Intermediary Balance Sheets and the Treasury Yield Curve

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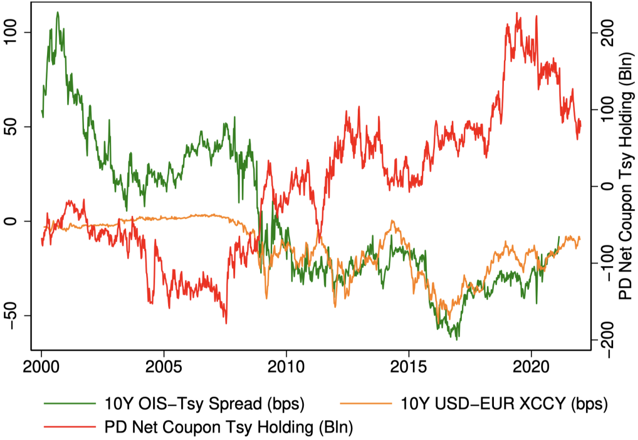
[1]The views expressed in this presentation are those of the authors and not those of the Federal Reserve Board of Governors or the Federal Reserve System.

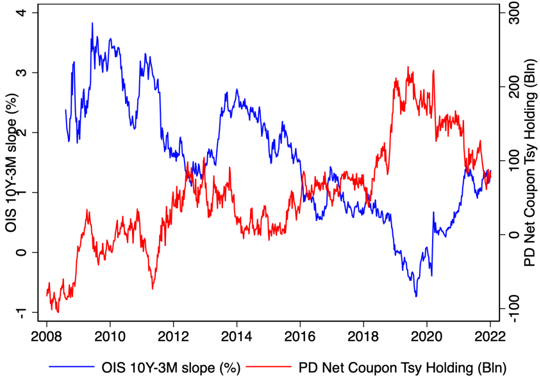
Dealer Treasury Position, Swap Spreads, and CIP Basis

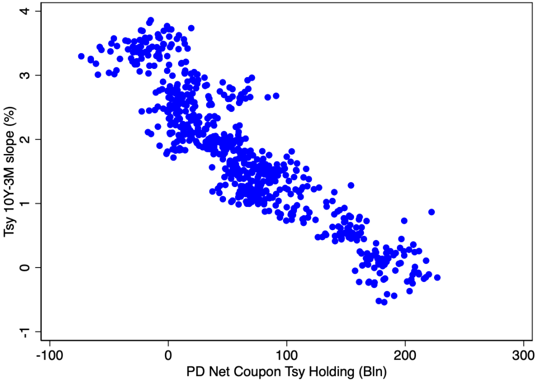


- Pre-GFC: zero basis, positive swap spreads, dealers short
- Post-GFC: negative basis, negative swap spreads, dealers long, co-movement

Arbitrage Drives Dealer Net Treasury Positions

- Dealer position decreases with term spread (proxy for term premium).





What We Do (1)

- Construct long and short arbitrage bounds for treasury yields
  - Novel approach: no-arbitrage-style reasoning that accommodates balance sheet costs
  - Affine term structure model.

- Show that actual yields switched bounds, regime really did change
  - close to short bound when dealers were short (pre-GFC)
  - close to long bound when dealers were long (post-GFC)
  - i.e. arbitrage explains dealer net demand for treasurys

What We Do (2)

- Interact dealers doing arb. with clients seeking returns
  - Two-period, two-market model (treasury bonds and synthetic dollars)
  - Swaps and money markets exogenous
  - Comparative statics depend on regime
  - $+$Tsy supply, $-$balance sheets can generate observed changes
- Policy implications:
  - curve flattening and quantitative tightening will constrain dealer balance sheets
  - leading to higher treasury yields, CIP basis
  - regulatory (SLR) exemptions and swap lines can help

Key Contributions

Key idea: Treasury market regime is central to understanding pricing dynamics and policy effects.

Contributions:

1. Quantitatively show *same* balance sheet costs can explain CIP and swap spreads
2. Show dealers net Treasury demand is driven by arbitrage (vs. market making or return seeking)
3. Suggest Treasury supply as key driver of regime change
4. Show that many monetary, fiscal, and regulatory policies have regime-dependent effects

Broader Agenda: Asset Pricing with Arbitrage

- Du, Hébert, Huber (2022): Is the risk that arbitrage spreads get bigger priced?
  - Yes; it is a substantial component of dealers' SDFs
- Hébert (2022): What can we learn about the optimality of policy from the signs of arbitrage spreads?
  - A lot: we can infer what kinds of externalities would justify current policy

Simplest Possible Dealer's Problem

- Dealer chooses single n-period zero coupon Treasury bond vs CIP arbitrage:

$$\max_{q^{bond},q^{syn}} \Big(\underbrace{ER^{bond}}_{\text{return of owning bond for one period}} - \underbrace{I^{l}}_{\text{financing of long position}} \Big) \cdot \max\{q^{bond},0\}$$
$$+ \Big(\underbrace{I^{s}}_{\text{return earned on cash collateral}} - \underbrace{ER^{bond}}_{\text{return of shorting bond for one period}} \Big) \cdot \max\{-q^{bond},0\}$$
$$+ \Big(\underbrace{R^{syn} - R}_{\text{CIP arbitrage spread}} \Big) \cdot q^{syn}$$

subject to a fixed balance sheet constraint:

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

Regimes

Assume $q^{syn} > 0$ (realistic). Three regimes:

1. Long: $q^{bond} > 0$, $ER^{bond} = I^l + (R^{syn} - R)$
2. Short: $q^{bond} < 0$, $ER^{bond} = I^s - (R^{syn} - R)$
3. Intermediate: $q^{bond} = 0$

Log-linearize (lowercase = log):

- $ER^{bond} = E[\exp(ny - (n-1)y')] \approx 1 + ny - (n-1)y_{\mathbb{Q}}$
- We have $y^s \leq y \leq y^l$, with
  - $y^s \approx \frac{n-1}{n} y_{\mathbb{Q}} + \frac{1}{n}(i^s - r^{syn} + r)$.
  - $y^l \approx \frac{n-1}{n} y_{\mathbb{Q}} + \frac{1}{n}(i^l + r^{syn} - r)$.
  - $y_{\mathbb{Q}}$: expected future bond yield

No Arbitrage Pricing with Balance Sheet Costs

- Much more generally, in multi-period setting: $y^s_{n,t} \leq y_{n,t} \leq y^l_{n,t}$

- net long curve: $y^l_{n,t} = -\frac{1}{n}\ln(E^{\mathbb{Q}}_t[\exp(-\sum_{j=0}^{n-1} x_{1,t+j})])$
  - $x_{1,t} = \ln(I^l_t + R^{syn}_t - R_t)$

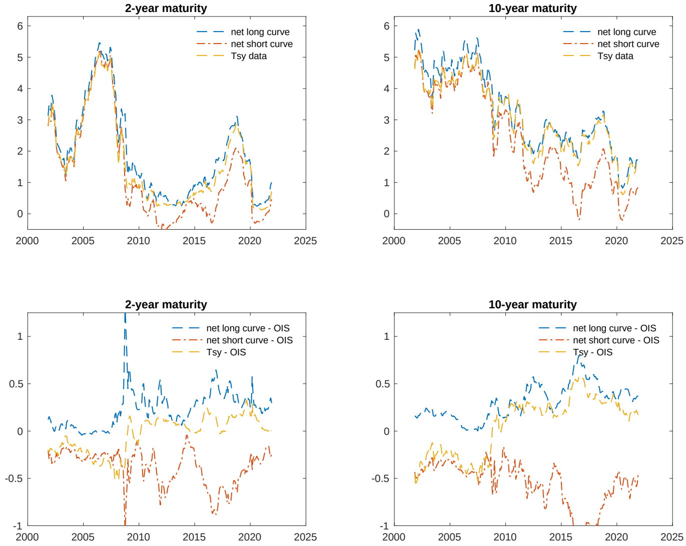
- net short curve: $y^s_{n,t} = -\frac{1}{n}\ln(E^{\mathbb{Q}}_t[\exp(-\sum_{j=0}^{n-1} x_{2,t+j})])$
  - $x_{2,t} = \ln(I^s_t + R_t - R^{syn}_t)$

- these are arbitrage bounds (see paper for details)

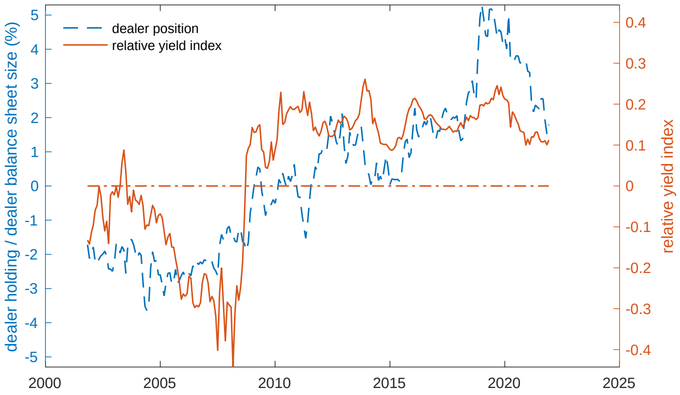
- $\mathbb{Q}$ is measure that prices derivatives (i.e. swaps)

- Quantitative exercise: first term structure model to swaps + CIP, construct net long and short curves

Quantitative Results



Prices vs. Quantities



An Equilibrium Model

- So far: dealers act as arbs, same balance sheet costs in CIP and swap spreads
- Next: equilibrium model to explain regime change + policy effects
- Agents:
  - intermediary: dealers and levered clients (consolidated),
  - real-money Treasury investors (e.g., pension funds),
  - FX-hedge foreign Treasury investors (e.g., foreign life insurance companies) .
  - other agents demanding synthetic dollars
- Exogenous: swaps, money markets (incl. t-bills), security lending, expected future bond prices ($y_{\mathbb{P}}$, $y_{\mathbb{Q}}$)
- Endogenous: current n-period treasury bond yield (y), synthetic dollar lending rates (r^{syn})

An Equilibrium Model (2)

- Intermediaries solve static problem described earlier, with 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-hedged foreign investors (e.g., foreign life insurance companies) demand

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

Market Clearing

- Bond supply: S^{bond} (in notional, i.e., number of bonds)
- Treasury market:

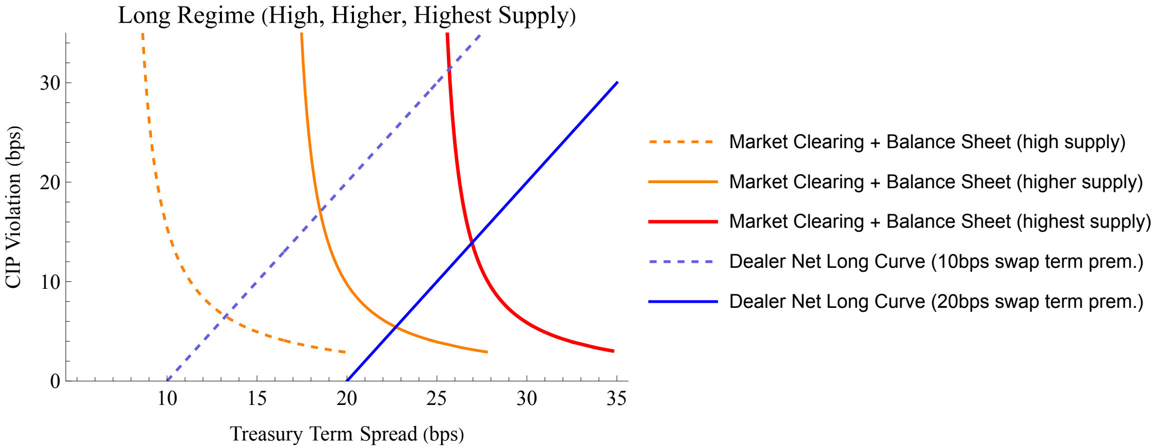
$$\underbrace{\exp(-ny)S^{bond}}_{\text{Treasury bond supply in dollars}} = q^{bond} + D_U^{bond} + D_H^{bond}$$

- Synthetic lending market:

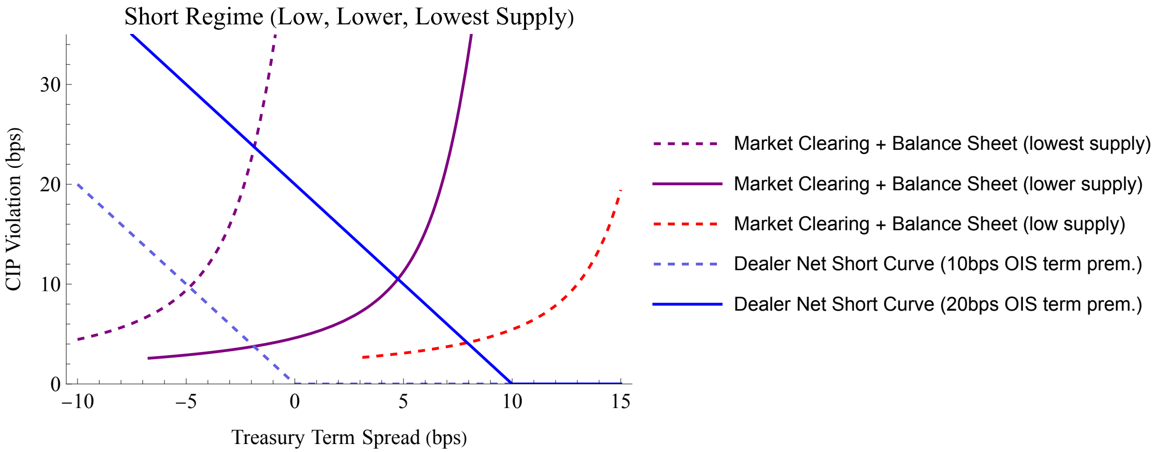
$$\underbrace{q^{syn}}_{\text{intermediary supply of syn lending}} = D_H^{bond} + \underbrace{D^{syn}(r^{syn} - r)}_{\text{residual demand}}$$

  - Each unit of bond requires synthetic financing

The Long Regime



The Short Regime



The Unique Equilibrium

Proposition 1

The equilibrium is a short regime ($q^{bond} < 0$) if S^{bond} is small enough. Comparative statics (all else equal):

- *Larger bond supply S^{bond} increases y but decreases r^{syn}.*
- *Larger dealer capacity $\bar{q}$ increases y but decreases r^{syn}.*

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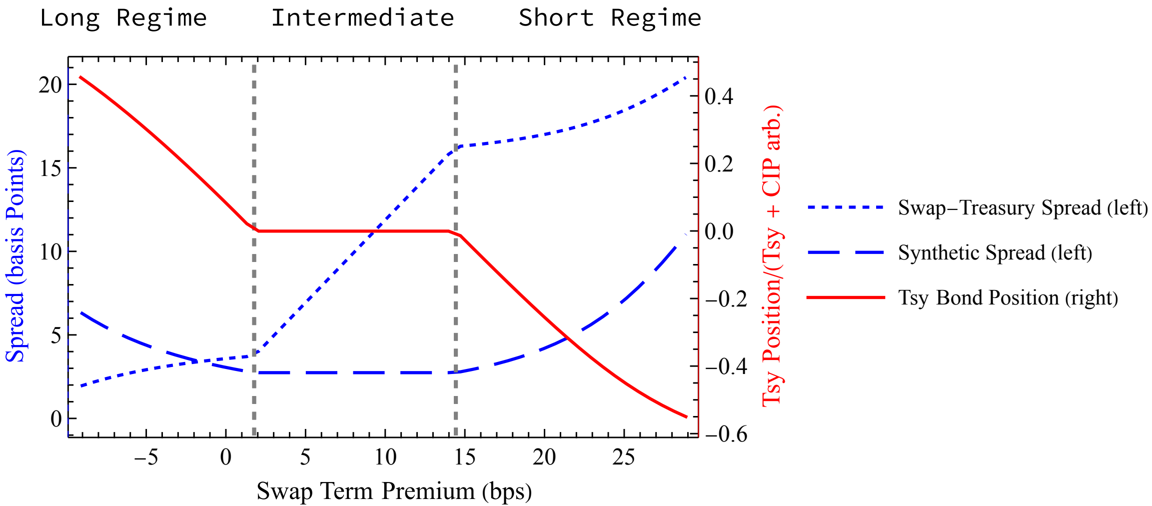
Proposition 2

The equilibrium is a long regime ($q^{bond} > 0$) if S^{bond} is large enough. Comparative statics (all else equal):

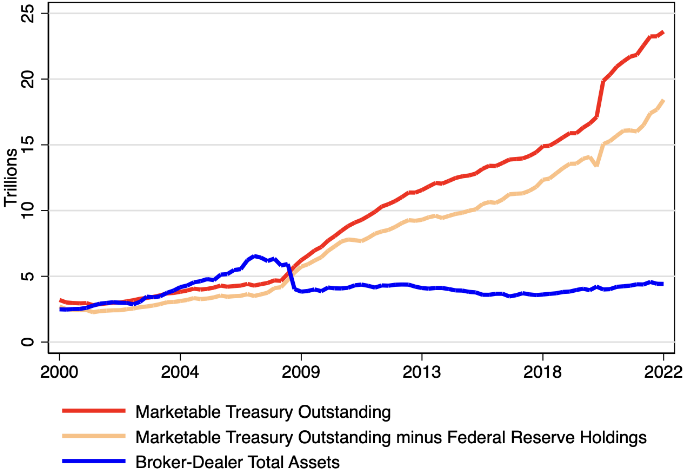
- *Larger bond supply S^{bond} increases y and r^{syn}.*
- *Larger dealer capacity $\bar{q}$ decreases y and r^{syn}.*

All Regimes (Illustration)



Key Changes Pre/Post GFC

- Supply of Treasurys has expanded
- paper: regressions with supply + pension demand proxy



Klingler and Sundaresan 2019 Regressions

	Dependent variable: Δ(OIS-Tsy Spread)$_t$ of maturity			
	30Y	10Y	5Y	2Y
ΔUFR$_t$	-0.685^{**}	-0.175	0.163	-0.175
	(0.339)	(0.279)	(0.251)	(0.233)
Δlog(Net Tsy$_t$)	-1.405^{***}	-1.156^{***}	-0.970^{***}	-0.702^{***}
	(0.364)	(0.300)	(0.271)	(0.251)
Constant	0.018	0.016	0.013	0.012
	(0.013)	(0.011)	(0.010)	(0.009)
Observations	76	76	76	76
Adjusted R^2	0.218	0.165	0.126	0.092

Policy Implications

- Caveat: partial equilibrium holds fixed swap and money market rates
  - prices changes here will dampen other price and quantity responses
  - interpret Tsy yield and lending rate as relative spreads to OIS.

- 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 (purchasing bills, selling bonds)	$\uparrow$	$\uparrow$	$\uparrow$	$\downarrow$
$\downarrow$ Term premium	$\uparrow$	$\uparrow$	$\uparrow$	$\downarrow$
SLR Exemptions	$\downarrow$	$\downarrow$	$\uparrow$	$\downarrow$
Swap line (Fed synthetic $ lending)	$\downarrow$	$\downarrow$	$\uparrow$	$\downarrow$

Conclusion

- "Regimes" are central to understanding the Treasury market
  - Dealers act as arbitrageurs between Treasury bonds and swaps
  - This explains Pre- vs. Post-GFC differences in basis, spreads, dealer positions, correlations
  - Change of regime due to Treasury supply
  - Regimes generate different comparative statics, policy implications

Appendix

Estimating Buy and Sell Curves

- Operationalize with affine term-structure model (based on Duffie (1996), Joslin, Singleton, and Zhu (2011)):

$$z_{t+1} = k_{0,z}^{\mathbb{P}} + K_{1,z}^{\mathbb{P}} \cdot z_t + (\Sigma_z)^{1/2} \epsilon_{z,t+1}^{\mathbb{P}}, \epsilon_{z,t+1}^{\mathbb{P}} \sim N(0, I_N),$$

$$m_{t+1} = -(\delta_0 + \delta_1^T \cdot z_t) - \frac{1}{2} \lambda_t^T \lambda_t + \lambda_t^T \epsilon_{z,t+1}^{\mathbb{P}}, \ \lambda_t = (\Sigma_z^{-1})(\lambda_0 + \Lambda_1 z_t)$$

- Augment with "macro" factors $x_t = (x_{1,t}, x_{2,t}, y_{6,t}^{bill})$

$$x_{1,t} = \ln((1-h)(e^{\frac{1}{12} r_t^{tri}} - e^{\frac{1}{12} r_t^{ois}}) + e^{\frac{1}{12} r_t^{syn}}), \text{ (for buy curve)}$$

$$x_{2,t} = \ln(e^{\frac{1}{12} r_t^{sec}} - (e^{\frac{1}{12} r_t^{syn}} - e^{\frac{1}{12} r_t^{ois}})), \text{ (for sell curve)}$$

  - Assume $y_{6,t} = y_{6,t}^b = y_{6,t}^s = y_{6,t}^{bill}$ (unwind when bond is equivalent to 6-mo bill)
  - affects short-maturity bonds, not so much for long maturities
- Fit the OIS curves and the basis curves.

Hedge Funds and Primary Dealers