Intermediary Balance Sheets and the Treasury Yield Curve

Wenxin Du[1] Benjamin Hébert[2] Wenhao Li[3]

[1]Chicago, FRBNY, NBER, and CEPR

[2]Stanford and NBER

[3]USC Marshall School of Business

April 2023

Treasury “Inconvenience”?

Pre-GFC:

- Treasury bonds were convenient (low yield relative to swap rates)
  - i.e. positive swap spreads (swap rate - Treasury yield)
- Covered interest parity (CIP) violations were roughly zero

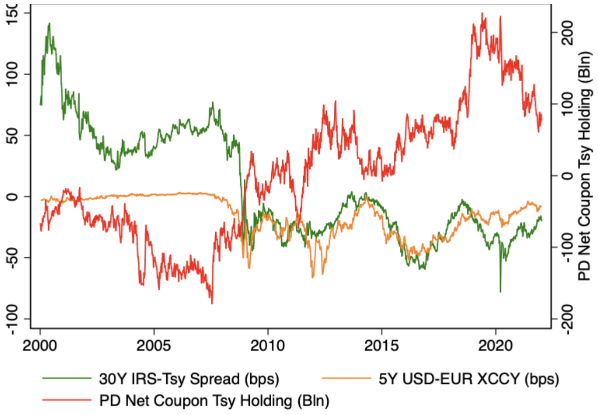
Post-GFC:

- Treasury bonds are inconvenient (negative swap spreads)
- CIP violations are non-zero

This paper: unified framework to explain the swap spread, dealers’ positions, and CIP deviations

- Sign of position, swap spreads coincide (“regimes”)
- Regime determines effects of QE/QT and other policies

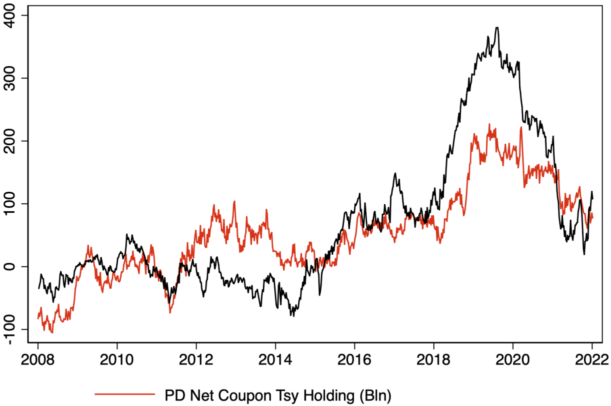
Dealer Treasury Position, Swap Spreads, and CIP Deviations



- Known Facts: (i) swap spread pos. to neg. and (ii) CIP zero to neg.
- New Facts: (i) dealer net position neg. to pos. and (ii) CIP/swap spread

Dealers and the Implied Levered Investors' Holdings

- Levered investors rely on dealers' balance sheet to finance Treasury holdings.
- Dealer's own holdings are quite correlated with the implied relative-value hedge fund holdings.



What We Do?

1. Using swap rate and CIP deviations to construct a dealer-long and dealer-short curve for Treasury bonds
   - The actual yield switched from the dealer-short to the dealer-long curve, consistent with the change in the net position.
   - Different from alternative views: (1) dealers seek Treasury returns; (2) dealers take a net-neutral position and only charge bid-ask spreads.

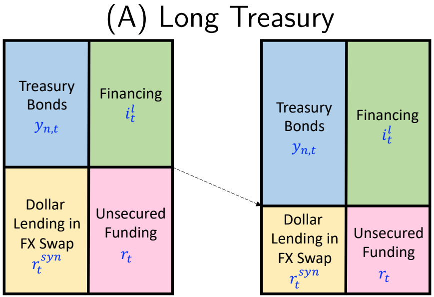
2. Two-period, two-market equilibrium model (Treasury bonds and synthetic dollars)
   - Endogenous dealer position
   - Policy implications

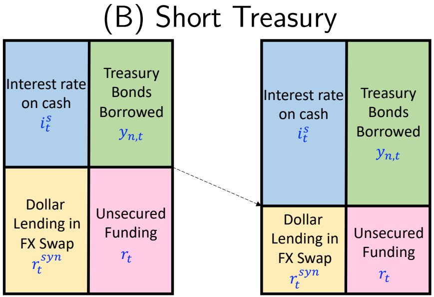
Related Literature

- Jermann (2020): calibration in which dealer constraints explain negative swap spreads
  - We measure quantities, quantify constraints with CIP, explain quantity-slope correlation
- He, Nagel, and Song (2021): shares focus on dealer leverage constraints and swap-treasury spreads.
  - They compare GFC vs. COVID crisis events; explanation: sign of customer shocks
  - We compare pre- and pre-GFC periods; explanation: regimes, no change in shocks
- Our view: Treasurys are convenient to clients but inconvenient to intermediaries.
  - Treasury convenience: Longstaff (2004), Krishnamurthy and Vissing-Jorgensen (2012), Greenwood, Hanson, and Stein (2015), etc.
- The market equilibrium model in Hanson, Malkhozov, and Venter (2022) is similar in spirit to ours but focuses on the swap market. Complementary approach.
- Our arbitrage view of dealer bond trading contrasts the return-seeking view of commercial banks in Haddad and Sraer (2020).

1. Dealer-Long and Dealer-Short Curves

Balance-Sheet Neutral Treasury Trading Strategies





A Simple Model of Dealers and Arbitrage

- Consider a dealer that chooses between trading a single *n*-period zero-coupon Treasury bond, v.s. CIP arbitrage.
- $\mathbb{Q}$ reflects dealer's SDF for zero-cost, zero-balance-sheet trades (i.e. derivatives).
- Define the expected next-period bond price as

$$p_{\mathbb{Q}} \equiv \exp(-(n-1)y_{\mathbb{Q}}) \equiv E^{\mathbb{Q}}[\exp(-(n-1)y_{n-1,1})]$$

Dealer's Problem

$$\max_{q^{bond},q^{syn}} \Big(\underbrace{e^{r^{syn}} - e^{r}}_{\text{synthetic lending spread}} \Big) \cdot q^{syn}$$
$$+ \Big(\underbrace{\frac{p_{\mathbb{Q}}}{e^{-ny}}}_{\text{sell after one period}} - \underbrace{e^{r^{l}}}_{\text{secured financing rate}} \Big) \cdot \max\{q^{bond}, 0\}$$
$$+ \Big(\underbrace{e^{r^{s}}}_{\text{principal+interest on cash}} - \underbrace{\frac{p_{\mathbb{Q}}}{e^{-ny}}}_{\text{buy back}} \Big) \cdot \max\{-q^{bond}, 0\}$$

subject to balance sheet constraint:

$$|q^{bond}| + q^{syn} \leq \bar{q}$$

- We avoid corner solutions by assuming dealers do CIP arbitrage, i.e., $q^{syn} > 0$.

The Long Regime

- Long regime (the optimal $q^{bond} > 0$): dealer FOC implies

$$e^{-ny} = \frac{p_{\mathbb{Q}}}{e^{r^l} + (e^{r^{syn}} - e^r)}.$$

- Denote the long-regime yield as y^l. Consider a special case of one-period bond $(n = 1, p_{\mathbb{Q}} = 1)$. The log-linearized version is

$$y^l \approx r^{syn} - r + r^l,$$

or equivalently,

$$\underbrace{r - y^l}_{\text{swap spread}} \approx - \underbrace{(r^{syn} - r)}_{\text{balance sheet cost}} + \underbrace{(r - r^l)}_{\text{funding benefit}} .$$

The Short Regime

- Short regime (the optimal $q^{bond} < 0$): dealer FOC implies

$$e^{-ny} = \frac{p_{\mathbb{Q}}}{e^{r^s} - (e^{r^{syn}} - e^r)}.$$

- Denote the short-regime yield as y^s. Consider a special case of one-period bond ($n = 1, p_{\mathbb{Q}} = 1$). The log-linearized version is

$$y^s \approx -(r^{syn} - r) + r^s,$$

or equivalently,

$$\underbrace{r - y^s}_{\text{swap spread}} \approx \underbrace{r^{syn} - r}_{\text{balance sheet cost}} + \underbrace{(r - r^s)}_{\text{lower return on cash collateral}}.$$

Multi-Period Net Long and Net Short Curve

- Same logic as the two-period model. All yields are now in annualized units, but each period is one month.
- Dealers must be willing to long if $y_{n,t} \geq y^l_{n,t}$, defined recursively by

$$e^{-\frac{n}{12} y^l_{n,t}} = \frac{E^Q_t[e^{-\frac{n-1}{12} y^l_{n-1,t+1}}]}{e^{\frac{1}{12} r^{tri}_t} + \left(e^{\frac{1}{12} r^{syn}_t} - e^{\frac{1}{12} r_t}\right)}$$

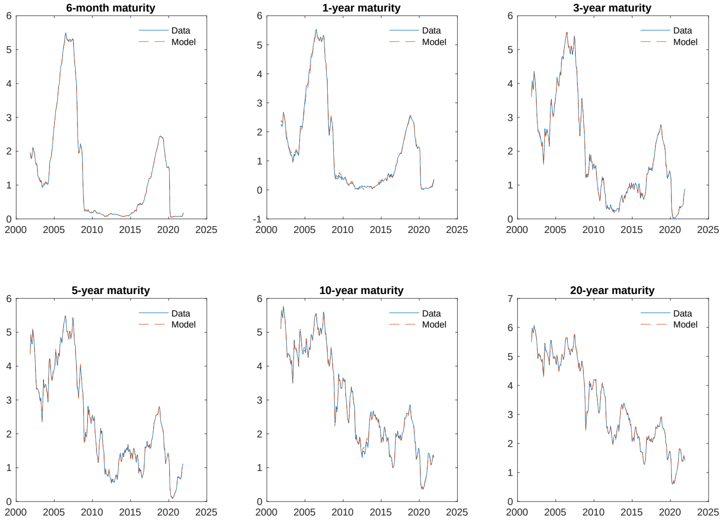
- Dealers must be willing to sell if $y_{n,t} \leq y^s_{n,t}$, defined recursively by

$$e^{-\frac{n}{12} y^s_{n,t}} = \frac{E^{\mathbb{Q}}_t[e^{-\frac{n-1}{12} y^s_{n-1,t+1}}]}{e^{\frac{1}{12} r^{sec}_t} - \left(e^{\frac{1}{12} r^{syn}_t} - e^{\frac{1}{12} r_t}\right)}$$

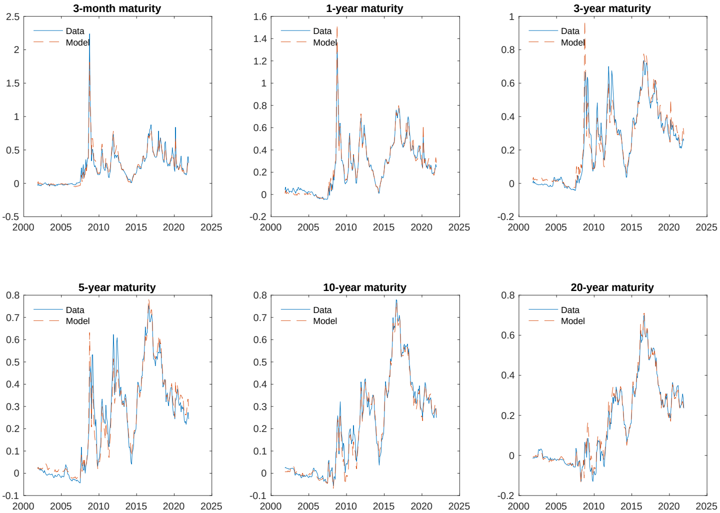
The Term Structure Model

- Fit term structure model to swap curves and CIP curves
- Use standard affine TS approach as in Joslin, Singleton, and Zhu (2011)
- Then construct net long and net short curves
- Key point: TS model for interpolation, Jensen's inequality, etc... Balance sheet costs + funding spreads are key inputs, determined by data

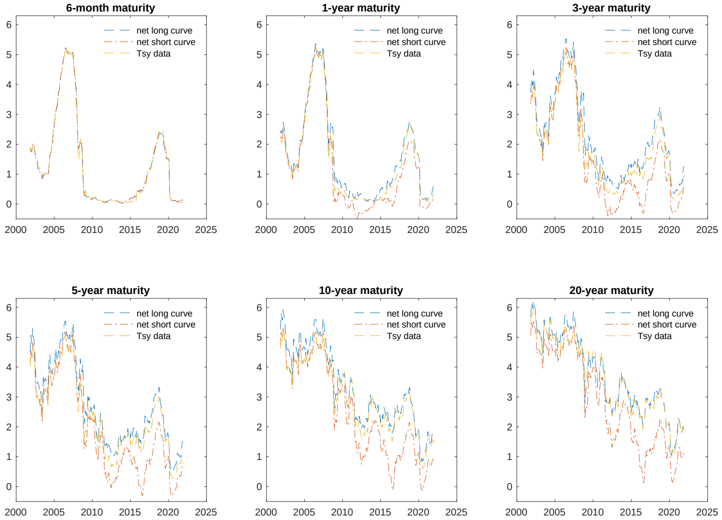
Swap Curve Fit



Cross-Currency Basis Fit

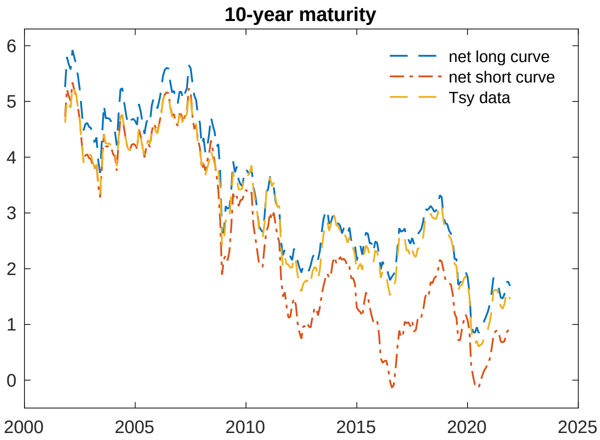


The Net Long and Net Short Curves

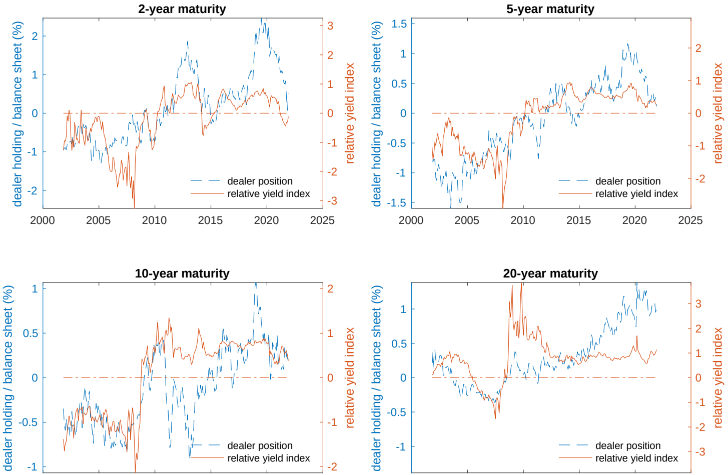


10Y Yield pre- and post-GFC

- The actual bond yield switches from the dealer-short to the dealer-long curve, consistent with the change in dealers' position.



Treasury Yields Relative to Long/Short Curves and Dealer Positions



2. Equilibrium Model

An Equilibrium Model

- Endogenous variables: (1) current n-period treasury bond yield y; (2) synthetic dollar lending rates r^{syn}. (3) Intermediary choices q^{bond} and q^{syn}.
- Intermediaries (consolidated dealers and levered clients) optimize profit subject to constraint

$$|q^{bond}| + q^{syn} \leq \bar{q}$$

- Real-money investors (e.g., pension funds and mutual funds) demand

$$D_U^{bond} = D_U(\underbrace{ny - (n-1)y_{\mathbb{P}} - y^{bill}}_{\text{Exp. Dollar Return vs Bill}})$$

- FX-hedge foreign investors (e.g., foreign life insurance companies) demand

$$D_H^{bond} = D_H(\underbrace{ny - (n-1)y_{\mathbb{P}} - r^{syn}}_{\text{Exp. Dollar Hedged Excess Return}})$$

- Each unit of bond requires synthetic financing, so $D_H^{syn} = D_H^{bond}$.

Market Clearings

- Treasury market:

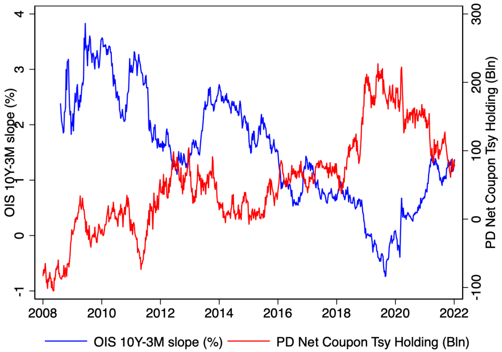
$$\underbrace{\exp(-ny)S^{bond}}_{\text{Treasury bond supply in dollars}} = q^{bond} + D_U^{bond} + D_H^{bond}$$

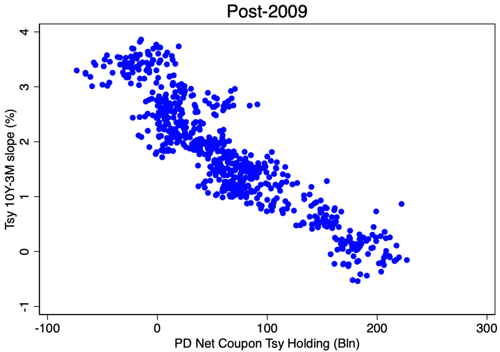
- Synthetic lending market:

$$\underbrace{q^{syn}}_{\text{intermediary supply of syn lending}} = D_H^{bond} + \underbrace{D^{syn}(r^{syn} - r)}_{\text{residual demand}}$$

Dealers' Position Negatively Correlated with the Slope

- The model implies that a steeper Treasury yield slope is correlated with stronger real-money demand for Treasury, which results in a lower dealer position, and a more negative swap spread.
- Contrasts with Jermann (2020) that the dealer inventory increases in the slope.



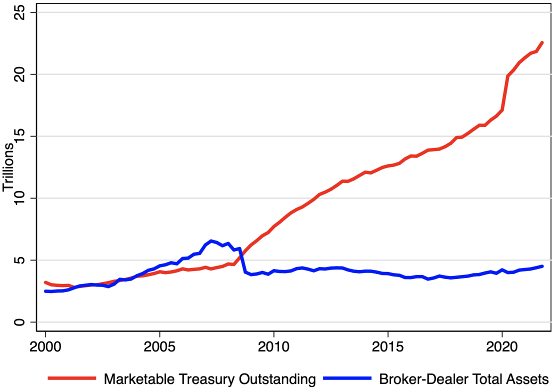


Key Results (Summary)

- The equilibrium is unique
- Equilibria can be classified as long/intermediate/short based on q^{bond}
- Comparative statics differ across equilibria. For example:
  - long regime: larger bond supply S^{bond} increases y and r^{syn}.
  - short regime: larger bond supply S^{bond} increases y but decreases r^{syn}.
- Key regime determinant: bond supply and term premium.
  - Bond supply high (low): long (short) regime
  - swap term premium high (low): short (long) regime

Key Changes Pre/Post GFC

- Supply of Treasury bonds has increased significantly, dealer balance sheets have contracted



Source: U.S. Flow of Funds

Regimes and Treasury Market Fragility

- Crises reduce dealer capacity $\bar{q}$.
  - In the short regime (pre-2009) a bad shock to intermediary balance sheet decreases the Treasury yield relative to swaps.
  - In the long regime (post-2009) a bad shock to intermediary balance sheet increases the Treasury yield relative to swaps.
- An explanation of the Treasury market turmoil in March 2020 (Duffie (2020)).
  - Our explanation does not rely on "selling pressure" in the Treasury market (He, Nagel, and Song (2022)). Quantifying both forces is an interesting future direction.

Policy Implications

- Caveat: partial equilibrium, holds fixed swap and money market rates $\rightarrow$ determined by policy expectations
  - interpret Tsy yield and lending rate as relative spreads to swaps.
- Synthetic lending rate r^{syn} is the rate on all non-repo-financed, balance-sheet-using assets.

Policy Type	Long Regime		Short Regime	
	Tsy Yield	Lending Rate	Tsy Yield	Lending Rate
QT	$\uparrow$	$\uparrow$	$\uparrow$	$\downarrow$
$\downarrow$ Term premium	$\uparrow$	$\uparrow$	$\uparrow$	$\downarrow$
SLR Exemptions	$\downarrow$	$\downarrow$	$\uparrow$	$\downarrow$
Dollar swap line	$\downarrow$	$\downarrow$	$\uparrow$	$\downarrow$