The short rate disconnect in a monetary economy

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Motivation

- Standard approach: short rate satisfies household Euler equation
- Important equation for monetary economics: short rate = policy rate
- With sticky prices, transmission through intertemporal choices
- Empirical evidence: fit models to long rates, can't fit short rate

  e.g., macro models with consumption data, arbitrage-free models in finance
- Household Euler equation implies shadow rate > observed short rate
- Surprising? Households do not hold short bonds directly

This paper: monetary asset pricing with banks

- study environment in which banks hold short bonds
- "banks" are payment intermediaries: commercial banks & MMMF
- study Euler equations of banks
  - important: banks are corporations, maximize shareholder value
  - provide inside money to non-financial sector, debt issuance is cheap
  - key friction: asset management costly, more so if leverage high
  - when risky assets drop in value, leverage is high, costly
  - → banks value short bonds as safe assets to back inside money
- safe short bonds are scarce:
  - endogenous market segmentation: banks hold them
  - disconnect: shadow spread = shadow rate - observed short rate > 0
- Euler equations link shadow spread, leverage and safe portfolio share
- Find: stable business cycle relationships, consistent with model

Literature

- Quantitative monetary asset pricing consumption-based: Lucas 80... related: short end disconnect in arbitrage free models: Duffee 96, Piazzesi 05...
- Convenience yield on bonds Patinkin 56, Tobin 63, Bansal-Coleman 96, Krishnamurthy-Vissing-Jorgensen 12, Venkateswaran-Wright 12, Andolfatto-Williamson 14, Nagel 15
- Intermediary asset pricing He-Krishnamurthy 13, Brunnermeier-Sannikov 14, Greenwood-Vayanos 14, Bocola 15, Moreira-Savov 15, Koijen-Yogo 15, He-Kelly-Manela 17, Muir 17, diTella-Kurlat 17, Haddad-Sraer 18, Haddad-Muir 18, Hanson-Lucca-Wright 18
- Bank liquidity management & demand for reserves Bhattacharya-Gale 87, Whitesell 06, Curdia-Woodford 11, Reis 16, Bianchi-Bigio 17, Drechsler-Savov-Schnabl 18, DeFiore-Hoerova-Uhlig 17, Piazzesi-Schneider 17
- Monetary policy with financial frictions & banking Curdia-Woodford 10, Gertler-Karadi 11, Gertler-Kiyotaki-Queralto 11, Christiano-Motto-Rostagno 12, Del Negro-Eggertson-Ferrero-Kiyotaki 17, Brunnermeier-Sannikov 16, *Williamson 12, 14, Piazzesi-Schneider 17, Piazzesi-Rogers-Schneider 18*

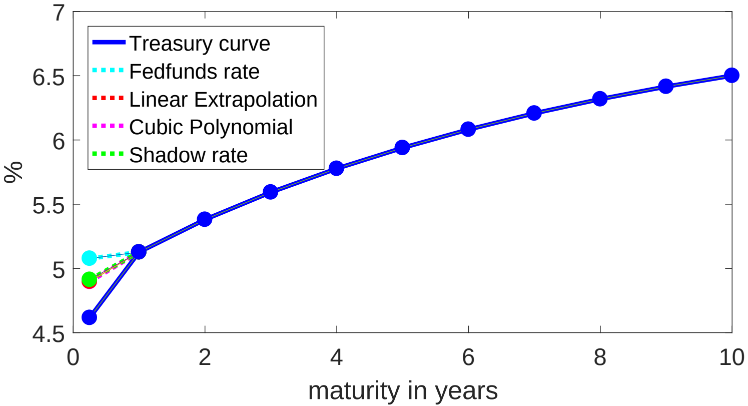
Outline

- evidence on short rate disconnect
- bank maximization problem and Euler equations
- connection between shadow spread, leverage, and safe portfolio share

Short rate disconnect – on average in the data

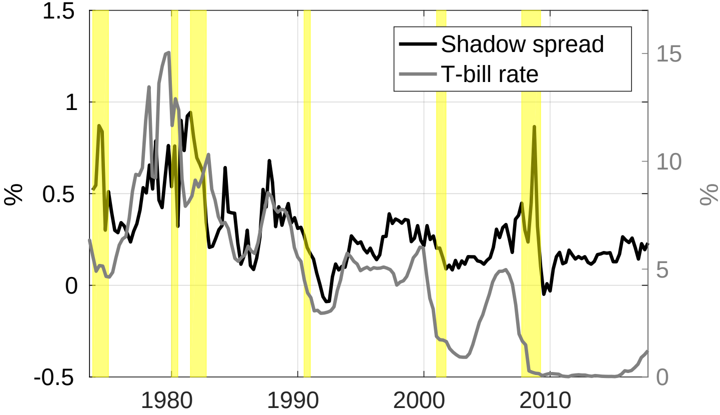
- quarterly data on nominal interest rates
  from Treasury bills and bonds, 1975:Q1-2017:Q4

- fit model to long rates, implied rate > observed short rate
  shadow rate: based on Nelson-Siegel model, reestimated every period



Short rate disconnect – variation over time in the data

- shadow spread = shadow rate − T-Bill rate,
  comoves with T-bill rate, high at the end of booms



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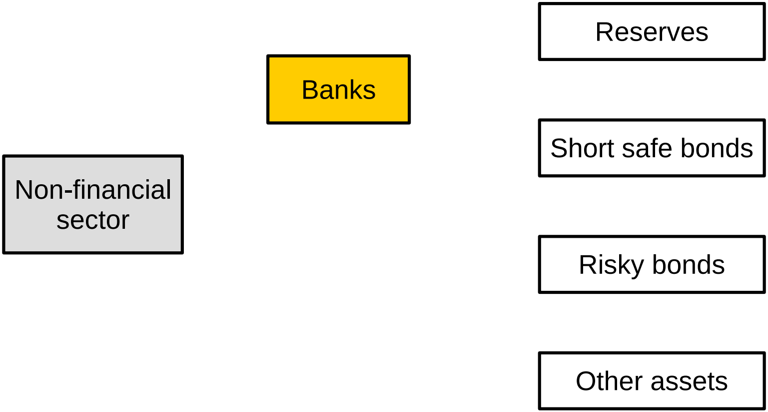
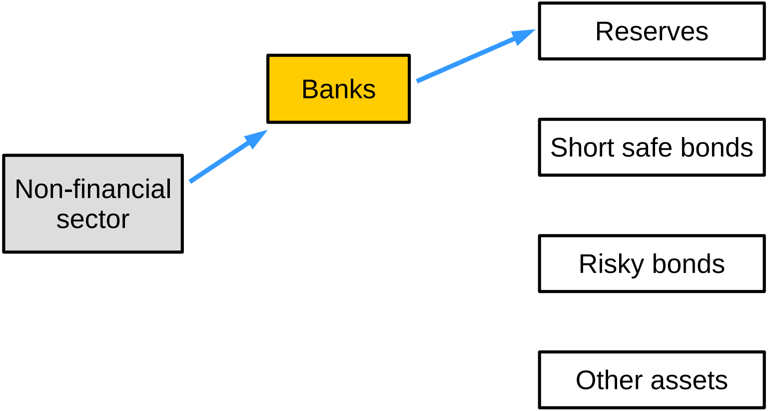
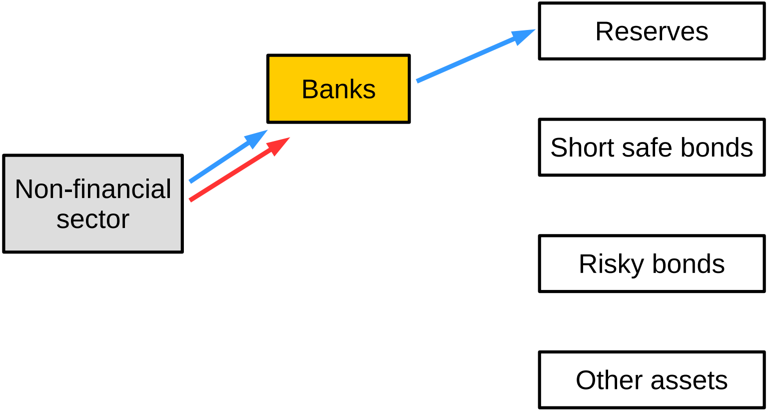
Environment: Households, banks, assets



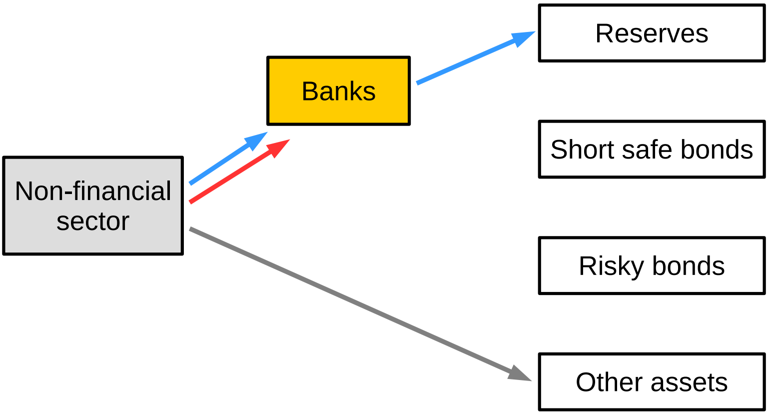
Liquidity benefits from inside money and reserves



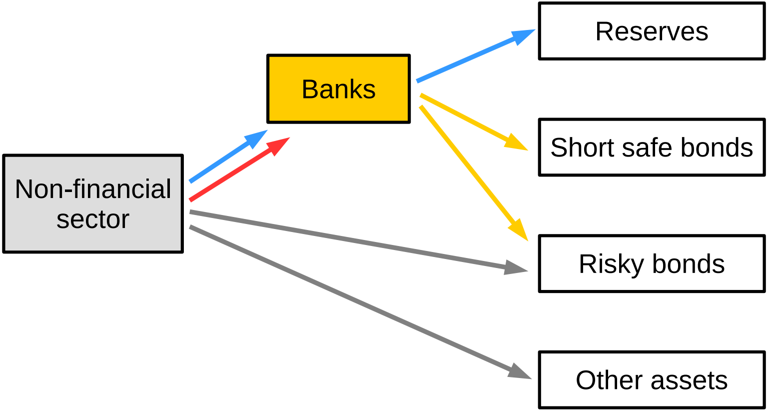
Bank capital structure: debt (inside money) vs equity



Some assets held directly by households



Who holds short safe bonds? Banks want safe collateral



Model in discrete time, infinite horizon

- Nonfinancial sector
  - has demand for inside money D_t, nominal pricing kernel $M^{\$}_{t+1}$

  $\Rightarrow$ nominal "shadow rate" $E_t[M^{\$}_{t+1}](1+i^S_t) = 1$

- Banks are competitive firms, issue deposits and equity
  - maximize shareholder value $\rightarrow$ nominal payoffs discounted by $M^{\$}_{t+1}$
  - total asset value A_t: reserves, short nominal bonds, risky bonds

    $\rightarrow$ portfolio weights: reserves α^M_t, short bonds α^B_t

    $\rightarrow$ weighted nominal return on assets $r^{\alpha,\$}_{t+1}$
  - deposits D_t are cheap source of finance
  - leverage $\ell_t = D_t(1+i^D_t)/A_t$
  - no adjustment costs for equity or assets

Frictions

- Asset management cost, per dollar of assets
  - can be derived from bankruptcy cost, regulation ...
  - $k(.)$ increasing and convex in ex-post leverage:

    $\tilde{\ell}_{t+1} = \ell_t / \left(1 + r_{t+1}^{\alpha,\$}\right)$ = deposits/ nominal return on assets

    $\rightarrow$ large if nominal return on assets is low

    $\rightarrow$ convexity makes bank effectively more risk averse

    $\rightarrow$ $k(0) > 0$: asset management costly even at zero leverage
- Liquidity management cost, per dollar of deposits
  - can be derived from frictional interbank credit market
  - $f(.)$ decreasing and convex in liquidity ratio:

    m_t = reserves / depositors' transactions

Short rate disconnect

- Bank pricing kernel $M_{t+1}^{\$,B} = M_{t+1}^{\$}\left(1 - k\left(\tilde{\ell}_{t+1}\right) + k'\left(\tilde{\ell}_{t+1}\right)\tilde{\ell}_{t+1}\right)$
  - bad states for the bank? low nominal return on assets
  - short nominal bonds have no nominal risk, attractive collateral

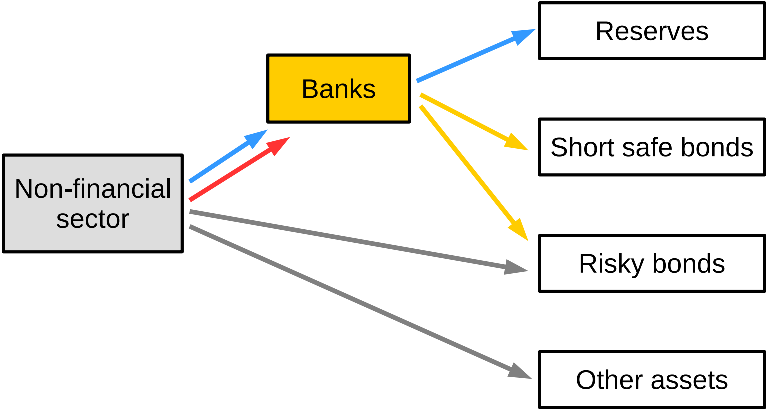
- narrow banks value short safe bonds like non-fin sector $i_t^B = i_t^S$

- risky banks value short safe bonds more than non-fin sector

$\rightarrow$ short rate disconnect, $i_t^B < i_t^S$

- endogenous segmentation: banks hold short safe bonds

Who holds short safe bonds? Banks want safe collateral



Optimal portfolio and leverage

Use bank FOCs to solve for portfolio shares and leverage

- cost function: $k\left(\tilde{\ell}_{t+1}\right) = b\left(\bar{k} + \tilde{\ell}_{t+1}^{\gamma}\right)$, $\gamma > 1$
- summarize portfolio choice by share invested in safe assets:

$$\alpha_t = \alpha_t^M + \alpha_t^B$$

- compression is useful:
  - short safe bonds: $E\left[M_{t+1}^{\$,B}\right]\left(1 + i_t^B\right) = 1$
  - reserves: extra liquidity benefit, $E\left[M_{t+1}^{\$,B}\right]\left(1 + i_t^M\right) = 1 + f'(m_t)$
  - before QE 1, few reserves, $f'(m_t) < 0$, hold mostly bonds, $i_t^B > i_t^M$
  - after QE 1, huge reserves, $f'(m_t) = 0$, perfect substitutes $i_t^M = i_t^B$

Optimal portfolio and leverage

- assume: $M^{\$}_{t+1}$ and risky nominal return are cond. jointly lognormal
- risky nominal log return has conditional variance σ_t^2
- optimal safe portfolio share: $\alpha_t \approx 1 - \frac{1}{\gamma\sigma_t^2} \log\left(1 + \frac{i_t^S - i_t^B}{b\bar{k}}\right)$
  - higher shadow spread makes safe assets expensive,

  $\rightarrow$ lower α_t, hold higher fraction of risky assets

  $\rightarrow$ procyclical risk taking
  - increasing in risk σ_t^2 and curvature γ

- optimal leverage:

$$\ell_t \approx \exp(i_t^S - \alpha_t(i_t^S - i_t^B))\exp\left(-\frac{1}{2}(1-\alpha_t)\left(\log\left(1 + \frac{i_t^S - i_t^B}{b\bar{k}}\right)\right)^2\right)\ell^*$$

  - higher shadow spread, hold higher fraction of risky assets, lower α_t

  $\rightarrow$ lower leverage, not synonymous with low risk

  $\rightarrow$ countercyclical leverage

Outline

- evidence on short rate disconnect
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Quantitative strategy

- 3 observable series:

  shadow spread $i_t^S - i_t^B$, safe portfolio share α_t, leverage ℓ_t

- estimate 2 parameters, $b\bar{k}$ and ℓ^*, by min sum of squares

  $$\ell_t \approx \exp(i_t^S - \alpha_t(i_t^S - i_t^B))\exp\left(-\frac{1}{2}(1-\alpha_t)\left(\log\left(1+\frac{i_t^S - i_t^B}{b\bar{k}}\right)\right)^2\right)\ell^*$$

- back out $\gamma\sigma_t^2$ from $\alpha_t \approx 1 - \frac{1}{\gamma\sigma_t^2}\log\left(1+\frac{i_t^S - i_t^B}{b\bar{k}}\right)$

- "success": 1. good model fit of ℓ_t given α_t, $i_t^S - i_t^B$

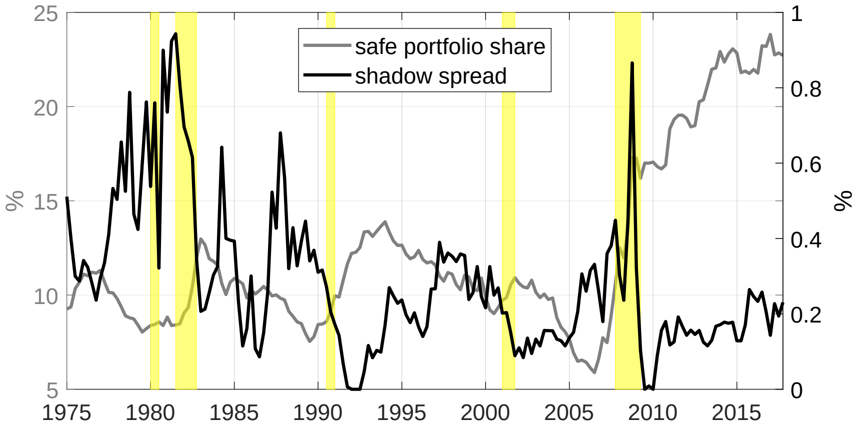
  2. reasonable backed out time series of σ_t^2

Data for quantitative assessment

- Measure deposits D_t: money of zero maturity (MZM)
  - stable money demand for MZM, includes money market funds
- Measure assets A_t: depository institutions, MMFs in Flow of Funds
  - consolidate sectors, subtract liabilities with higher seniority than D_t
- Measure safe portfolio share α_t: fraction of short safe bonds in above
  - e.g. vault cash, reserves, T-bills, net repo-loans

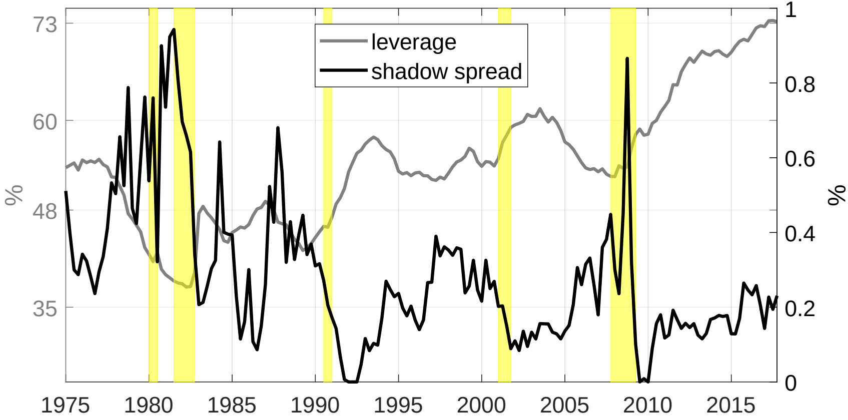
Raw data: shadow spread and portfolio share

- Model prediction: low cost of safety → high safe portfolio share

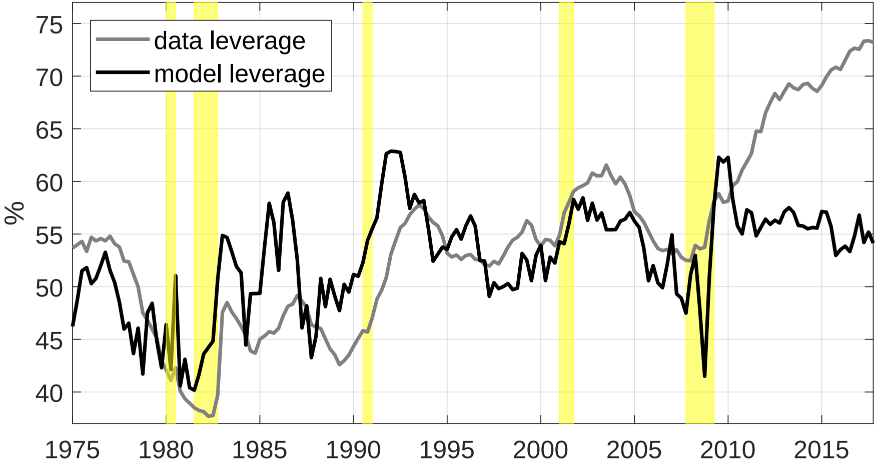


Raw data: shadow spread and leverage

- Model prediction: low cost of safety → high leverage

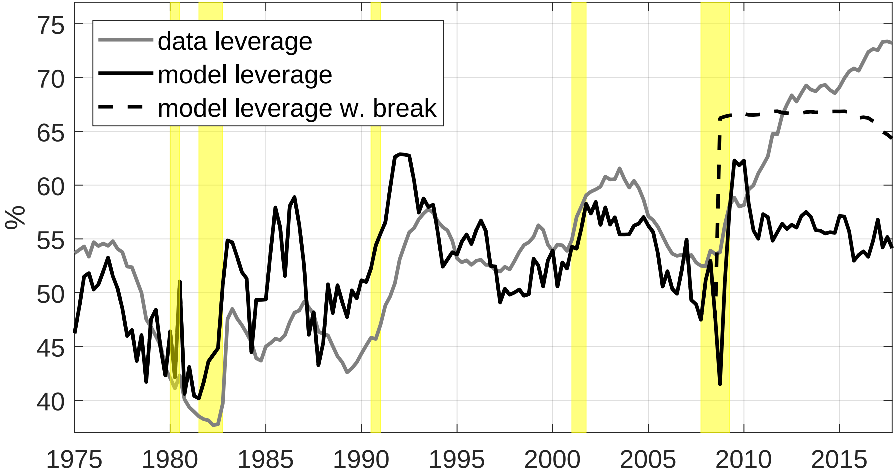


Model vs data



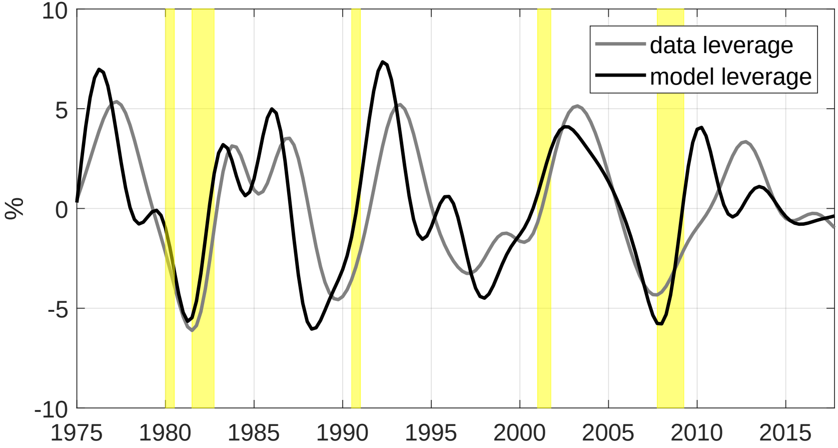
Model vs data

- re-estimate parameter of asset management cost function post crisis



Model vs data

- Use bandpass filter (1.5y-8y) to isolate cyclical component



Conclusion

- Model of monetary economy with payment intermediaries
  - banks value short safe bonds as collateral

    $\rightarrow$ disconnect of short rate from "shadow rate"
  - shadow spread measures cost of safety
  - cost of safety and return risk $\rightarrow$ leverage & portfolio choice
- Estimated Euler equations capture cyclical co-movement
  - procyclical costs of safety and risk taking
  - countercyclical leverage
  - changes in asset management cost improves overall fit
- Transmission of monetary policy through intermediary balance sheets