Intermediation Frictions in Incomplete Markets

ECON 810A - Project

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Secondary Treasury Market in COVID-19 Crisis

- The U.S. Treasury market - widely considered the world's deepest and most liquid financial market - is intermediated by large U.S. banks acting as broker-dealers.
- In March 2020, concerns about COVID-19 prompted many large investors (e.g., hedge funds and foreign governments) to liquidate their holdings of Treasuries.
- Intermediaries in the secondary market for U.S. Treasuries were overwhelmed (Duffie 2020).
  - Yield rose sharply.
  - Space on the balance sheet of broker-dealers for warehousing additional trades diminished.
  - Bid-offer spreads widened.
  - Settlement failures increased.
- Aggressive intervention by the Fed restored market liquidity.

Sources of Intermediation Frictions in Treasury Market

- This episode raised questions about the functioning of the secondary Treasury market, doubts about the safe-haven status of Treasuries, and calls for reform.
- The growth in U.S. government debt outstanding may have outstripped the ability of broker-dealers to effective intermediate the secondary Treasury market.
- Broker-dealers pointed to post-financial-crisis bank regulatory reform - in particular, the Supplementary Leverage Ratio requirement - as the source of the disruption.
- **Research Question:** How does the intermediation of illiquid assets affect portfolio choice?

Multiple Assets

- To explore this question, I turned to Bewley-style models with multiple assets.
- In the baseline Bewley model (and models covered in ECON 810A), household can only invest in one-period risk-free bonds.
- In reality, households invest in many assets, including cash, real estate, stocks, bonds, etc.
- Optimal portfolio choices change with wealth and age (Brandsas 2020).
- The curse of dimensionality quickly hampers rich portfolio choice problems in Bewley-style model.

Literature Review - Kaplan and Violante (2014)

- Empirical literature finds that households spend about 25 percent of tax rebates on consumption immediately inconsistent with prediction from single-asset Bewley.
- Build a Bewley-style model with two assets: low return liquid asset and high return illiquid asset.
- HHs must pay fixed cost to adjust illiquid asset holding.
- Many HHs are optimally "wealthy hand-to-mouth" (i.e., hold very little liquid assets despite sizable amount of illiquid assets).
- Wealthy hand-to-mouth HHs have high MPC and rationalize empirical motivation.

Literature Review - Rios-Rull and Sanchez-Marcos (2008)

- Build a Bewley-style model with financial assets and nonfinancial assets.
- Financial assets are perfectly divisible and costless to buy or sell.
- Nonfinancial assets are bulky, indivisible, and have transaction costs.
- Label the nonfinancial assets as “houses”.
- Find reasonable lifecycle pattern: HHs accumulate some financial assets for downpayment, then buy a small house, then buy a large house.
- HHs pay a fixed cost to trade their house.

Approach

- Similar to Kaplan and Violante (2014) and Rios-Rull and Sanchez-Marcos (2008), I use two assets.
    - Here, cash and a long-term bond with stochastic maturity.
- Instead of second asset coming from fixed transaction cost, I use random search for intermediary (i.e. broker-dealer).

Environment

- Two agents:
  - Households.
  - Intermediaries.

- Two assets:
  - Cash/consumption good without no return.
  - Long-term illiquid bonds with return r.
  - Fraction $\delta \in (0,1)$ of long-term bonds mature into cash each period.

- Households randomly search for intermediaries:
  - If an household and an intermediary meet, the household can sell long-term bonds.
  - Nash bargain over price with $\theta \in (0,1)$ being the bargaining power of the household.
  - Households can always buy long-term bonds (i.e. "on-the-run" Treasuries), but can only sell them through an intermediary (e.g. "off-the-run" Treasuries).

Model Timing

1. Exogenous labor income is drawn.
2. Long-term bonds return r.
3. Households and intermediaries meet.
4. Consumption good is eaten.
5. Households and intermediaries bargain and trade.
6. Value functions are evaluated.

Intermediaries

- Intermediaries are infinitely lived and risk-neutral.
- Discount factor β_I.
- They have "deep pockets".
- They consume long-term bonds as they mature.
- Their value for buying b long-term bonds from a HH:

$$W(b) = \underbrace{\beta_I \delta b}_{\text{consumption one period after trade}} + \underbrace{\beta_I^2 (1-\delta)\delta b}_{\text{consumption two period after trade}} + \underbrace{\beta_I^3 (1-\delta)^2 \delta b}_{\text{consumption three periods after trade}} + \ldots$$

$$= \frac{\beta_I \delta b}{1 - \beta_I (1-\delta)}$$

Households

- Live for T periods.
- Risk averse.
- Discount factor β.
- Exogenous Markov process for labor earnings y.
- Make consumption-savings choice with zero borrowing limit.
- Hold cash a.
- Hold long-term illiquid bonds b.
- Meet an intermediaries with probability γ and can liquidate fraction ℓ of their long-term illiquid bonds.
- The HHs value function is:

$$V_t(y, a, b) \equiv \gamma \underbrace{V_t^M(y, a, b)}_{\text{value if matched}} + (1 - \gamma) \underbrace{V_t^U(y, a, b)}_{\text{value if matched}}$$

Unmatched Households Value Function

- A HH that is not matched with an intermediary choose consumption c, cash tomorrow a', and purchase new long-term bonds $\tilde{b}'$ to maximize utility:

$$V_t^U(y,a,b) = \max_{c,a',\tilde{b}'} \left\{ \underbrace{u(c)}_{\text{instantaneous value}} + \underbrace{\beta E[V_{t+1}(y',a',b')]}_{\text{continuation value}} \right\}$$

subject to

$$c + a' + \underbrace{\tilde{b}'}_{\text{new LT bonds}} = y + a + \underbrace{\delta b(1+r)}_{\text{matured LT bonds}}$$

$$b' = \underbrace{\tilde{b}'}_{\text{new LT bonds}} + \underbrace{(1-\delta)b(1+r)}_{\text{unmatured LT bonds}}$$

$$a', \tilde{b}' \geq 0$$

Matched Households Value Function

- A HH that is matched with an intermediary can either buy LT bonds (same problem as unmatched) or sell LT bonds:

$$V_t^M(y,a,b) = \max\left\{ \underbrace{V_t^U(y,a,b)}_{\text{buying LT bonds}}, \right.$$

$$\left. \underbrace{\max_{c,a',\ell}\left\{u(c) + \beta E[V_{t+1}(y', a' + \overbrace{P(\ell(1-\delta)b(1+r))}^{\text{proceeds from selling LT bonds}}, b')]\right\}}_{\text{selling LT bonds}} \right\}$$

subject to

$$\begin{aligned} c + a' &= y + a + \delta b(1+r) \\ b' &= \underbrace{(1-\ell)(1-\delta)b(1+r)}_{\text{unsold, unmatured LT bonds}}, \quad a' \geq 0, \ell \in [0,1] \end{aligned}$$

Nash Bargaining

- The matched household has $\hat{b}' \equiv \ell(1-\delta)b(1+r)$ LT bonds to sell.
- The value to the intermediary is $W(\hat{b}') - P$.
- The outside option for the intermediary is zero.
- The value to the household is $\beta E[V_{t+1}(y', a' + P, b')]$.
- The outside option for the household is the unmatched value function: $\beta E[V_{t+1}(y', a', b' + \hat{b}')]$.

Nash Bargaining (con't)

- Nash bargaining solves:

$$\max_{P} \left[\underbrace{\beta E[V_{t+1}(y', a' + P, b') - \beta E[V_{t+1}(y', a', b' + \hat{b}')]}_{\text{surplus of HH}} \right]^{\theta}$$

$$\times \left[\underbrace{W(\hat{b}') - P}_{\text{surplus of intermediary}} \right]^{1-\theta}$$

FOC

Nash Bargaining (con't)

$$\theta E[V_{a,t+1}(y', a' + P, b')] \left[W(\hat{b}') - P \right]$$
$$- (1-\theta) \left[E[V_{t+1}(y', a' + P, b') - E[V_{t+1}(y', a', b' + \hat{b}')] \right] = 0$$

We can solve this pricing condition numerically by:

- Numerically calculating $E[V_{a,t+1}(y', a' + P, b')]$.
- Using root solver.

Computational Strategy

- Start at period T, where households eat all labor earnings, cash, and matured long-term bonds. There's no $T+1$ period, so matched HHs do not liquidate any LT bonds.
- For any period t,
  - Solve unmatched HH problem.
  - Solve matched HH problem conditional on selling LT bonds. Guess ℓ and a', solve price condition (with root solver) for P, evaluate value function, and choose optimum.
  - Matched HH problem solution is max of unmatched solution and matched solution conditional on selling.
- Use linear interpolations due to two continuous state variables.
- Coarse grid for solving the model; finer grid for simulating the model.

Calibration

- Average maturity of outstanding U.S. Treasury is 70 months, so $\delta = 0.17143$. more
- CRRA utility with coefficient of relative risk aversion equal to 2.
- Annual frequency.
- Two state Markov earnings process with $y_e = 1.0$ and $y_u = 0.5$ with $\pi_{ee} = 0.9$ and $\pi_{uu} = 0.5$ to match employment rate and employment duration.
- $T = 30$.
- $\beta = 0.99$
- $\theta = 0.5$
- $r = 0.1$

Policy Experiments changing Intermediation Frictions

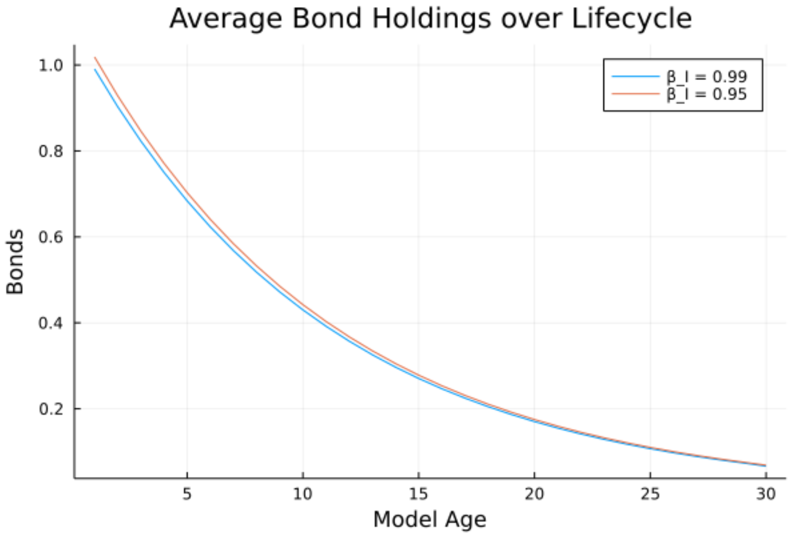
	Baseline	Policy Experiment #1	Policy Experiment #2
β_I	0.99	0.95	0.99
γ	0.2	0.2	0.1

- Policy Experiment #1: Intermediaries are less patient $\implies$ consuming b over time less $\implies$ price drops

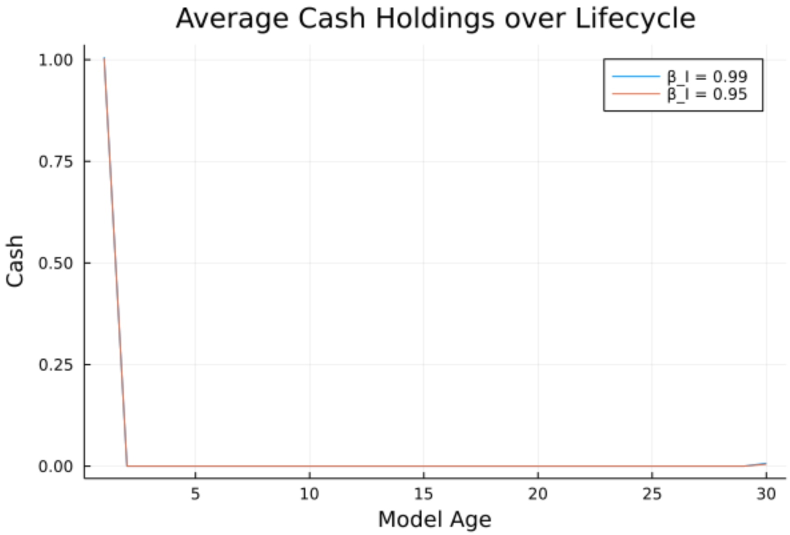
$$\frac{\partial W(b)}{\partial \beta_I} = \frac{\delta b}{[1-\beta_I(1-\delta)]^2} > 0$$

- Policy Experiment #2: HH is less likely to meet intermediate.

Policy Experiment #1



Policy Experiment #1



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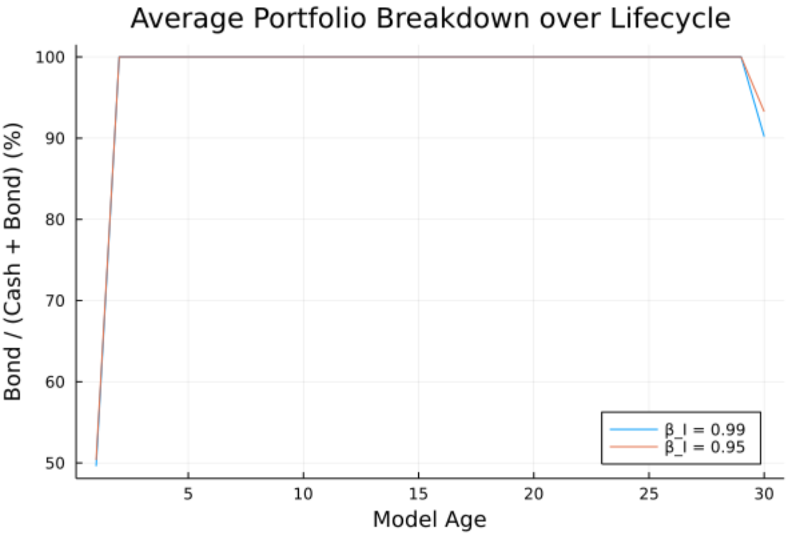

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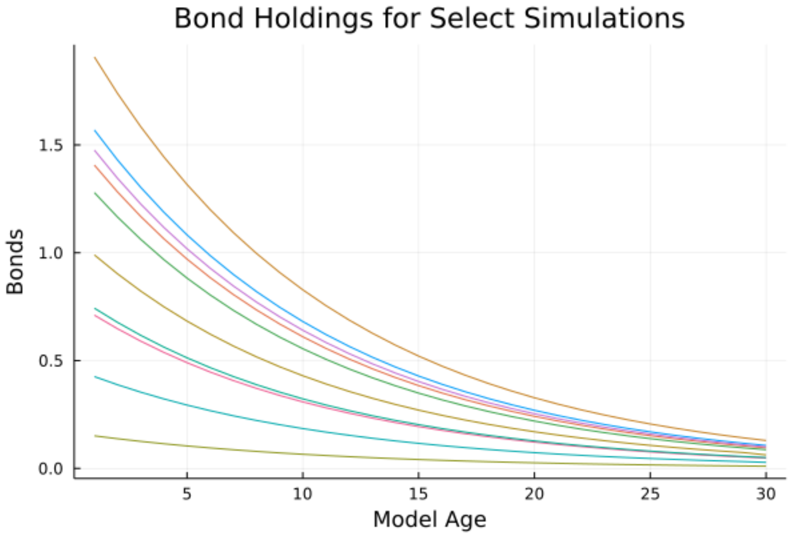

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Kaplan, Greg and Giovanni L. Violante (2014). "A Model of the Consumption Response to Fiscal Stimulus Payments," Econometrica, Vol. 82, No. 4, July 2014, 1199-1239.

Rios-Rull, Jose-Victor and Virginia Sanchez-Marcos (2008). "An Aggregate Economy with different Size Houses," Journal of European Economic Association, Vol. 6, No. 2/3, Proceedings of the Twenty-Second Annual Congress of the European Economic Association (Apr. - May, 2008), pp. 705-714

Nash Bargaining (con't)

- First order condition:

$$\theta\left[\beta E[V_{t+1}(y',a'+P,b') - \beta E[V_{t+1}(y',a',b'+\hat{b}')]\right]^{\theta-1}$$

$$\times\ \beta E[V_{a,t+1}(y',a'+P,b')]\left[W(\hat{b}')-P\right]^{1-\theta}$$

$$=(1-\theta)\left[W(\hat{b}')-P\right]^{-\theta}$$

$$\times\ \left[\beta E[V_{t+1}(y',a'+P,b') - \beta E[V_{t+1}(y',a',b'+\hat{b}')]\right]^{\theta}$$

Calibration δ

Average maturity of LT bond is:

$$\delta + 2(1-\delta)\delta + 3(1-\delta)^2\delta + ... = \delta \sum_{t=1}^{\infty} t(1-\delta)^{t-1}$$

For average maturity of $70/12 \approx 5.833 \implies \delta \approx 0.17143$