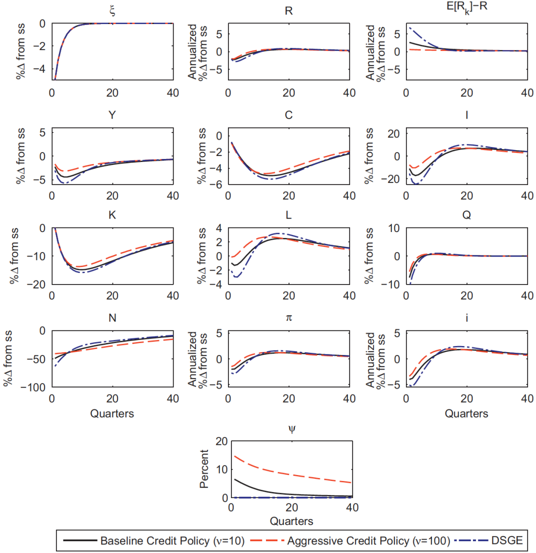


Fig. 3. Responses to a Capital Quality Shock with Credit Policy.

Credit Policy: The Economics

- The expected excess return widening is an indicator of a binding constraint
- Government lending is not subject to the constraint so it overcomes the shortage of lending due to the friction, despite at the cost of lower efficiency
- With aggressive credit policy, the responses of real variables are smaller

Companion Readings

- Gertler and Kiyotaki (2010) Handbook chapter
- Dou, Fang, Lo and Uhlig (2023 ARFE)
- Brunnermeier, Eisenbach and Sannikov (2012)
- Quadrini (2011)

Cole's Summary

Three critical features

- Each period, intermediate good producers refinance from scratch to buy capital
- Intermediaries start out small and die randomly, preventing the financial sector from being large enough to grow out of the constraint
- Intermediaries never hedge the risk that the financial constraint binds - net worth shocks transmitted to the supply of funds

Cole's Comment (1)

- What if a fraction of firms can pile up internal resources to self-finance investments, then they face an internal cost of capital
- Chari and Kehoe (2008): in aggregate, the retained earnings exceed investments
  - Questioning whether **all** firms are really constrained in their investments
  - A different approach: heterogeneous firms + a fraction of firms constrained (Shourideh and Zetlin-Jones, 2017 JME)
- Labor wedge, not investment wedge, accounts for a big fraction of US business cycles (Chari, Kehoe and McGrattan, business cycle accounting, 2007 ECMA)

Cole's Comment (2)

- Are intermediaries constrained?
  - Crisis suggests they are: credit spread spikes, intermediation volume drops
  - Banks seems less so: deposit are sticky and hold excess reserves
  - Implicitly, the GK story relies on some degree of segmentation traditional banking business and modern business that relies on wholesale funding
  - How long can it last? (Echo the critique by Cochrane (2017) and many others)

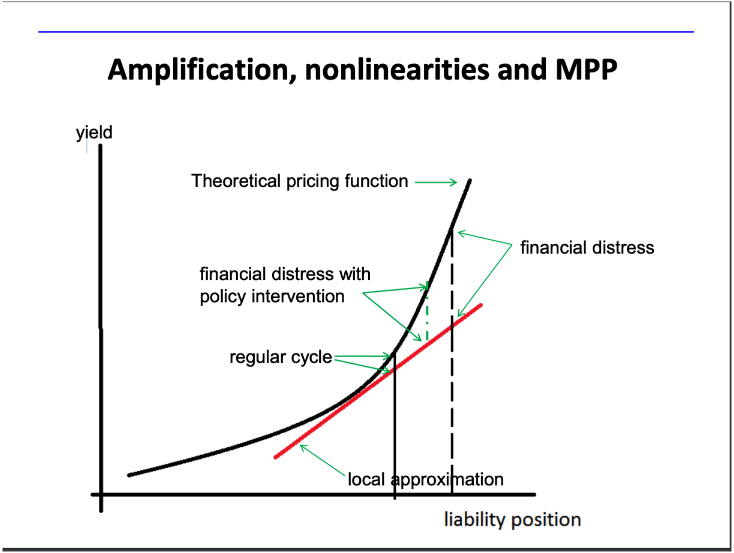
Cole's Comment (3)

- Financial intermediaries do not hedge the risk of a binding constraint enough
- Suppose the intermediaries are allowed to enter into state-contingent contracts where wealth is transferred from states when net worth is ample to states when net worth is scarce, the effect of constraints will be much dampened
- A pervasive feature of the literature
  - Rampini and Viswanathan (2010 JF) : the opportunity cost of hedging
- A related issue: why don't intermediaries accumulate net worth?
  - Ad hocly assumed in the GK model
  - Discussed in the literature, e.g., Midrigan and Xu (2014 AER) and Moll (2014 AER)

2. Nonlinear models

Gertler and Kiyotaki (2015 AER), Bianchi (2011 AER)

Nonlinearity (1)



Source: Enrique Mendoza's course lecture notes

Nonlinearity (2)

"Black swans," nonlinearities and amplification

- *"Things are not conceptually out of control, this is not some mystery black swan we don't understand and we need to rewrite all the paradigms because all the modeling is wrong.* ***If people are acting using a linear model, what looks like a ten-sigma event can actually be a two-sigma event…"***
- *"Most of the models in credit, in trading desks, in macro models do quite well locally, the problem is when you stop being locally nonlinearities are really quite large,…If you want to see what happened in AIG…they wrote a whole lot of credit default swaps…the assets underlying them went down not one shock, not two shocks, not three shocks, but over and over. Each time* ***the same size shock is going to create something even larger…"***

R. Merton, *"Observations on the Science of Finance in the Practice of Finance,"* (Muh Award Lecture, 03/05/2009)

Source: Enrique Mendoza's course lecture notes

Gertler and Karadi (2011) and Model Nonlinearity

- Why nonlinear models?
  - Financial crises: small primitive shocks lead to large crisis
  - Depending on the state of the economy
- GK(2011): can potentially be nonlinear due to the occasionally binding feature of the constraint, but quantitatively not so much
- Introduce two nonlinear models
  - Gertler and Kiyotaki (2015, AER) bank runs
  - Bianchi (2011, AER) quantitative model with occasionally binding constraint

Bank Runs in Macroeconomic Models

- In all the previous analysis, bank deposits are free of default
  - Natural specification for retail deposits with deposit insurance
  - Not for wholesale funding
- Bank run is a natural feature to generate nonlinear dynamics
- How to embed bank run insights into a macroeconomic model?
  - Self-fulfilling runs: Diamond-Dybvig (1983)
  - Fundamental-based runs: Calomeris and Gorton (1991)
- Gertler and Kiyotaki (2015, AER) the first to model bank run under standard macro framework and nest both views

Gertler and Kiyotaki (2015 AER)

- Two types of agents (households, bankers), each with unity measure
- Bankers are specialists in making loans
- Households can also make loans but less efficient by paying cost $f(K_t^h) = \frac{\alpha}{2}(K_t^h)^2$
- Fix total capital, which can be owned by banks and households

$$K^b + K^h = \bar{K} \equiv 1$$

- Production function $Y_t^i = Z_t K_t^i, (i = h, b)$

Households

- Households can choose to deposit into banks or hold capital directly
- Endowment $Z_t W^h$
- Deposit return $\bar{R}_{t+1}$ if the bank does not run and $x_{t+1}\bar{R}_{t+1}$ if the bank runs, where $\bar{R}_{t+1}$ is the contractual return and x_{t+1} is the recovery rate
  - A key difference with Diamond and Dybvig: depositors receive the same pro rata share of assets, no sequential service constraint
  - Why bank run? Due to the presence of collateral constraint

Household Optimization Problem

$$\max E_t \sum_{i=0}^{\infty} \beta^i \ln C_{t+i}^h$$

$$s.t.: C_t^h + D_t + Q_t K_t^h + f(K_t^h) = Z_t W^h + R_t D_{t-1} + (Z_t + Q_t) K_{t-1}^h$$

Two Euler equations

$$E_t M_{t,t+1} R_{t+1} = 1$$

$$E_t M_{t,t+1} R_{t+1}^h \leq 1$$

where $R_{t+1}^h = \frac{Z_{t+1} + Q_{t+1}}{Q_t + f'(K_t^h)}$. The second Euler equation holds with equality if $K_t^h = 0$

Banks

- Each bank is run by a banker and bankers have their own consumption and utility
  - Different from the previous model that banks are ultimately owned by households
  - Banks take deposits and purchase capital subject to a friction similar to GK (2011) that the franchise value of the bank cannot be less than θ fraction of total asset and each period the exit prob is σ
  - Bankers have linear utility and new bankers every period has endowment w^b
  - The exiting bankers consume the net worth $c_t^b = n_t$

Bankers' Problem

$$V(n_t; N_t, Z_t) = \max_{d_t, k_t^b} E_t M_{t+1} \left[(1-\sigma) n_{t+1} + \sigma V(n_{t+1}; N_{t+1}, Z_{t+1}) \right]$$

$$s.t.: n_t + d_t = Q_t k_t^b = (Z_t + Q_t) k_{t-1}^b - R_t d_{t-1}$$

$$V_t \geq \theta Q_t k_t^b$$

Equilibrium

- Aggregate balance sheet of the banks

$$Q_t K_t^b = D_t + N_t$$

$$N_t = \sigma \left[(Z_t + Q_t) K_{t-1}^b - R_t D_{t-1} \right] + W^b$$

- Consumption

$$C_t^b = (1 - \sigma) \left[(Z_t + Q_t) K_{t-1}^b - R_t D_{t-1} \right]$$

- Market clearing

$$Y_t = Z_t + Z_t W^h + W^b = C_t^h + C_t^b + f(K_t^h)$$

Unanticipated Bank Runs

- An MIT shock: when agents make decisions, they think the bank will never run so the decisions are based on a risk-free rate for deposit (easier to analyze)
- The condition for bank run

$$(Z_t + Q_t)K_{t-1}^b - D_t R_t \leq 0$$

  - This is generally not right in standard corporate finance models: we should compare the value function of defaulting and not defaulting
  - Here the constraint plays the key role: if $n_t = 0$, there is no collateral and banks receive no funding
  - If banks run (systematically), households have to hold capital
- The price of capital depends on who holds the capital, which creates room for multiple equilibria

Self-Fulfilling Bank Runs

- There are two possible capital prices, run price $\underline{Q}$ and Q if banks do not run where

$$\underline{Q} = E_t\left[\sum_{i=1}^{\infty} M_{t,t+i}(Z_{t+i} - f'(K_{t+i}^h))\right] - \alpha$$

  is the capital price if all capital is held by the households
- Bank runs are self-fulfilling if

$$(Z_t + Q_t)K_{t-1}^b - D_{t-1}R_t \geq 0, (Z_t + \underline{Q}_t)K_{t-1}^b - D_{t-1}R_t \leq 0$$

- If households perceive banks will not run, they provide funding to banks and the capital price is Q_t
- If households perceive banks will run, they don't provide funding to banks and the capital price is $\underline{Q}_t$

Two Views of Bank Runs

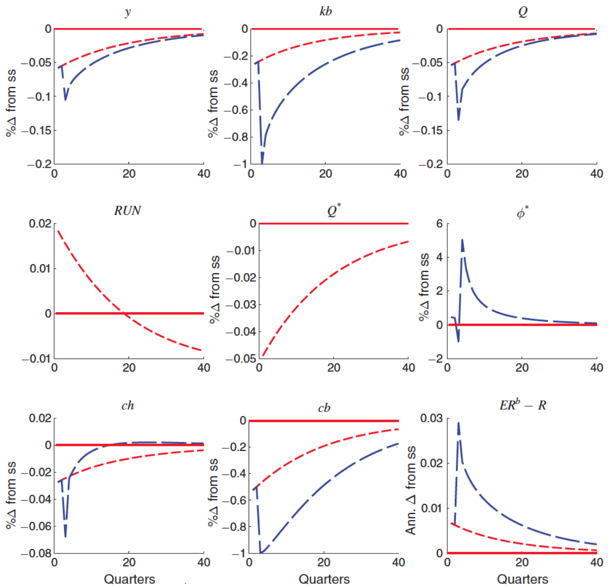
- Self-fulfilling view: Bank run or not depends on perceptions
  - The mechanism of "run" is different from Diamond and Dybvig, in which sequential withdrawal triggers the run
  - In this model, it is the collateral constraint that triggers the run
- Fundamental-based view: bank runs or not depends on the fundamental Z_t
  - Z_t determines the threshold of the three regimes
- The role of leverage: the higher the leverage, the easier bank run will happen
- Bank run in this model is a **systematic** one, i.e., all banks in the economy run

Parameters

TABLE 1—PARAMETERS

		Baseline model
β	0.99	Discount rate
σ	0.95	Bankers survival probability
θ	0.19	Seizure rate
α	0.008	Household managerial cost
ρ	0.95	Serial correlation of productivity shock
Z	0.0126	Steady state productivity
ω^b	0.0011	Bankers endowment
ω^h	0.045	Household endowment

Impulse Responses



Anticipated Bank Runs

- When bank runs are anticipated, the deposit rate will be higher
- Banks will take the higher cost of deposit into consideration and reduce their balance sheet size
- *When banks choose their leverage, how much do they consider the impact of leverage choice on run probability?*

Deposit Rate

- Since households face the risk that their deposits may not be repaid, the deposit rate is no longer a risk-free rate
- Household Euler equation (full-fledged case)

$$\underbrace{\int_0^{Z_{t+1}^1} M_{t+1} \frac{Z_{t+1} + \underline{Q}_{t+1}}{Q_t} dF(Z)}_{\text{run for sure}} + \underbrace{\int_{Z_{t+1}^1}^{Z_{t+1}^2} \xi \frac{Z_{t+1} + \underline{Q}_{t+1}}{Q_t} dF(Z)}_{\text{self-fulfilling run}}$$

$$+ \underbrace{\int_{Z_{t+1}^1}^{Z_{t+1}^2} (1-\xi) R_{t+1} dF(Z)}_{\text{self-fulfilling not run}} + \underbrace{\int_{Z_{t+1}^2}^{\infty} R_{t+1} dF(Z)}_{\text{not run for sure}} = 1$$

- When in the self-fulfilling region, whether to run or not is determined by a sunspot - prob ξ to run
- R_{t+1} is the contractual deposit rate
- Z_{t+1}^1 and Z_{t+1}^2 are the cutoffs to the three regimes

A Short-cut

- In principle, the cutoffs are endogenous and depends on R_{t+1} and they in turn determine R_{t+1}
- This paper takes a shortcut: assign p_t the probability of run where

$$1 = \bar{R}_{t+1} E_t \left[(1 - p_t) M_{t,t+1} + p_t M_{t,t+1} x_{t+1} \right]$$

and x_{t+1} is defined as recovery rate

$$x_{t+1} = \min \left[1, \frac{(Q^*_{t+1} + Z_{t+1}) k^b_t}{\bar{R}_{t+1} d_t} \right]$$

Assume that p_t is a decreasing function of $E_t x_{t+1}$:

$$p_t = 1 - E_t x_{t+1} \text{ if } E_t(x_{t+1}) < 1$$

Recession Due to Anticipation of Bank Runs

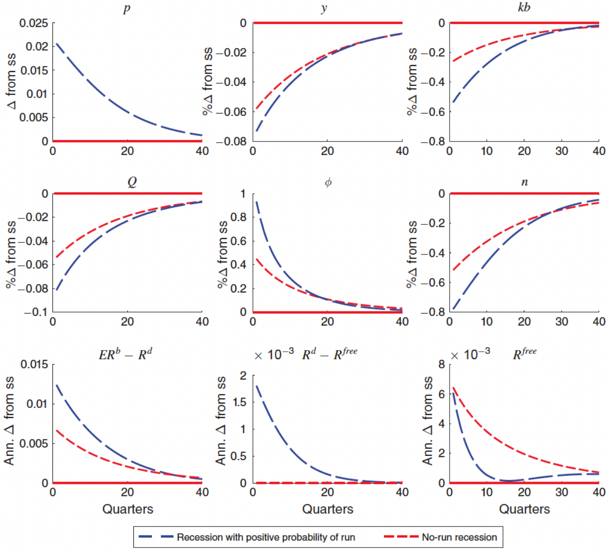
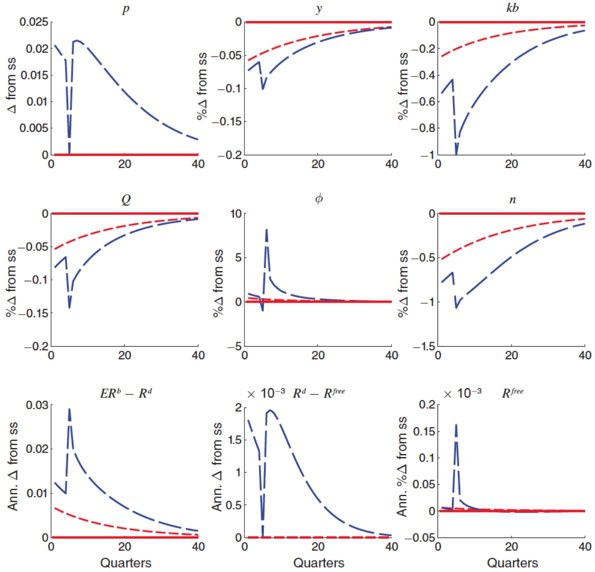


FIGURE 5. RECESSION WITH POSITIVE PROBABILITY OF A RUN

Anticipated Runs



Financial Policies

- Capital requirement/leverage restriction
- Lender of last resort: preventing runs
- A more full-fledged analysis: Gertler, Prestipino and Kiyotaki (2019, RES)

Bianchi (2011, AER)

- A canonical open economy model with
  - Incomplete financial market
  - Price-dependent collateral constraint
  - Currency mismatch
  - Quantitative analysis of macroprudential policies

Small Open Economy

- The small open economy consumes two goods, tradable and nontradable aggregated as

$$c_t = \left[\omega(c_t^T)^{-\eta} + (1-\omega)(c_t^N)^{-\eta}\right]^{-\frac{1}{\eta}}$$

- Utility maximization

$$\max_{c_t^T, c_t^N} E_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$$

$$c_t^T + b_{t+1} + p_t^N c_t^N = b_t(1+r) + y_t^T + p_t^N y_t^N$$

$$b_{t+1} \geq -(\kappa^N p_t^N y_t^N + \kappa^T y_t^T)$$

- Borrowing is denominated in tradable good and interest rate is r
- Note that $\beta(1+r) < 1$

Collateral Constraint

- The collateral constraint specified the borrowing limit as a function of the income
- The price of nontradable good (real exchange rate) enters into the borrowing limit
- The effect of the collateral constraint
  - Limit borrowing when it actually binds
  - Change borrowers' precautionary behavior by borrowing less

Pecuniary Externality

- When the borrowing constraint is price dependent, the decentralized equilibrium is not constrained optimal
- The private agents fail to consider their decision's effect on the real exchange rate (both today and tomorrow), while a government takes this into consideration
- Theoretical argument made by Lorenzoni (2008, RES), a simple model illustration in Erten et al (2020,JEL)
- Room for government macroprudential policies

Optimality Conditions

$$\lambda_t = u_T(t)$$

$$p_t^N = \left(\frac{1-\omega}{\omega}\right)\left(\frac{c_t^T}{c_t^N}\right)^{1+\eta}$$

$$\lambda_t = \beta(1+r)E_t\lambda_{t+1} + \mu_t$$

$$b_{t+1} + \left(\kappa^N p_t^N y_t^N + \kappa^T y_t^T\right) \geq 0$$

The last equation holds with equality if $\mu_t > 0$. Note that $c_t^N = y_t^N$ and therefore the market clearing condition is

$$c_t^T = y_t^T + b_t(1+r) - b_{t+1}$$

Social Planner's Problem

$$V(b,y) = \max_{b',c^T} u(c(c^T, y^N)) + \beta EV(b', y')$$

$$s.t.: b' + c^T = y^T + b(1+r)$$

$$b' \geq -\left(-\kappa^N \frac{1-\omega}{\omega}\left(\frac{\mathbf{c^T}}{\mathbf{y^N}}\right)^{\eta+\mathbf{1}} y^N + \kappa^T y^T\right)$$

Two Euler equations

$$\lambda_t^{sp} = u_T(t) + \mu_t^{sp}\Psi_t$$

$$\lambda_t^{sp} = \beta(1+r)E_t\lambda_{t+1}^{sp} + \mu_t^{sp}$$

where $\Psi_t = \kappa^N(p^N c^N)/c^T(1+\eta)$, indicating how much the collateral value changes in equilibrium in response to a change in tradable consumption.

- Key difference: when the social planner chooses c^T, she takes into account its effect on p^N while the private agents are price takers

Macroprudential Policy

$$u_T(t) = \beta(1 + r)(1 + \tau_t)E_t u_T(t + 1) + \mu_t$$

Solve for τ_t using the social planner's solution. See Appendix A of the paper for derivation. The optimal tax implements the constrained efficient allocation.

Solution Method

- Cannot solve in dynare, occasionally binding constraint
- The precautionary behavior due to the constraint is important (not Occbin)
- Solved by policy function iteration
  - Create state space and construct Markov chain for y
  - Conjecture solution $c_k(b, y), b_k^{'}(b, y)$, solve for $p_k^N(b, y)$
  - Assume the constraint binds, calculate $b_{k+1}^{'}(b, y)$ and $c_{k+1}(b, y)$
  - Assuming time $t+1$ consumption rule follows k conjecture, calculate $E_y[u_T(c_k^B(b_k^{'}(b, y), y'))]$. Note $b_k^{'}(b, y)$ may not be on the grid, need interpolation
  - Check whether the constraint binds by comparing $u_T((c_{k+1}(b, y)))$ and $E_y[u_T(c_k^B(b_k^{'}(b, y), y'))]$. If difference > 0, the constraint binds and keep $c_{k+1}(b, y)$. Otherwise, replace $c_{k+1}(b, y)$ by solution to the Euler equation with $\mu = 0$
  - Calculate $b_{k+1}^{'}(b, y)$ and $p_{k+1}^N(b, y)$
  - Stop if the k-th iteration and $k+1$-th iteration is close enough
- More materials, see Enrique Mendoza's website

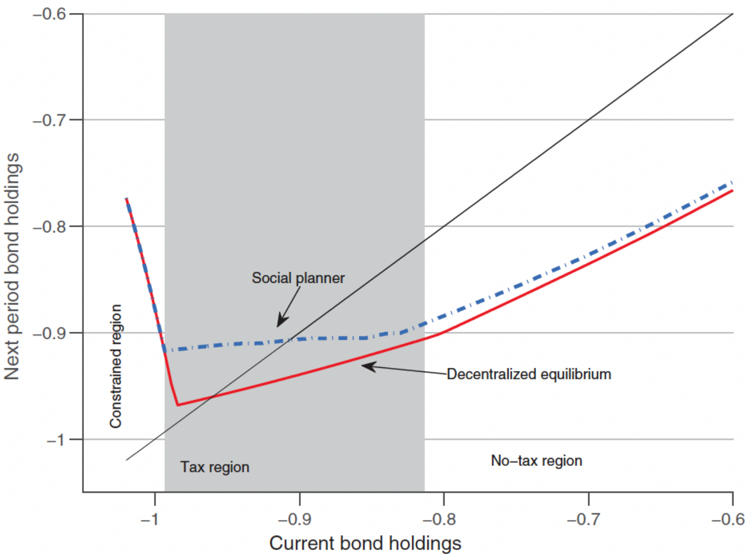
Calibration

TABLE 1—CALIBRATION

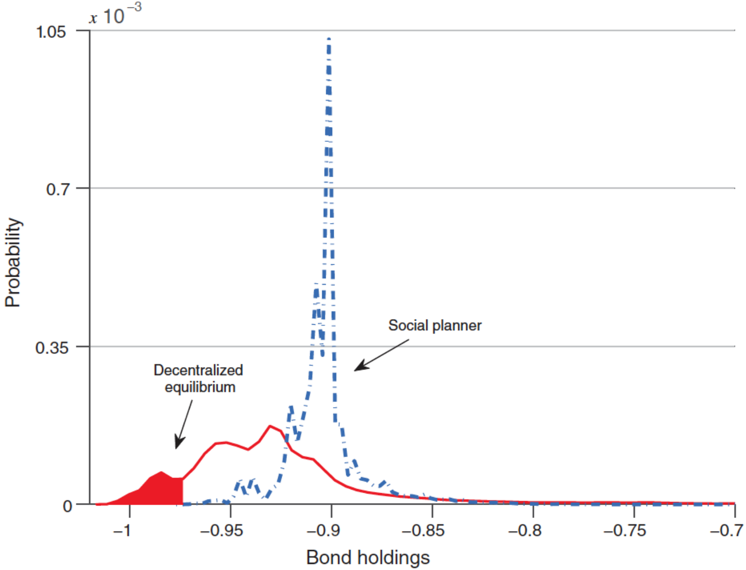
	Value	Source/target
Interest rate	$r = 0.04$	Standard value DSGE-SOE
Risk aversion	$\sigma = 2$	Standard value DSGE-SOE
Elasticity of substitution	$1/(1 + \eta) = 0.83$	Conservative value
Stochastic structure	See text	Argentina's economy
Relative credit coefficients	$\kappa^N/\kappa^T = 1$	Baseline value
Weight on tradables in CES	$\omega = 0.31$	Share of tradable output=32 %
Discount factor	$\beta = 0.91$	Average NFA-GDP ratio = −29 %
Credit coefficient	$\kappa^T = 0.32$	Frequency of crisis = 5.5 %

The output processes are estimated directly from the data.

Decision Rule



Ergodic Distribution of Debt



Financial Crisis

Table 2—Severity of Financial Crises

	Decentralized equilibrium	Social planner
Consumption	−16.7	−10.1
Current account-GDP	7.8	0.0
Real exchange rate depreciation	19.2	1.1

Note: Consumption and real exchange rate depreciation represent responses on impact expressed as percentage deviations from averages in the corresponding ergodic distribution.

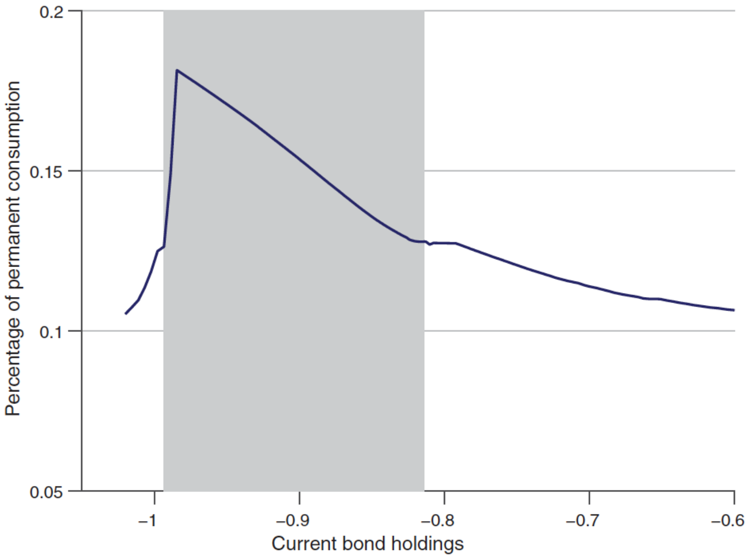
Business Cycles

TABLE 3— SECOND MOMENTS

	Decentralized equilibrium	Social planner	Data
Standard deviations			
Consumption	5.9	5.3	6.2
Real exchange rate	7.5	3.4	8.2
Current account-GDP	2.8	0.6	3.6
Trade balance-GDP	2.9	0.6	2.4
Correlation with GDP in units of tradables			
Consumption	0.83	0.86	0.88
Real exchange rate	0.79	0.44	0.41
Current account-GDP	−0.76	−0.05	−0.63
Trade balance-GDP	−0.77	−0.16	−0.84

Notes: Data are annual from WDI for Argentina from 1965–2007. The real exchange rate is calculated as $\left[\omega^{1/(1+\eta)} + (1-\omega)^{1/(1+\eta)}\left(p^N\right)^{\eta/(1+\eta)}\right]^{-(1+\eta)/\eta}$ and is measured empirically using value added deflators.

Welfare Gains



Other Nonlinear Models

- Information acquisition: Gorton and Ordonez (2014, AER)
- Brunnermeier and Sannikov (2014, AER)
- He and Krishnamurthy (2013, AER)
- ...

3. Intermediary asset pricing theory

He and Krishnamurthy (2020 ARFE)

He and Krishnamurthy (2020 ARFE)

- A simplified static model to deliver the insight of intermediary asset pricing
- Nest implications for further empirical work
- Highlight the asset pricing implications

Setup

- Two sectors: an intermediary sector and a household sector
- Households do not directly invest in "intermediated" assets, but delegate investments to the intermediary sector
- Delegation is frictional, to be specified later

Investors' Preference

- Two period, $t = 0, 1$, dividend payout at $t = 1$
- $\tilde{D} \sim N(\mu, \sigma^2)$, exogenous interest rate $1 + r$ and aggregate supply of risky asset θ
- Two classes of agents, intermediary managers (M) and households (H), both CARA

  $$u_i(W_1^i) = -\exp\left(-\frac{W_1^i}{\rho_i}\right)$$

  ρ_M, ρ_H are the risk tolerance of managers and households
- Households cannot directly invest in the market for the risky asset - create scope for intermediation
- Households give some of the wealth to intermediary managers who invest in the risky asset **on their behalf**
  - When households delegate investment to specialists, their exposure is determined by the contract
  - GK: banks bear all risks

The Delegation Friction

- A manager in the intermediary chooses the quantity of risky assets to buy x_F and a due diligence decision $s \in \{0, 1\}$
  - Shirk $s = 0$: intermediary return falls by Δ, manager gets a private benefit of b
  - A profit-sharing contract (K, ϕ)
    - ϕ: linear share of the return paid to the intermediary manager
    - K: management fee paid to the managers (set $K = 0$ without loss of generality)
  - Contractual foundation: He and Krishnamurthy (2012 RES)

Intermediary Managers' Optimization Problem

Given the contract ϕ, the intermediary manager maximizes

$$\max_{x_F, s} E\left\{-\exp\left(-\frac{1}{\rho_M}\left[\phi\left(x_F(\tilde{D}-(1+r)p)-s\Delta\right)+sb\right]\right)\right\}$$

Assume $s=1$, the solution is

$$x_F = \rho_M \frac{\mu - p(1+r)}{\phi\sigma^2}$$

Households hold

$$x_H = \rho_M \frac{1-\phi}{\phi} \frac{\mu - p(1+r)}{\sigma^2}$$

The Unconstrained Case

Suppose there is no constraint, the optimal portfolio of households is

$$x_H = \rho_H \frac{\mu - p(1+r)}{\sigma^2}$$

When households choose the contract, they will target at the first-best, i.e.

$$\phi = \frac{\rho_M}{\rho_H + \rho_M}$$

The Constraint

- With ϕ and x_F, the manager effectively holds $x_M = \phi x_F$ risky asset, and the households hold the rest $x_H = (1 - \phi)x_F$
- The cost of shirking to the intermediary $\phi\Delta$, the benefit b
- To induce $s = 1$, the incentive compatibility condition

$$\phi\Delta \geq b$$

Equity Interpretation

- Effective holdings interpreted in terms of financing
  - For each ϕ dollars the manager puts in, the household investor puts in $1-\phi$ dollars
  - Profit sharing based on equity share
- The constraint is written as

$$\phi \geq \frac{b}{\Delta} \equiv \frac{1}{1+m}$$

- m: households' max willingness to contribute given every dollar of specialist's contribution

The Constrained Case

- If $\frac{\rho_M}{\rho_H+\rho_M} \leq \frac{1}{1+m}$, the first-best is not achievable
- Households have to choose $\phi = \frac{1}{1+m}$
- If m suddenly drops, the constraint will bind
- If the specialist's risk aversion ρ_M suddenly drops, the constraint will bind

Equilibrium Asset Prices

- If the constraint does not bind, $m \geq \frac{\rho_H}{\rho_M}$, $\phi = \frac{\rho_M}{\rho_M + \rho_H}$. Market clearing implies

$$p = \frac{\mu}{1+r} - \frac{\theta\sigma^2}{(1+r)(\rho_M + \rho_H)}$$

- If the constraint binds, $m < \frac{\rho_H}{\rho_M}$, $\phi = \frac{1}{1+m}$. Market clearing implies

$$p = \frac{\mu}{1+r} - \frac{\theta\sigma^2}{(1+r)(1+m)\rho_M}$$

Constraint Narrative

- Investors in the market have their appetite for risky assets, but some do not have the skills (households)
- Households have to dump their risy assets when the intermediary friction is severe (they cannot delegate, otherwise specialists will shirk), so that these intermediated risky asset prices drop sharply

Intermediation Shocks: m

- If m decreases unexpectedly
  - Only matters if it triggers the constraint to bind
  - Asset prices drop sharply
  - Nonlinearity: the defining feature
- Interpretations: complexity (information), panic, moral hazard, etc

Intermediation Shocks: Wealth

Wealth shock has no effect with CARA preference

- From CARA to CRRA: the risk tolerance depends on the wealth, $\frac{1}{\rho_M} = \frac{\gamma}{W_M}$, so that a drop in W_M decreases the risk tolerance of the managers
- A drop in W_M lowers asset prices through multiple channels
  - If the constraint does not bind, increased risk aversion of managers lower asset prices
  - The cutoff for the constraint to bind increases with a lower ρ_M, and the constraint is more likely to bind
- A feedback loop between W_M and asset price - absent here, need a dynamic model, generate stronger nonlinearity

Multiple Assets and Households

- Consider two assets, $j = 1, 2$

$$\tilde{D}_j \sim N(\mu_j, \sigma_j^2), cov(\tilde{D}_1, \tilde{D}_2) = 0$$

- Households can directly invest in asset 2, but must invest through intermediaries for asset 1
- Introduce sophisticated investors with CARA risk tolerance ρ_S that can fully participate in all asset markets

Equilibrium Asset Prices with Binding Equity Constraint

- Independent return makes the portfolio choice for two assets separate
- Equilibrium asset price

$$p_1 = \frac{\mu}{1+r} - \frac{\theta_1 \sigma_1^2}{1+r} \frac{1}{(1+m)\rho_M + \rho_S}$$

$$p_2 = \frac{\mu}{1+r} - \frac{\theta_2 \sigma_2^2}{1+r} \frac{1}{\rho_H + \rho_M + \rho_S}$$

- One potential way to test intermediary asset pricing theory
  - If there are two assets, one intermediated (asset 1) and ther other not (asset 2)
  - The price of asset 1 should drop more than asset 2 with a shock in m or ρ_M
  - The basis of Haddad and Muir (2021, JF)
  - **The role of correlation and cross-asset return predictability?**

Euler Equation: $E(R_i^e) = \beta_i \lambda$

- Take the two-asset solution, and recast the expected return into $\beta\lambda$ form
- The risk factor: wealth of the intermediary $\tilde{W}_{1M}$
- The expected return of asset i

$$\mu_i - (1+r)p_i = \beta_i \lambda_M, \beta_i = \frac{cov(\tilde{W}_{1M}, \tilde{D}_i)}{var(\tilde{W}_{1M})}$$

- The price of risk equals the manager's absolute risk aversion $\times$ variance of manager's wealth
- Note: not only asset 1 satisfies the Euler equation, asset 2 as well, although it is not forced to be intermediated

Regulation

Discuss regulatory constraint in this framework

- Equity constraint

$$E_F \leq W_M(1+m)$$

- Regulatory constraint L incidates other assets such as loans

$$k_x \times px_F + k_L \times x_L \leq E_F$$

- Regulatory constraint binds only if the equity constraint binds, so that the intermediary cannot raise more equity
  - In the banking (corporate finance) literature, sticky equity issuance is a stylized fact and a common assumption (e.g.,pecking order theory)

What is Intermediary Asset Pricing Really About?

- Note that intermediary SDF prices all assets no matter whether the intermediary constraint binds or not
  - The wealth of the sophisticated investor also prices all assets, but not households
- The real bite: β_1^M versus β_2^M - more intermediated assets should have higher β with respect to intermediary wealth
- Intermediary asset pricing is a **joint hypothesis**: intermediary wealth prices the cross-section of assets, but the household wealth does not

4. Empirical advances in intermediary asset pricing

He, Kelly, and Manela (2017, JFE), Muir (2017, QJE), Haddad and Muir (2021, JF)

A broad review of macro-finance: Cochrane (2017, RF)

How to Take the Intermediary AP Theory to the Data?

- Who are the intermediaries?
- How to measure intermediaries' marginal value of wealth?

He, Kelly and Manela (2017,JFE)

- Intermediaries: primary dealers
  - Counterparties of NY Fed when conducting monetary policy
- Measuring merginal value of wealth: intermediary capital ratio

$$\eta_t = \frac{\sum_i \text{Market Equity}_{i,t}}{\sum_i \left(\text{Market Equity}_{i,t} + \text{Book Debt}_{i,t}\right)}$$

- Need to assess the appropriateness of the definition
- Gap between theory and data
  - Theory: intermediary's wealth share (of total wealth)
  - Data: intermediary's capital over assets - positively correlated

Primary Dealers

Primary Dealer	Start Date	End Date	Primary Dealer	Start Date	End Date
ABN Amro	9/29/1998	9/15/2006	HSBC	5/9/1994	Current
Aubrey Lanston	5/19/1960	4/17/2000	Hutton	11/2/1977	12/31/1987
BA Securities	4/18/1994	9/30/1997	Irving	5/19/1960	7/31/1989
Banc One	4/1/1999	8/1/2004	Jefferies	6/18/2009	Current
Bank of America	5/17/1999	11/1/2010	JP Morgan	5/19/1960	Current
Bank of America	11/17/1971	4/15/1994	Kidder Peabody	2/7/1979	12/30/1994
Bank of Nova Scotia	10/4/2011	Current	Kleinwort Benson	2/13/1980	12/27/1989
Bankers Trust	5/19/1960	10/22/1997	Lehman	11/25/1976	9/22/2008
Barclays	4/1/1998	Current	Lehman	2/22/1973	1/29/1974
Barclays De Zoete Wedd	12/7/1989	6/30/1996	LF Rothschild	12/11/1986	1/17/1989
Bartow Leeds	5/19/1960	6/14/1962	Lloyds	12/22/1987	4/28/1989
Bear Stearns	6/10/1981	10/1/2008	Malon Andrus	5/19/1960	11/24/1965
Becker	11/17/1971	9/10/1984	Manufac. Hanover	8/31/1983	12/31/1991
Blyth	4/16/1962	1/14/1970	Merrill Lynch	5/19/1960	2/11/2009
Blyth Eastman Dillon	12/5/1974	12/31/1979	Merrill Lynch	11/1/2010	Current
BMO	10/4/2011	Current	MF Global	2/2/2011	10/31/2011
BMO Nesbitt	2/15/2000	3/31/2002	Midland-Montagu	8/13/1975	7/26/1990
BNP Paribas	9/15/2000	Current	Mizuho	4/1/2002	Current
BNY	8/1/1989	8/9/1990	Morgan Stanley	2/1/1978	Current
Brophy, Gestal, Knight	5/8/1987	6/19/1988	NationsBanc	7/6/1993	5/16/1999
BT Alex Brown	10/23/1997	6/4/1999	Nesbitt Burns	6/1/1995	2/14/2000
BZW	7/1/1996	3/31/1998	Nikko	12/22/1987	1/3/1999
Cantor Fitzgerald	8/1/2006	Current	Nomura	12/11/1986	11/30/2007
Carroll McEntee	9/29/1976	5/6/1994	Nomura	7/27/2009	Current
CF Childs	5/19/1960	6/29/1965	Northern Trust	8/8/1973	5/29/1986
Chase	7/15/1970	4/30/2001	Nuveen	11/18/1971	8/27/1980
Chemical	5/19/1960	3/31/1996	NY Hanseatic	2/8/1984	7/26/1984
CIBC	3/27/1996	2/8/2007	Paine Webber	11/25/1976	12/4/2000
Citigroup	6/15/1961	Current	Paine Webber	6/22/1972	6/27/1973
Continental	5/19/1960	8/30/1991	Paribas	5/1/1997	9/14/2000
Country Natwest	9/29/1988	1/13/1989	Pollock	5/19/1960	2/3/1987
Countrywide	1/15/2004	7/15/2008	Prudential	10/29/1975	12/1/2000
Credit Suisse	10/12/1993	Current	RBC	7/8/2009	Current
CRT	12/22/1987	7/5/1993	RBS	4/1/2009	Current
Daiwa	12/11/1986	Current	REFCO	11/19/1980	5/7/1987
Dean Witter Reynolds	11/2/1977	4/30/1998	Robertson Stephens	10/1/1997	9/30/1998
Deutshe Bank	12/13/1990	Current	Salomon Smith Barney	5/19/1960	4/6/2003
Dillon Read	6/24/1988	9/2/1997	Sanwa	6/20/1988	7/20/1998
Discount Corp.	5/19/1960	8/10/1993	SBC	3/29/1990	6/28/1998
DLJ	3/6/1974	1/16/1985	Second District	6/15/1961	8/27/1980
DLJ	10/25/1995	12/31/2000	Securities Groups	5/19/1960	6/5/1983
Dresdner Kleinwort	5/8/1997	6/26/2009	Security Pacific	12/11/1986	1/17/1991
Drexel Burnham	5/19/1960	3/28/1990	SG Americas	2/2/2011	Current
DW Rich	5/19/1960	12/31/1969	SG Cowen	7/1/1999	10/31/2001
Eastbridge	6/18/1992	5/29/1998	SG Warburg	6/24/1988	7/26/1995
FI Dupont	12/12/1968	7/18/1973	Smith Barney	8/22/1979	8/31/1998
First Boston	5/19/1960	10/11/1993	Souther Cal. S&L	6/7/1983	8/5/1983
First Chicago	5/19/1960	3/31/1999	TD	2/11/2014	Current
First Interstate	7/31/1964	6/17/1988	Thomson McKinnon	12/11/1986	7/7/1989
First N.B. of Boston	3/21/1983	11/17/1985	UBS	12/7/1989	Current
First Pennco	3/7/1974	8/27/1980	Weeden	6/17/1976	5/15/1978
Fuji	12/28/1989	3/31/2002	Wertheim Schroder	6/24/1988	11/8/1990
Goldman Sachs	12/4/1974	Current	Westpac Pollock	2/4/1987	6/27/1990
Greenwich	7/31/1984	4/1/2009	White Weld	2/26/1976	4/18/1978
Harris	7/15/1965	5/31/1995	Yamaichi	9/29/1988	12/4/1997
			Zions	8/11/1993	3/31/2002

Table A.1: **Primary Dealers, 1960–2014**
The New York Federal Reserve Bank's list of primary dealers. We have condensed the list slightly by combining entries that differ due to name changes but maintain continuity in primary dealer role, most commonly due to the dealer acquiring another firm. However, we continue to list acquisition targets or merged entities separately for the period that they appear on the dealer list prior to acquisition.

A Two-factor Model

$$\Lambda_t = e^{-\rho t}(W_t^I)^{-\gamma} = e^{-\rho t}(\eta_t W_t)^{-\gamma}$$

- Return to aggregate wealth: capture TFP-type shock
- Intermediary capital ratio: capture financial shock
  - Shock to m: intermediation disruption

Intermediary Capital Ratio

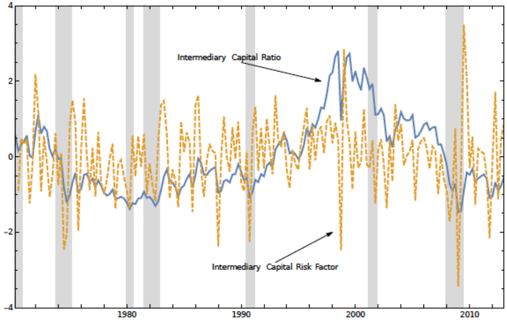


Figure 1: **Intermediary Capital Ratio and Risk Factor**
Intermediary capital risk factor (dashed line) is AR(1) innovations to the market-based capital ratio of primary dealers (solid line), scaled by the lagged capital ratio. Both time-series are standardized to zero mean and unit variance for illustration. The quarterly sample is 1970Q1–2012Q4. The intermediary capital ratio is the ratio of total market equity to total market assets (book debt plus market equity) of primary dealer holding companies. Shaded regions indicate NBER recessions.

- Procyclical capital ratio

Test Assets

- Expand to stocks, governmennt bonds, CDS, corporate bonds, options, commodities, FX, and sovereign bonds
  - A more powerful test of asset pricing models
  - More and more used in empirical asset pricing

Cross-Sectional Test

	FF25	US bonds	Sov. bonds	Options	CDS	Commod.	FX	All
Capital	6.88	7.56	7.04	22.41	11.08	7.31	19.37	9.35
	(2.16)	(2.58)	(1.66)	(2.02)	(3.44)	(1.90)	(3.12)	(2.52)
Market	1.19	1.42	1.24	2.82	1.11	-0.55	10.14	1.49
	(0.78)	(0.82)	(0.32)	(0.67)	(0.41)	(-0.25)	(2.17)	(0.80)
Intercept	0.48	0.41	0.34	-1.11	-0.39	1.15	-0.94	-0.00
	(0.36)	(1.44)	(0.33)	(-0.31)	(-2.77)	(0.83)	(-0.83)	(-0.00)
R^2	0.53	0.84	0.81	0.99	0.67	0.25	0.53	0.71
MAPE, %	0.34	0.13	0.32	0.14	0.18	1.15	0.44	0.63
MAPE-R, %	0.40	0.26	0.45	0.68	0.39	1.40	0.62	0.63
RRA	2.71	3.09	2.52	8.90	3.61	2.88	8.26	3.69
Assets	25	20	6	18	20	23	12	124
Quarters	172	148	65	103	47	105	135	172

Table 5: **Cross-sectional Asset Pricing Tests by Asset Class**

Risk price estimates for shocks to the intermediary capital ratio and the excess return on the market. The capital ratio is defined as the ratio of total market equity to total market assets (book debt plus market equity) of primary dealer holding companies. Risk prices are the mean slopes of period-by-period cross-sectional regressions of portfolio excess returns on risk exposures (betas), reported in percentage terms. Betas are estimated in a first-stage time-series regression. The quarterly sample is 1970Q1–2012Q4. Mean absolute pricing error (MAPE) is in percentage terms. MAPE-R uses a restricted model which restricts the risk prices (λs) to be the same in all asset classes, as in the last column. Relative risk aversion (RRA) is implied by the price of intermediary capital risk factor and the factors covariance matrix. GMM t-statistics in parentheses adjust for cross-asset correlation in the residuals and for estimation error of the time-series betas.

Price of Risk

- A **consistent** estimate across asset classes (around 9 percent)
- Quite large price of risk: 9.35 percent per quarter: one sd (0.11) increase in beta leads to a $0.11 \times 9.35 \times 4 = 4.11$ percent in annual risk premium
- Positive price of intermediary capital risk

Is It A Sideshow of some Known Factors?

Benchmark:	CAPM	FF3F	FF5F	Momentum	PS-liquidity	LMW
Capital	9.35	9.14	8.81	9.69	7.87	7.56
	(2.52)	(1.98)	(2.46)	(2.84)	(1.75)	(1.76)
Market	1.49	1.62	1.33	1.54	1.21	
	(0.80)	(0.90)	(0.74)	(0.81)	(0.69)	
SMB		0.39	0.59			
		(0.42)	(0.68)			
HML		2.23	2.01			
		(1.36)	(1.46)			
CMA			-0.33			
			(-0.09)			
RMW			0.08			
			(0.04)			
MOM				-1.20		
				(-0.14)		
PS^{nt}					5.71	
					(0.64)	
LMW^{-}						0.77
						(0.58)
LMW						0.63
						(0.31)
Adj. R^2	0.71	0.80	0.69	0.73	0.67	0.70
MAPE, %	0.63	0.65	0.62	0.61	0.59	0.63
RRA	3.69	3.32	3.50	3.74	2.61	2.58
Assets	124	124	124	124	124	124
Quarters	172	172	172	172	172	172
Adj. R^2 w/o Capital	0.32	0.65	0.65	0.27	0.67	0.50
MAPE w/o Capital	0.85	0.86	0.82	0.85	0.83	0.87

Table 6: **Comparison with Commonly-used Pricing Factors**
Risk price estimates for shocks to the intermediary capital ratio and the excess return on the market, controlling for commonly used benchmark pricing factors. All test portfolios are included in all columns. The capital ratio is defined as the ratio of total market equity to total market assets (book debt plus market equity) of primary dealer holding companies. The Fama and French factors Small Minus Big (SMB), High Minus Low (HML), Conservative Minus Aggressive (CMA), Robust Minus Weak (RMW), and the momentum factor (MOM) are from Ken French's website. The non-traded Pástor and Stambaugh liquidity factor (PS^{nt}) is from L'uboš Pástor's website. Risk prices are the mean slopes of period-by-period cross-sectional regressions of portfolio excess returns on risk exposures (betas), reported in percentage terms. Betas are estimated in a first-stage time-series regression. Risk prices on the Lettau, Maggiori, and Weber downside risk (LMW^{-}) and normal times (LMW) factors are estimated as in the original paper. The quarterly sample is 1970Q1–2012Q4. Mean absolute pricing error (MAPE) is in percentage terms. MAPE-R uses a restricted model which restricts the risk prices (λs) to be the same in all asset classes, as in the last column. Relative risk aversion (RRA) is implied by the price of intermediary capital risk factor and the factors covariance matrix. GMM t-statistics in parentheses adjust for cross-asset correlation in the residuals and for estimation error of the time-series betas. The bottom two statistics are adjusted R^2 and MAPE for similar specifications

Are Primary Dealer Special?

	FF25	US bonds	Sov. bonds	Options	CDS	Commod.	FX	All
Capital	16.25	12.37	43.26	-85.93	66.77	-10.20	-2.61	11.03
	(2.45)	(0.69)	(1.24)	(-2.33)	(2.55)	(-1.52)	(-0.12)	(1.04)
Market	-2.45	3.82	5.56	-6.53	6.86	-0.87	11.76	1.40
	(-1.66)	(2.51)	(1.74)	(-1.20)	(2.99)	(-0.49)	(2.45)	(0.80)
Intercept	4.40	0.38	0.26	7.22	-0.41	-0.38	-2.14	0.25
	(3.36)	(1.49)	(0.22)	(1.48)	(-2.72)	(-0.62)	(-2.14)	(0.95)
R^2	0.54	0.82	0.81	0.97	0.86	0.11	0.50	0.46
MAPE, %	0.36	0.14	0.32	0.23	0.15	1.30	0.45	0.90
MAPE-R, %	0.62	0.30	1.29	1.33	0.34	1.67	1.06	0.90
RRA	1.94	1.49	3.95	-10.95	5.16	-1.33	-0.34	1.32
Assets	25	20	6	18	20	23	12	124
Quarters	165	148	65	103	47	105	135	172

(a) **Non-Primary Broker-Dealers**

	FF25	US bonds	Sov. bonds	Options	CDS	Commod.	FX	All
Capital	-1.02	2.87	1.50	4.19	0.26	-0.38	6.87	0.32
	(-0.70)	(2.90)	(1.42)	(2.01)	(0.15)	(-0.45)	(2.16)	(0.45)
Market	-1.03	2.77	2.42	9.30	8.78	-0.91	14.30	1.73
	(-0.83)	(1.72)	(0.88)	(3.09)	(1.78)	(-0.52)	(2.78)	(1.04)
Intercept	3.31	0.38	1.56	-6.33	-0.21	0.53	-1.85	0.11
	(3.09)	(1.08)	(1.57)	(-2.99)	(-1.38)	(0.87)	(-1.55)	(0.20)
R^2	0.08	0.85	0.74	0.91	0.90	0.01	0.51	0.37
MAPE, %	0.54	0.12	0.46	0.38	0.13	1.40	0.46	0.84
MAPE-R, %	0.66	0.39	1.09	1.12	0.25	1.47	1.23	0.84
RRA	-1.57	5.78	3.35	9.16	0.53	-0.85	15.00	0.49
Assets	25	20	6	18	20	23	12	124
Quarters	172	148	65	103	47	105	135	172

(b) **Non-Banks**

Table 7: **Primary Dealers are Special: a Placebo Test**

Risk price estimates for shocks to the capital ratios of complementary sets of financial intermediaries, and the excess return on the market. Panel (a) examines non-primary dealers defined as US firms in the broker-dealer SIC groups (6211, 6221) that are not in the NY Fed primary dealer list. Panel (b) examines non-banks defined as US firms with an SIC code that does not start with 6. Risk prices are the mean slopes of period-by-period cross-sectional regressions of portfolio excess returns on risk exposures (betas), reported in percentage terms. Betas are estimated in a first-stage time-series regression. The quarterly sample is 1970Q1–2012Q4. The intermediary capital ratio is the ratio of total market equity to total market assets (book debt plus market equity) of primary dealer holding companies. Shocks to capital ratio are defined as AR(1) innovations in the capital ratio, scaled by the lagged capital ratio. Mean absolute pricing error (MAPE) is in percentage terms. MAPE-R uses a restricted model which restricts the risk prices (λs) to be the same in all asset classes, as in the last column. Relative risk aversion (RRA) is implied by the price of intermediary capital risk factor and the factors covariance matrix. GMM t-statistics in parentheses adjust for cross-asset correlation in the residuals and for estimation error of the time-series betas.

The Intermediation Sector

- Heterogeneity between primary dealers and other broker dealers
- A large degree of homogeneity in intermediaries that are marginal in different asset markets
  - The same set of intermediaries
  - Highly correlated capital ratio

Equity or Debt?

	FF25	US bonds	Sov. bonds	Options	CDS	Commod.	FX	All
ME	7.22	4.72	5.03	13.77	5.56	8.72	19.13	9.71
	(1.62)	(1.34)	(0.86)	(1.54)	(1.32)	(1.56)	(4.30)	(2.35)
BD	-2.00	4.09	-6.89	-5.85	-10.19	2.06	-0.18	-0.26
	(-1.51)	(1.53)	(-2.24)	(-0.93)	(-2.12)	(1.14)	(-0.08)	(-0.07)
Market	0.76	4.54	1.85	0.91	-0.52	0.00	8.62	1.68
	(0.46)	(2.01)	(0.48)	(0.19)	(-0.17)	(0.00)	(2.12)	(0.93)
Intercept	0.85	0.22	-0.19	-0.06	-0.42	0.43	-0.79	-0.18
	(0.56)	(1.19)	(-0.12)	(-0.02)	(-3.25)	(0.38)	(-0.76)	(-0.40)
R^2	0.51	0.89	0.90	0.99	0.86	0.28	0.54	0.77
MAPE, %	0.35	0.09	0.29	0.12	0.15	1.21	0.44	0.64
MAPE-R, %	0.44	0.41	0.47	0.68	0.22	1.53	0.52	0.64
RRA	2.39	1.55	1.38	4.20	1.50	2.65	6.57	3.21
Assets	25	20	6	18	20	23	12	124
Quarters	172	148	65	103	47	105	135	172

Table 9: **Both Market Equity and Book Debt are Important for Pricing**
Risk price estimates for the market equity growth (ME) and book debt growth (BD) of the aggregate intermediary sector, and the excess return on the market. Both growth (log change) measures rely only on firms that are in the sample in both periods. Risk prices are the mean slopes of period-by-period cross-sectional regressions of portfolio excess returns on risk exposures (betas), reported in percentage terms. Betas are estimated in a first-stage time-series regression. The quarterly sample is 1970Q1–2012Q4. Mean absolute pricing error (MAPE) is in percentage terms. MAPE-R uses a restricted model which restricts the risk prices (λs) to be the same in all asset classes, as in the last column. Relative risk aversion (RRA) is implied by the price of intermediary capital risk factor and the factors covariance matrix. GMM t-statistics in parentheses adjust for cross-asset correlation in the residuals and for estimation error of the time-series betas.

Adrian, Etula and Muir (2014, JF)

- An earlier paper by Adrian, Etula and Muir (2014) shows the pricing power of broker dealer leverage for stocks and bonds
- Define broker-dealer leverage as the reciporal of HKM's intermediary capital ratio
- AEM finds a positive price of risk for broker-dealer leverage risk factor

AEM Main Results (1)

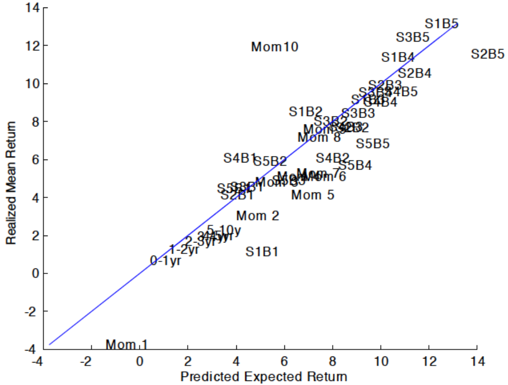


Figure 1: Realized vs. Predicted Mean Returns: Leverage Factor. We plot the realized mean excess returns of 35 equity portfolios (25 Size and Book-to-Market Sorted Portfolios and 10 Momentum Sorted Portfolios) and 6 Treasury bond portfolios (sorted by maturity) against the mean excess returns predicted by our single-factor financial intermediary leverage model, estimated without an intercept ($E[R^e] = \beta_{lev}\lambda_{lev}$). The sample period is Q1/1968-Q4/2009. Data are quarterly, but returns are expressed in percent per year.

AEM Main Results (2)

Table III: Main Table: Pricing the Size, Book to Market, Momentum, and Bond Portfolios

Pricing results for the 25 size and book-to-market and 10 momentum portfolios, and 6 Treasury bond portfolios sorted by maturity. Each model is estimated as $E[R^e] = \lambda_0 + \beta_{fac}\lambda_{fac}$. FF denotes the Fama-French 3 factors, Mom the momentum factor, PC1 the first principal component of the yield curve, LevFac our leverage factor. Panel A reports the prices of risk with Fama-MacBeth and Shanken t-statistics, respectively. Panel B reports test diagnostics, including mean absolute pricing errors (MAPE) by portfolio group, adjusted R-Squares with corresponding confidence intervals (C.I.), and a χ^2 statistic that tests whether the pricing errors are jointly zero. $E[R^e]$ gives the average excess return to be explained. Data are quarterly, 1968Q1-2009Q4. Returns and risk premia are reported in percent per year (quarterly percentages multiplied by 4).

Panel A: Prices of Risk

	CAPM	FF	FF,Mom	FF,Mom,PC1	LevFac	LevMkt
Intercept	3.39	3.16	1.06	0.66	0.12	-0.19
t-FM	3.55	4.09	1.51	1.14	0.06	-0.21
t-Shanken	3.54	4.03	1.34	1.01	0.04	-0.14
LevFac					62.21	60.97
t-FM					4.62	5.29
t-Shanken					3.12	3.65
Mkt	3.06	2.30	4.54	4.89		5.46
t-FM	0.99	0.80	1.59	1.71		1.75
t-Shanken	0.99	0.80	1.58	1.70		1.55
SMB		1.76	1.57	1.63		
t-FM		0.93	0.83	0.87		
t-Shanken		0.93	0.82	0.86		
HML		3.33	4.37	4.34		
t-FM		1.45	1.90	1.89		
t-Shanken		1.45	1.86	1.85		
MOM			7.82	7.75		
t-FM			2.94	2.91		
t-Shanken			2.92	2.89		
PC1				14.99		
t-FM				1.03		
t-Shanken				0.93		

Panel B: Test Diagnostics

MAPE	$E[R^e]$	CAPM	FF	FF,Mom	FF,Mom,PC1	LevFac	LevMkt
Size B/M	7.86	2.62	1.81	1.05	1.01	1.16	1.11
MOM	5.80	3.05	3.75	1.47	1.48	1.79	1.85
Bond	1.65	1.83	1.59	0.17	0.17	0.37	0.26
Intercept		3.39	3.16	1.06	0.66	0.12	0.12
Total	6.45	6.00	5.41	2.08	1.66	1.31	1.36
AdjR2		0.10	0.16	0.81	0.81	0.77	0.78
C.I.AdjR2		[0.02, 0.30]	[0.02, 0.36]	[0.74, 0.88]	[0.72, 0.88]	[0.82, 1]	[0.76, 1]
$T^2(\chi^2_{N-K})$		174.48	167.46	111.45	110.19	67.87	68.86
p-value		0.0%	0.0%	0.0%	0.0%	0.3%	0.0%

46

Comparison

- AEM leverage measure positively correlated with HKM capital factor
- AEM prices stocks and bonds well, but not other asset classes, especially those heavily intermediated
- Data sources are different
  - Primary dealer vs. the whole broker dealer sector - heterogeneity
  - Holding company vs. subsidiary (the role of internal capital markets)

Leverage Cyclicality and the Nature of Constraint

- Countercyclical leverage: **equity constraint**
  - Common implication in almost all macroeconomic models (Gertler and Kiyotaki, 2010; Brunnermeier and Sannikov, 2014; Mendoza, 2010)
  - Do not allow for external equity issuance in bad times
- Procylical leverage: **debt constraint** (Adrian and Shin, 2014)
  - In bad times, debt constraint binds and intermediaries have to delever
- Not necessarily mutually inconsistent
  - Different intermediaries (Adrian and Shin, 2010)
  - Both constraints may be relevant, but bind at different times or in different states of the world - **when?**
  - Intermediaries interact in equilibrium - heterogeneous intermediaries

Adrian and Shin (2010)

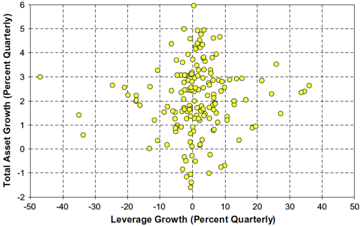


Fig. 3. Total assets and leverage of commercial banks.

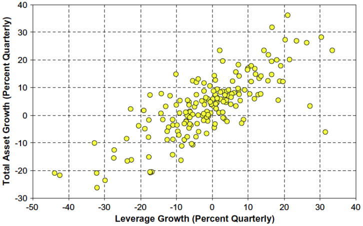


Fig. 4. Total assets and leverage of security brokers and dealers.

Adrian and Shin (2010)

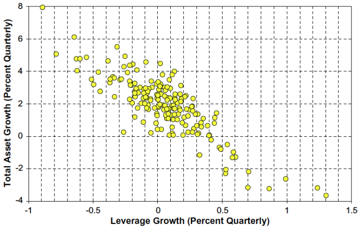


Fig. 1. Total assets and leverage of household.

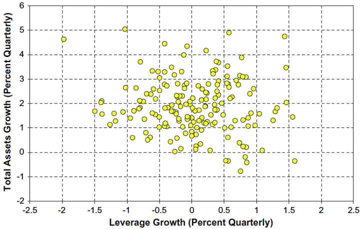


Fig. 2. Total assets and leverage of non-financial, non-farm corporates.

Debt and Equity Constraint

"An interesting direction for future theory is to investigate different economic conditions underwhich debt or equity constraints are more likely to impact asset values, and to use this to guide construction of a more sophisticated pricing kernel that nests both mechanisms in a state-dependent manner."
A quote from HKM (2017)

Return Predictability and Time-varying Risk Premia

	FF25		US bonds		Sov. bonds		Options	
	HKM	AEM	HKM	AEM	HKM	AEM	HKM	AEM
Leverage	0.12	-2.12	0.09	-1.63	0.15	-0.33	0.09	-2.92
	(3.19)	(-1.73)	(1.75)	(-1.81)	(4.41)	(-0.15)	(2.05)	(-2.00)
R^2	0.15	0.08	0.09	0.06	0.21	0.00	0.06	0.16
Assets	25	25	20	20	6	6	18	18
Quarters	168	168	145	145	62	62	100	100
	CDS		Commod.		FX		All	
	HKM	AEM	HKM	AEM	HKM	AEM	HKM	AEM
Leverage	0.14	-1.30	0.00	-0.95	-0.10	0.65	0.10	-1.95
	(3.20)	(-0.49)	(0.18)	(-1.29)	(-2.15)	(0.70)	(3.13)	(-2.02)
R^2	0.21	0.04	0.00	0.06	0.10	0.01	0.16	0.11
Assets	20	20	23	23	12	12	124	124
Quarters	44	44	102	102	132	132	169	169

Table 15: **Predictive Regressions by Asset Class**
One-year-ahead predictive regression results for each asset class. The quarterly sample is 1970Q1–2012Q4. We regress the mean return on all assets of an asset class on lagged intermediary leverage, which is either the squared inverse of the intermediary capital ratio (HKM), or the Adrian et al. (2014a) leverage ratio (AEM). Regression coefficients are multiplied by 100. Hodrick (1992) t-statistics are reported in parentheses.

Summary of HKM (2017)

- A cross-sectional Euler equation test
  - Positive price of intermediary capital ratio risk
  - Consistently estimated across asset classes
- Highlight the special role of primary dealers
- Explain why HKM differs from AEM and why it makes sense
  - Broker-dealer vs. primary dealder (heterogeneity)
  - Holding company vs. subsidiary (internal capital market)
  - Implication on the nature of constraint: equity vs. debt

What's Next?

- Intermediary AP: intermediaries are marginal but **households are not**
  - Cross-sectional Euler equation test is indirect
  - More direct test?
    - Muir (2017, QJE): crisis of different natures
    - Haddad and Muir (2021, JF): compare different asset classes with different degree of intermediation

Crises: Muir (2017, QJE)

- Analyzes dynamics of risk premia during crises, wars, and recessions and show these risk premia spikes cannot be explained by consumption dynamics, lending support to intermediary AP
- Punchline: distinguish consumption-based AP models and intermediary AP models in crises events

Stylized Fact

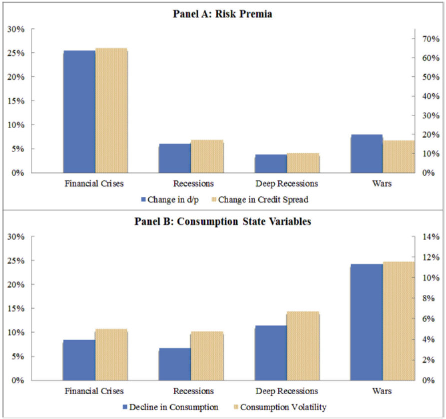


FIGURE I

Main Results

This figure computes changes in risk premia, as measured by dividend yields (left axis) and credit spreads (right axis), in Panel A across financial crises, recessions, deep recessions, and wars. Panel B plots consumption state variables argued to capture variation in risk premia: the peak to trough decline in consumption (left axis) and consumption volatility (right axis).

Data

- 14 countries, 1870-2009
- Real consumption per capita, dividend yields, real stock returns, credit spreads
- Identify periods with financial crises, recessions, deep recessions, and wars

Asset Prices and Consumption Dynamics in Crisis

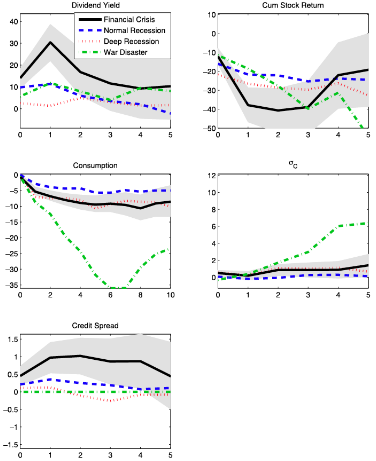


FIGURE II

Impulse Responses

This figure plots responses to each event. The x-axis is in years. War denotes “war-related disasters,” Rec “recessions,” Fin “financial crises,” Deep “deep recessions” (defined as the worst 30% of recessions). I plot the dividend yield, cumulative log stock return, log consumption, and volatility of consumption, all relative to means. 90% confidence bands for financial crises in gray.

Asset Prices and Drivers of Risk Premia in Conventional AP Models

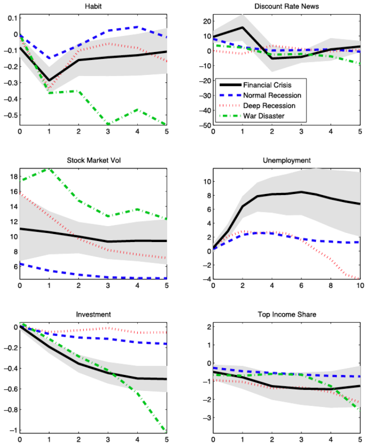


FIGURE III

Additional Impulse Responses

This figure plots the log habit or surplus consumption ratio, the normalized credit spread, discount rate news, unemployment, investment, and income share of the top 1% of earners, all relative to means. War panels are left blank when data are missing. 90% confidence bands for financial crises in gray.

Diagnosis

- During financial crises, large stock return drop and credit spread increase without large consumption drop
- Volatility barely increases in crises, while risk premia spikes
- In recessions and wars when consumption (or surplus) has a large drop, risk premia does not move much
- Unemployment and investment dynamics support a discount rate effect in financial crises
- Top income share does not move much, not support a limited participation explanation

Haddad and Muir (2021, JF)

- The idea: risk premia of more intermediated assets respond more to intermediaries' risk bearing capacity and less to households' risk bearing capacity

$$r_{i,t+1} = \alpha_i + \beta_{i,H}\gamma_{H,t} + \beta_{i,I}\gamma_{I,t} + \varepsilon_{i,t+1}$$

  - $\beta_{i,I}$ lines up with the degree of intermediation
  - $\beta_{i,H}$ lines up (reversely) with the degree of intermediation
- Challenges
  - How to measure $\gamma_{H,t}, \gamma_{I,t}$?
  - How to rank assets in their degree of intermediation?

A Simple Model

- Two periods, $t = 0, 1$, n risky assets supply S, risk-free rate 0
- Risky asset payoff follows $N(\mu, \Sigma)$
- Households and intermediaries have mean-variance utility with risk aversion γ_H, γ_I
- Households can delegate to intermediaries (but cannot control intermediary's behavior) or hold directly subject to a cost $\frac{1}{2} D' \Sigma_{diag} CD$
- Assume $\gamma_I \geq \gamma_H$ so that intermediaries are not willing to take all risks that households want to take

Optimization

- Intermediary

$$\max_{D_I} D_I'(\mu - p) - \frac{\gamma_I}{2} D_I' \Sigma D_I$$

- Households

$$\max_{D_H} (D_H + D_I)'(\mu - p) - \frac{\gamma_H}{2}(D_H + D_I)'\Sigma(D_H + D_I) - \frac{1}{2} D_H' \Sigma_{diag} C D_H$$

- Market clearing

$$D_H + D_I = S$$

Model Predictions

- If $\gamma_I \neq \gamma_H$ and $\neq 0$, intermediary matters for asset prices, i.e.

$$\frac{\partial(\mu - p)}{\partial \gamma_i} \neq 0$$

- The elasticity of risk premium to intermediary (household) risk aversion γ_I (γ_H) is increasing (decreasing) in the cost of direct holding

$$\beta_{i,I} = \frac{c_i}{\gamma_I + c_i}$$

Empirical Implementation

- How to measure γ_I?
  - Broker-dealer leverage (AEM) and intermediary equity (HKM)
- How to measure γ_H?
  - CAY and habit measure in Campbell and Cochrane (1999)
- How to rank assets?
  - Holding and volume data (HH vs. financial institutions, FoF and BIS)
  - VaR exposures relative to the total size
  - Direct expenses (ETF fees)

Ranking of Intermediation Degree

Table II

Ranking of Asset Classes

This table reports rankings by degree of intermediation by source, with our chosen ranking on the top row. From left to right: less intermediated asset classes, with relatively easier access of investing by households, to more intermediated asset classes, with lower participation by households. Sources for the rankings are: Flow of Funds (FoF), BIS derivatives positions, Vale-at-Risk (VaR), and ETF expense ratios. The text explains these sources and rankings in detail.

Our Ranking	Stocks	Treas.	Options	Sov Bonds	Comm	FX	MBS	CDS
FoF	Stocks	Treas.		Sov Bonds			MBS	
VaR	Stocks	Treas.			Comm	FX		
BIS		Treas.	Options		Comm	FX		CDS
Expense	Stocks	Treas.	Sov Bonds	FX	Comm	Options	MBS	CDS

Comparability

- To ensure comparability, returns need to be normalized
  - Otherwise, a levered return has a larger coefficient mechanically
  - Scaling by vol or expected return both work, but the latter is harder as expected return is harder to measure

Main Results

Table III

Intermediary Health and Excess Returns

This table reports results of predictive regressions of future excess returns in each asset class on our proxy for intermediary risk aversion, $\tilde{\gamma}_{I,t}$. We run $r^{\sigma}_{i,t+1} = a_i + b_i \times \tilde{\gamma}_{I,t} + \epsilon_{i,t+1}$ and report b_i. Excess returns $r^{\sigma}_{i,t+1}$ are normalized by their full-sample volatility. $\tilde{\gamma}_{I,t}$ is the standardized average of the AEM and HKM intermediary factors. Standard errors are computed using the reverse-regression approach of Hodrick (1992). *, **, and *** indicate statistically different from zero at the 10%, 5%, and 1% level of significance, where p-values are computed using the bootstrap approach described in Section A. The last row computes the elasticity of expected returns, $b_i/E[r^{\sigma}_{i,t+1}]$. See text for more details.

	Stocks (1)	Treas. (2)	Options (3)	Sov. (4)	Comm. (5)	FX (6)	MBS (7)	Credit (8)
γ_I	0.12	−0.01	0.29***	0.38**	0.18*	0.18*	0.30**	0.57***
	(0.09)	(0.07)	(0.10)	(0.17)	(0.10)	(0.09)	(0.13)	(0.22)
Boots. p-value	0.198	0.904	0.005	0.019	0.083	0.056	0.016	0.006
Observations	167	160	103	65	105	116	97	47
Adjusted R^2	0.008	−0.006	0.075	0.126	0.022	0.021	0.078	0.316
Elasticity	0.71	−0.04	0.58	1.03	0.87	0.43	2.34	2.67

Interpretations and Alternative Hypothesis

- H1: intermediary health is purely a proxy for household risk capacity
  - Rejected - otherwise we should see a declining coefficient
- H1: intermediary health matters but is correlated with household risk capacity
  - Not rejected, but the increasing effect of intermediaries on risk premia dominates the decreasing effect from households
  - Offer **a lower bound** on intermediary health's effect on risk premia

Intermediaries and Households

Table IV

Including Household Risk Aversion

This tables presents results of predictive regressions of future excess returns in each asset class on our proxy for intermediary risk aversion, $\tilde{\gamma}_{I,t}$, and household risk aversion, $\tilde{\gamma}_{H,t}$. We run $r^{\sigma}_{i,t+1} = a_i + b_{I,i} \times \tilde{\gamma}_{I,t} + b_{H,i} \times \tilde{\gamma}_{H,t} + \epsilon_{i,t+1}$ and report b_i. Excess returns $r^{\sigma}_{i,t+1}$ are normalized by their full-sample volatility. $\tilde{\gamma}_{I,t}$ is the standardized average of the AEM and HKM intermediary factors. $\tilde{\gamma}_{H,t}$ is proxied by the consumption wealth ratio (cay) of Lettau and Ludvigson (2001). Standard errors are computed using the reverse-regression approach of Hodrick (1992). *, **, and *** indicate statistically different from zero at the 10%, 5%, and 1% level of significance, where p-values are computed using the bootstrap approach described in Section A. The last row computes the elasticity of expected returns, $b_i/E[r^{\sigma}_{i,t+1}]$. See text for more detail.

	Stocks (1)	Treas. (2)	Options (3)	Sov. (4)	Comm. (5)	FX (6)	MBS (7)	Credit (8)
γ_I	0.15*	−0.00	0.29***	0.36**	0.18*	0.18*	0.31**	0.59**
	(0.09)	(0.07)	(0.10)	(0.17)	(0.10)	(0.09)	(0.13)	(0.27)
γ_H^{cay}	0.21***	0.06	0.12	0.22	0.01	0.12	0.20*	−0.06
	(0.07)	(0.07)	(0.12)	(0.14)	(0.12)	(0.11)	(0.11)	(0.34)
Observations	167	160	103	65	105	116	97	47
Adjusted R^2	0.044	−0.009	0.075	0.144	0.013	0.022	0.092	0.302
Elasticity								
γ_I	0.91	−0.02	0.58	1.00	0.87	0.43	2.39	2.74
γ_H^{cay}	1.23	0.25	0.24	0.59	0.05	0.29	1.53	−0.26

Decomposing Variations in Expected Returns

$$E_t(r^{\sigma}_{i,t+1}) = b_{i,I}\tilde{\gamma}_{I,t} + b_{i,H}\tilde{\gamma}_{H,t}$$

- Recall that $\beta_{i,I} = \frac{c_i}{\gamma_I + c_i}$, project $b_{i,I}$ and $b_{i,H}$ to c_i and use the projected value for decomposition

$$b_{i,I} = A_I + B_I \times c_i + u_{I,i}, b_{i,H} = A_H + B_H \times c_i + u_{H,i}$$

- A lower bound for the role of intermediaries

$$\sigma^2_{Intermediaries} \geq \sigma^2((B_I \times c_i)\tilde{\gamma}_{I,t})$$

Decomposition Results

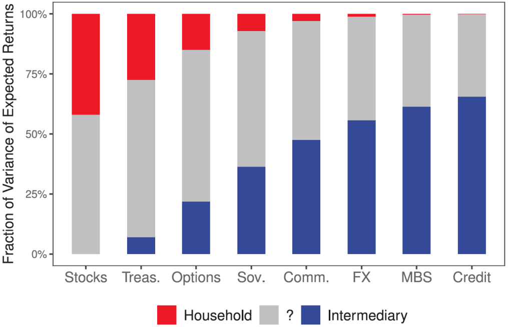


Figure 9. Decomposition of risk premium variation. This figure shows lower bounds of variation in risk premia coming from households and intermediaries for each asset class using the pattern of predictability across asset classes. See text for more details. (Color figure can be viewed at wileyonlinelibrary.com)

Variation in Risk

Table V

Predicting Risk with Intermediary Risk Aversion

This tables presents results of predictive regressions of future risk measures in each asset class on our proxy for intermediary risk aversion, $\tilde{\gamma}_{I,t}$. We run $Y_{i,t+1} = a_i + b_{I,i} \times \tilde{\gamma}_{I,t} + \epsilon_{i,t+1}$ and report $b_{I,i}$. Excess returns $r_{i,t+1}$ are normalized by their full-sample volatility. Panel A predicts the square returns, $Y_{i,t+1} = r^2_{i,t+1}$. Panel B predicts the exposure to market returns, $Y_{i,t+1} = r_{i,t+1} \times r_{MKT,t+1}$. Panel C predicts the exposure to the liquidity factor of Pástor and Stambaugh (2003), $Y_{i,t+1} = r_{i,t+1} \times r_{LIQ,t+1}$. Standard errors are computed using the reverse-regression approach of Hodrick (1992). *, **, and *** indicate statistically different from zero at the 10%, 5%, and 1% level of significance, where p-values are computed using the bootstrap approach described in Section A.

	Stocks (1)	Treas. (2)	Options (3)	Sov. (4)	Comm. (5)	FX (6)	MBS (7)	Credit (8)
Panel A. Variance ($r^2_{i,t+1}$)								
γ_I	0.34**	0.17	0.10	0.23	0.30	−0.09	0.15	0.35
	(0.16)	(0.13)	(0.17)	(0.34)	(0.26)	(0.11)	(0.20)	(0.54)
Observations	167	160	103	65	105	116	97	47
Adjusted R^2	0.041	−0.002	−0.007	−0.005	0.004	−0.004	−0.004	−0.000
Panel B. Market Risk Exposure ($r_{i,t+1} \times r_{MKT,t+1}$)								
γ_I	0.38**	0.07	0.27*	0.24	0.09	0.14	0.11	0.22
	(0.16)	(0.08)	(0.14)	(0.28)	(0.11)	(0.12)	(0.17)	(0.39)
Observations	167	160	103	65	105	116	97	47
Adjusted R^2	0.057	−0.003	0.046	0.009	−0.004	0.006	−0.003	−0.005
Panel C. Liquidity Risk Exposure ($r_{i,t+1} \times r_{LIQ,t+1}$)								
γ_I	0.07	−0.03	0.27**	0.06	0.14	0.04	0.13	0.00
	(0.14)	(0.06)	(0.14)	(0.14)	(0.18)	(0.10)	(0.16)	(0.27)
Observations	167	160	103	65	105	116	97	47
Adjusted R^2	−0.004	−0.006	0.026	−0.013	−0.004	−0.008	−0.002	−0.022

Evidence from Hedge Fund Returns

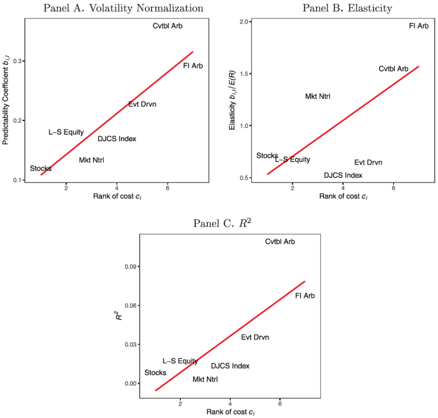


Figure 10. Hedge fund strategy returns. This figure shows the behavior of risk premiums across stocks and hedge fund returns by category: long-short equity, market-neutral equity, the DJCS hedge fund index weighted across all hedge fund styles, event driven, convertible bond arbitrage, and fixed income arbitrage. Panel A runs $r^{\sigma}_{i,t+1} = a_i + b_i \times \tilde{\gamma}_{I,t} + \epsilon_{i,t+1}$ and plots b_i across fund categories. Excess returns $r^{\sigma}_{i,t+1}$ are normalized by their full-sample volatility. Panel B plots the risk premia elasticity found by running $r_{i,t+k}/E[r_{i,t+k}] = a_i + b_i\tilde{\gamma}_{I,t} + \varepsilon_{i,t+k}$. The right-hand side variable $\gamma_{I,t}$ that captures intermediary health is an equal-weighted average of the AEM and HKM factors. Panel C plots the R^2 in this predictive regression. See text for more details. (Color figure can be viewed at wileyonlinelibrary.com)

Empirical Studies on Intermediary Asset Pricing

- "Macro evidence" that shows intermediaries matter for asset prices in generaal in the time-series and cross-section
  - Euler equation test
  - Crisis diagnosis
  - Cross-sectional predictability comparison
  - Historical and international evidence: Baron and Muir (2022 RFS)
- "Micro evidence" for a particular asset class
  - Example: Haddad and Sraer (2020, JF)

Cochrane (2017, RF) Interpretation of Intermediary AP

- Basic story: when income declines toward debt, investors take less risk
- Distinct from other models: the absence of most investors from the market is central to the story
  - The vast bulk of people would have loved to have bought assets at fire-sale prices during crises- but they were not "marginal", unable or unwilling to buy cheaply priced stock directly

Cochrane (2017, RF) Critique

- Why do people get more risk averse as they approach bankruptcy, not less?
- Not everyone is in debt
  - Explain obscure CDO, CDS, or other hard to trade instruments, but how to explain widespread, coordinated, long-lasting movements in stock and bond markets?
  - Part of everyone's opportunity set - we are all marginal
  - Large, sophisticated, unconstrained, debt-free wealthy investors and institutions
- If there is such severe agency problem, why do fundamental investors put up with it? Why not invest directly, or find better contract?

5. Monetary policy, risk premium, and intermediaries

Drechsler, Savov, and Schnabl (2017 QJE, 2018 JF, 2018 ARFE)

Monetary Policy and Financial Market

- Before 1980s
  - Monetary policy through the control of reserve quantity
  - Banks create (inside) money through reserves
- After the 1980s, less bank funding from deposit and requires reserve holding
  - $M2$ no longer stable and reliable indicators of inflation
- Standard view in macro: monetary economics without money, interest rate tool
- Evidence on the role of financial market in monetary policy transmission using high-frequency data
  - Bernanke and Kuttner (2005, JF): stock return drops shortly after Fed raises rate surprisingly, driven by risk premia
  - Gertler and Karadi (2015, AEJ Macro): credit spread spike
  - Hanson and Stein (2015, JFE): long-term rate
- This section: monetary policy transmission through the financial system

Liquidity

- Liquidity: public liquidity and private liquidity
  - Private liquidity: liabilities of the financial sector
    - Unsecured: wholesale funding
    - Secured: for example, deposit
  - Public liquidity: liabilities of the government

Liquidity and Financial Panic

- Private liquidity causes financial panic or instability
  - Bank runs: run on unsecured funding
  - Liquidity crunch
- Public liquidity helps deal with bank run or liquidity crunch, since their values are maintained in financial panic
  - If the government bonds are non-defaultable
  - Command a liquidity premium
- Secured private liabilities: not subject to run
  - Also command a liquidity premium

The Deposit Channel of Monetary Policy: Drechsler, Savov, and Schnabl (2017, QJE)

- Banks have market power over supply of deposit (i.e., can set the deposit rate)
- Depositors are willing to pay a premium (accpet lower rate) to hold deposit
- The spread charge depends on the interest rate, the cost of holding cash
    - When interest rate is high, the cost of holding cash is high, banks can set a higher deposit spread and charge a higher liquidity premium
    - As a result, deposit flows out of the banking system
    - Deposits are low-cost funding and are not easily substitutable, so the loss of deposits contracts lending

The Deposit Channel of Monetary Policy

- FFR rise widens the spreads between FFR and deposit rate, inducing deposits to flow out of the banking system
- The opposite direction of response of deposit and spread $\rightarrow$ a supply change
- More results with identification power later

A Simple Model of Deposit Channel

- Single period, no risk
- Households derive utility from wealth and liquidity with CES aggregation ($\rho < 1$, complementary)

$$u = \left(W^{\frac{\rho-1}{\rho}} + \lambda l^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}$$

- Liquidity service derived from cash M and deposit D with CES aggregation ($\varepsilon > 1$, substitutable)

$$l(M, D) = \left(M^{\frac{\varepsilon-1}{\varepsilon}} + \delta D^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

- Deposit derived from N banks with CES aggregation ($\eta > 1$, substitutable)

$$D = \left(\frac{1}{N} \sum_{i=1}^{N} D_i^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}$$

- Outside asset, Fed funds rate f

Monopolistic Competitive Banks as Deposit Supplier

- Let the deposit spread charged by bank i be s_i, deposit rate is $f - s_i$
- Monopolistic banks set s_i

$$\max_{s_i} D_i s_i$$

$$s.t. : \text{Depositors' demand function } D_i(s_i)$$

Optimality condition:

$$\frac{\partial D_i / D_i}{\partial s_i / s_i} = -1$$

Deposit Demand

- Denote s: average spread of deposit, the forgone wealth is Ds

$$\frac{\partial D_i/D_i}{\partial s_i/s_i} = \frac{1}{N}\left(\frac{\partial D/D}{\partial s/s}\right) - \eta\left(1 - \frac{1}{N}\right)$$

  - Aggregate effect: when s_i increases, the overall cost of deposit s increases, so deposit flows out of the banking system in aggregate (scale of $1/N$)
  - Inter-bank competition effect: when s_i increases, depositors shift to other banks for deposits, govered by η, the elasticity of substitution among deposits provided by different banks
  - At the optimum, we solve for

$$-\frac{\partial D/D}{\partial s/s} = 1 - (\eta - 1)(N - 1) = \mathcal{M}$$

Aggregate Deposit Elasticity

The aggregate deposit elasticity

$$-\frac{\partial D/D}{\partial s/s} = \left[\frac{1}{1+\delta^{\varepsilon}\left(\frac{f}{s}\right)^{\varepsilon-1}}\right]\varepsilon + \left[\frac{\delta^{\varepsilon}\left(\frac{f}{s}\right)^{\varepsilon-1}}{1+\delta^{\varepsilon}\left(\frac{f}{s}\right)^{\varepsilon-1}}\right]\rho$$

- Two layers of CES optimization: cash and deposit, liquidity and wealth
- Assume $\rho < 1 < \varepsilon, \eta$, solve for

$$s = \delta^{\frac{\varepsilon}{\varepsilon-1}} \left(\frac{\mathcal{M}-\rho}{\varepsilon-\mathcal{M}}\right)^{\frac{1}{\varepsilon-1}} f$$

- Spread charge increases with the Fed funds rate

The Economics

- When the Fed funds rate increases (cost of holding cash increases), banks worry less about competition from cash and can raise the spread charge for deposit
- All banks have similar incentives and thus the aggregate effect is similar
- When the spread charge is higher, deposit supplied by banks is reduced since $D_i(s_i)$ is downward sloped
- The increase of s with respect to f, increases with banks' market power $\mathcal{M}$

Lending and Wholesale Funding

- D_i retail deposit, H_i wholesale funding, L_i lending
- Banks' revised problem

$$\max_{D_i, H_i} \left(f + l_0 - \frac{l_1}{2} L_i \right) L_i - \left(f + \frac{h}{2} H_i \right) H_i - (f - s_i) D_i$$

$$s.t.: L_i = D_i + H_i$$

  - The cost of wholesale funding increases with its reliance
  - Depsoit and wholesale funding are not perfectly substitute
  - A contraction of D_i leads to a contraction of lending L_i

Key Predictions

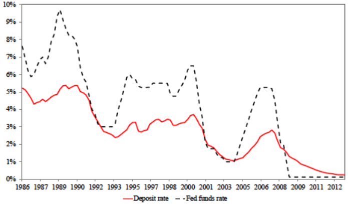
- When f increases, s increases and deposit flows out of the banking system
- The deposit outflow is associated with a lending contraction
- The s increases is larger if the banks have more market power

Aggregate Evidence: The Deposit Channel

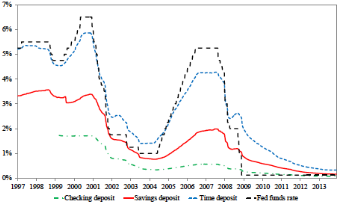
Figure I
Deposit rates and monetary policy

The figure plots the Fed funds rate and the average interest rate paid on core deposits. Panel A plots the average deposit rate for the commercial banking sector. The data is from U.S. call reports covering the years 1986 to 2013. Panel B plots the Fed funds rate and the rate paid on new accounts for the three most widely-offered deposit products (checking, savings, and small time deposits). The data are from RateWatch covering the years 1997 to 2013.

Panel A: Average deposit rate



Panel B: Average deposit rate by product



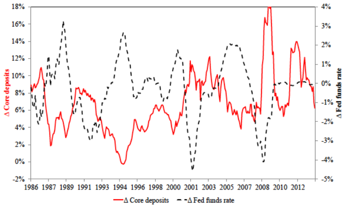
63

Aggregate Evidence: The Deposit Channel

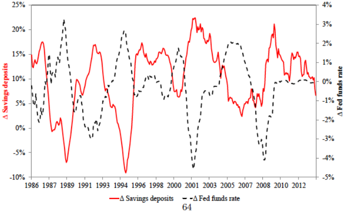
FIGURE II
DEPOSIT GROWTH AND MONETARY POLICY

This figure plots year-over-year changes in core deposits (Panel A), savings deposits (Panel B), checking deposits (Panel C) and small time deposits (Panel D) against year-over-changes in the Fed funds rate. Core deposits are the sum of checking, savings, and small time deposits. The data are from the Federal Reserve Board's H.6 release. The sample is from January 1986 to December 2013.

Panel A: Core deposits (checking + savings + small time)



Panel B: Savings deposits



64

Cross-sectional Evidence

- Utilize the geographic variation in market power induced by differences in the concentration of local deposit markets
- Consider the same bank located in different counties with different concentration
  - Facing the same investment opportunities

Deposit Spreads

TABLE II

DEPOSIT SPREADS AND MONETARY POLICY

Panel A: Savings deposits

	ΔSpread					
	≥ 2 Counties			All		
	(1)	(2)	(3)	(4)	(5)	(6)
ΔFF × Branch-HHI	0.141***	0.101***	0.099**	0.199***	0.155***	0.159***
	[0.033]	[0.031]	[0.043]	[0.028]	[0.026]	[0.026]
Bank × quarter f.e.	Y	Y	N	N	N	N
State × quarter f.e.	Y	N	N	Y	N	N
Branch f.e.	Y	Y	N	Y	Y	N
County f.e.	Y	Y	Y	Y	Y	Y
Quarter f.e.	Y	Y	Y	Y	Y	Y
Observations	117,701	117,701	117,701	412,037	412,037	412,037
R^2	0.810	0.799	0.559	0.659	0.650	0.645

Panel B: Time deposits

	ΔSpread					
	≥ 2 Counties			All		
	(1)	(2)	(3)	(4)	(5)	(6)
ΔT-Bill × Branch-HHI	0.073***	0.073***	0.156***	0.156***	0.119***	0.119***
	[0.025]	[0.026]	[0.037]	[0.026]	[0.024]	[0.023]
Bank × quarter f.e.	Y	Y	N	N	N	N
State × quarter f.e.	Y	N	N	Y	N	N
Branch f.e.	Y	Y	N	Y	Y	N
County f.e.	Y	Y	Y	Y	Y	Y
Quarter f.e.	Y	Y	Y	Y	Y	Y
Observations	122,008	122,008	122,008	430,080	430,080	430,080
R^2	0.808	0.796	0.442	0.513	0.492	0.488

Notes. This table estimates the effect of Fed funds rate changes on deposit spreads. The data are at the branch-quarter level and covers January 1997 to December 2013. In columns 1 to 3 the sample consists of banks with branches in two or more counties. In columns 4 to 6 the sample consists of all banks. Δ Spread is the change in branch-level deposit spread, which is equal to the change in the Fed funds target rate minus the change in the deposit rate. Branch-HHI measures market concentration in the county where a branch is located. Δ FF is the change in the Fed funds target rate. Δ T-Bill is the change in the one-year T-Bill rate. Panel A reports the results for savings deposits. Panel B reports the results for time deposits. The data are from Ratewatch. Fixed effects (f.e.) are denoted at the bottom of each panel. Standard errors are clustered by county.

Deposit Growth

TABLE III
Deposit growth and monetary policy

	Δ log Deposits					
	≥ 2 Counties			All		
	(1)	(2)	(3)	(4)	(5)	(6)
ΔFF $\times$ Branch-HHI	−0.661***	−1.008***	−0.826***	−1.827***	−1.796***	−0.963***
	[0.254]	[0.331]	[0.246]	[0.198]	[0.242]	[0.212]
Bank $\times$ year f.e.	Y	Y	N	N	N	N
State $\times$ year f.e.	Y	N	N	Y	N	N
Branch f.e.	Y	Y	N	Y	Y	N
County f.e.	Y	Y	Y	Y	Y	Y
Quarter f.e.	Y	Y	Y	Y	Y	Y
Observations	1,150,049	1,150,049	1,150,049	1,310,111	1,310,111	1,310,111
R^2	0.344	0.336	0.025	0.230	0.221	0.025

Notes. This table estimates the effect of Fed funds rate changes on deposit growth. The data are at the branch-year level and covers the years 1994 to 2013. In columns 1 to 3 the sample consists of all banks with branches in two or more counties. In columns 4 to 6 the sample consists of all banks. Deposit growth is the log change in deposits at the branch level. Branch-HHI measures market concentration in the county where a branch is located. Δ FF is the change in the Fed funds target rate. The data are from the FDIC. Fixed effects are denoted at the bottom of the table. Standard errors are clustered by county.

The Effect on Lending

- Assumption: lending is distributed freely across branches, so what determines lending is the average concentration
- Construct bank-level Herfindahl index by averaging across branches
- Within-bank estimation not apply, within-county variation
  - Assumption: Lending opportunities within the same county similar

Lending

TABLE VI
DEPOSITS CHANNEL AND NEW LENDING (BANK-COUNTY RESULTS)

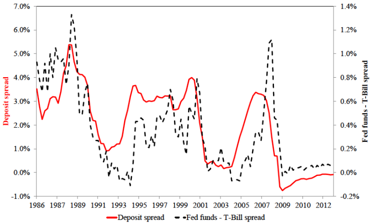
	log New lending			
	(1)	(2)	(3)	(4)
$\Delta FF \times$ Bank-HHI	−0.208**	−0.197**	−0.168**	−0.166**
	[0.085]	[0.088]	[0.076]	[0.075]
$\Delta FF \times$ Branch-HHI		0.026	0.010	
		[0.016]	[0.023]	
Time f.e.	Y	Y	Y	Y
County f.e.	Y	Y	Y	Y
Bank f.e.	Y	Y	Y	Y
County-Bank f.e.	Y	Y	N	N
County-Time f.e.	Y	N	N	N
Observations	620,443	620,443	620,443	620,443
R-squared	0.830	0.815	0.246	0.246

Notes. This table estimates the effect of the deposits channel on new small business lending. The data are at the bank-county level covering the years 1997 to 2013. Log(new lending) is the log of the total amount of new small business loans originated by a given bank in a given county and year. Bank HHI is bank-level average of Branch-HHI using lagged deposit shares across branches as weights. All other variables are defined in Table II. The regression includes a control for Bank HHI (coefficient not shown). The data are from the NCRC. Fixed effects are denoted at the bottom. Standard errors are clustered by bank and county.

Deposit Spread and Liquidity Premium

Figure VIII
The aggregate deposit spread and the liquidity premium

This figure plots the aggregate deposit spread against the T-Bill liquidity premium. The deposit spread is equal to the Fed funds rate minus the value-weighted average deposit rate paid by banks, computed from the quarterly Call Reports. The T-Bill liquidity premium is equal to the Fed funds rate minus the 3-month T-Bill rate. Both the Fed funds rate and T-Bill rate are calculated as quarterly averages. The data are from January 1986 to December 2013.



Further Thoughts

- Subtitution between deposits and wholesale funding (Whited, Wu and Xiao, 2023)
- The market power of banks and deposit rate making (Wang, 2022 JF), the debate between DSS and Begenau and Stafford (2022)
- Banks' exposure to monetary policy (Drechsler, Savov and Schnabl, 2021 JF)
- ...

So Far...

- The bank deposit channel: monetary policy alters banks' ability to utilize its market power to extract monopoly rents on deposits
- Lead to deposit outflow and lending contraction
- A simple theory and empirical evidence, both aggregate and cross-sectional
- What about risk premia? Drechsler, Savov, and Schnabl (2018, JF)

Monetary Policy, Leverage, and Risk Premia

- When interest rate is high, liquidity premium is high
  - Evidence: Nagel (2016, QJE), Drechsler, Savov, and Schnabl (2017, QJE)
  - Mechanism: the deposit channel (but abstract the substitution)
- Banks hold public liquidity (including cash) to prevent runs and are willing to forgo some returns (liquidity premium)
- If interest rate is high, liquidity premium is high, the cost of leveraging is high, so banks take less risk

Model Setup

- How to model savers and banks?
  - Two types of agents with different risk aversion ($\gamma^A < \gamma^B$)
- Liquidity premium: in the simplest case, equal to interest rate (the opportunity cost of holding cash)

Risky Asset

- Dividend process
$$\frac{dY_t}{Y_t} = \mu_Y dt + \sigma_Y dB_t$$
- Conjecture the return process, μ_t and σ_t to be solved endogenously

$$dR_{s,t} = \mu_t dt + \sigma_t dB_t$$

The Key Friction

- Banks face funding shocks (liquidity crunch, bank runs)
  - Private liabilities
  - Large loss if no enough public liquidity (including cash) to cover the shock
  - Create incentive to hold cash

Banks' Optimization

$$V_t^A = \max_{C_t^A, w_{s,t}^A, w_{l,t}^A} E_0 \int_0^\infty f^A(C_t^A, V_t^A) dt$$

$$s.t.: \frac{dW^A}{W^A} = -\frac{C_t^A}{W_t^A} dt + r_t dt + w_{s,t}^A (dR_{s,t} - r_t) dt - w_{l,t}^A n_t$$

$$- \left(\frac{\lambda}{1+\lambda} (w_{s,t}^A + w_{l,t}^A - 1) - w_{l,t}^A \right) \frac{\phi}{1-\phi} dN_t$$

- The second line: the effect of bank run and liquidity holding
- $\frac{\lambda}{1+\lambda}(w_{s,t}^A + w_{l,t}^A - 1)$ amount of funding withdraw
- $w_{l,t}^A$ public liquidity (cash) that can be used to cover the withdraw
- The remaining: incur a loss

Equilibrium Liquidity Holding

- If the cost of "firesale" is large enough, equilibrium liquidity holding

$$\frac{\lambda}{1+\lambda}(w^A_{s,t} + w^A_{l,t} - 1) = w^A_{l,t}$$

Solve for

$$w^A_{l,t} = \lambda(w^A_{s,t} - 1)$$

  - The economics: leveraging $w^A_{s,t} - 1$ exposure to runs
  - For each unit, need λ additional liquidity

An Array of Liquid Assets

- So far, only one liquid asset: cash
- Introduce an array of liquid assets
  - Very easy: perfectly substitutable liquid assets, price per unit of liquidity is identical
  - Does not make an impact on banks' risk taking
  - Check the paper for solving government bonds' liquidity premium and yield

Agents' Optimization Problem

- Rewrite banks' optimization problem as

$$V_t^A = \max_{C_t^A, w_{s,t}^A} E_0 \int_0^\infty f^A(C_t^A, V_t^A)dt$$

$$s.t.: \frac{dW^A}{W^A} = -\frac{C_t^A}{W_t^A}dt + r_t dt + w_{s,t}^A(\mu_t - r_t - \lambda n)dt + w_{s,t}^A \sigma_t dB_t$$

  - A standard consumpiton-portfolio choice problem, augmented by λn, which disincentives w_s^A

- Households' optimization problem

$$V_t^B = \max_{C_t^B, w_{s,t}^B} E_0 \int_0^\infty f^B(C_t^B, V_t^B)dt$$

$$s.t.: \frac{dW^B}{W^B} = -\frac{C_t^B}{W_t^B}dt + r_t dt + w_{s,t}^B(\mu_t - r_t)dt + w_{s,t}^B \sigma_t dB_t$$

Market Clearing

- Define wealth share $\omega_t = \frac{W_{A,t}}{W_{A,t}+W_{B,t}}$
- Consumption good

$$\omega_t C_t^A + (1-\omega_t) C_t^B = Y_t$$

Policy Implementation: Money Supply

- There exists a one-to-one mappting between money supply and interest rate
  - If the central bank wants to target an interest rate n, its money supply has to equal to banks' demand of reserves
  - Similar to the "money market equilibrium" in undergraduate macro
- Similar: a one-to-one mapping of government debt supply and liquidity premium for government debt

Inflation

- A problem of this model is inflation
  - Nominal rate is controlled by the central bank
  - Real rate is determined by the intertemporal substitution of households and banks
  - Inflation: purely passive and counterfactual

Solution Method

- Single state variable: wealth ratio ω_t
  - Standard in two-agent models
  - The wealth share of banks determine the aggregate risk appetite of the economy - if ω_t is high, most wealth is in the hands of banks, the economy's effective risk aversion is low, and vice versa
  - The asset pricing block: standard procedure starting from price-dividend ratio
- Solution method: projection using Chebyshev approximation
- All endogenous variables are functions of ω_t. Approximate the value functions, solve for endogenous variables and find out the approximation that makes the HJB equations hold

Solution

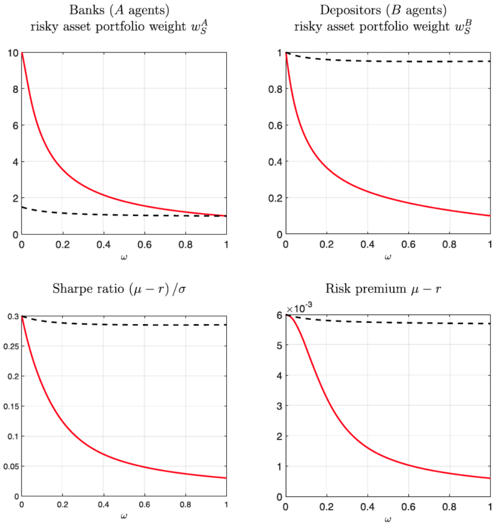


Figure 2. Risk taking, risk premia, and the price of risk. The figure plots the portfolio weight in the risky asset w_S for A agents (banks) and B agents (depositors), and the risk premium $\mu - r$ and Sharpe ratio $(\mu - r)/\sigma$ of the risky asset. Each line corresponds to a nominal rate policy: $n_l = 0\%$ (solid red) and $n_h = 5\%$ (dashed black). (Color figure can be viewed at wileyonlinelibrary.com)

Forward Guidance

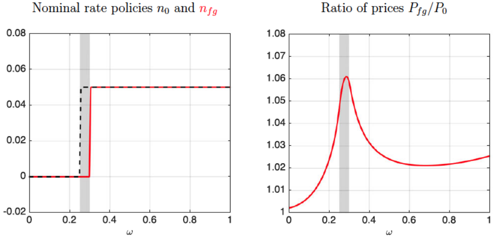


Figure 5. Forward guidance and asset prices. The figure plots the impact of forward guidance on asset prices. The left panel plots the two nominal rate policies n_0 (dashed black line) and n_{fg} (solid red line). The right panel plots the ratio of the price of the risky asset for n_{fg} relative to n_0, P_{fg}/P_0. (Color figure can be viewed at wileyonlinelibrary.com)

The Greenspan Put

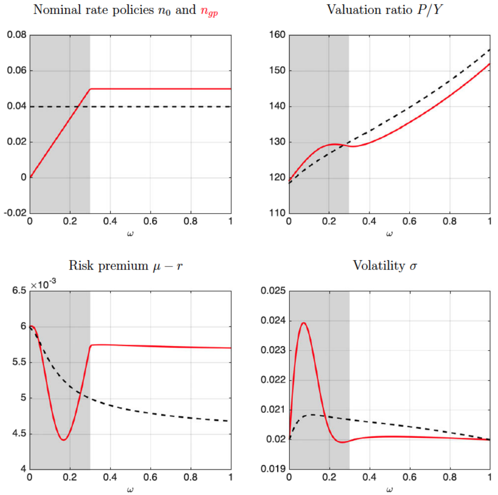


Figure 6. "Greenspan put" policy and asset prices. The figure plots the impact of a Greenspan put policy on prices, risk premia, and volatility. The top left panel plots the two nominal rate policies n_0 (dashed black line) and n_{gp} (solid red line). The top right panel plots the price-dividend ratio $P/Y = 1/F$. The bottom left panel plots the risk premium $\mu - r$, and the bottom right panel plots return volatility σ. (Color figure can be viewed at wileyonlinelibrary.com)

Possible Extensions

- Embed into a macroeconomic framework and fix the "inflation" property
- Imperfect substitution of different liquid assets
- Quantitative performance of the model
- Bank run on the equilibrium path and the role of public liquidity (Li, 2023)
- ....

Possible Directions of Intermediary Asset Pricing

Brunnermeier et al (2020), " Review Article: The Future of Asset Pricing", section 5-6

- Intermediary heterogeneity and their role in asset prices
  - Demand system approach
  - Which intermediaries in which markets?
- Why MM fails - the role of capital, debt overhang, ...
  - Open the box of the financial firm: capital allocation within the firm, career concerns, search for yield, benchmarking, ...
- Connect intermediary AP to macroeconomics