Anatomy of the Treasury Market: Who Moves Yields?

Manav Chaudhary (Chicago), Zhiyu Julie Fu (Olin), Haonan Zhou (HKU)

Chicago Booth Treasury Markets Conference

Who Moves Treasury Yields?

Widely recognized investor demand as a key driver of yields

...but how much does each investor influence yields, and how has this evolved?

Standard approaches to Treasury market not suitable,

- Term-structure/factor models are silent on the heterogeneity
- Models zooming on specific sectors are limited in aggregate implications

Calls for a unified framework of Treasury price and heterogeneous investors

A Framework for the U.S. Treasury Market

An equilibrium-pricing framework for the U.S. Treasury market

- A parsimonious yet flexible approach to model different players jointly
- A machinery to decompose changes in yields by macro factors $\times$ investors

Provides tools to uncover the "macrostucture" of the Treasury market:

- How liquid is the Treasury market, and who provides liquidity?
- How has the Treasury market ecosystem evolved after the Great Recession?
- Why do Treasuries appreciate during bad times? Who's fleeing to safety?

Uncovering the "macrostructure" of the Treasury market

1. Quantifying market liquidity

- Inelastic market: macro multiplier of 1 at the quarterly frequency
  - $\uparrow$ 1% demand $\Longrightarrow$ $\uparrow$ 1% price or $\downarrow$ 15*bp* avg. yield
- Large heterogeneity across investors&time

UNCOVERING THE "MACROSTRUCTURE" OF THE TREASURY MARKET

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2. Decomposing yield changes into their investor-level drivers

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- Foreign investors have stopped playing a big role, while the Fed stepped in

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- Foreign investors have stopped playing a big role, while the Fed stepped in

3. Zooming into flight-to-safety episodes

- Domestic, rather than foreign investors, contribute most to declining yields
- Foreign investors seem to use U.S. Treasuries more as a hedge

Related Literature

- Investor demand and the Treasury markets:
  - Foreign investors: Warnock and Warnock, 2009; Kekre and Lenel, 2024; Bernanke, 2005; Jiang, Krishnamurthy, and Lustig, 2021; Ahmed and Rebucci, 2024
  - The Fed and the QE: Gagnon, Raskin, Remache, and Sack, 2011; d'Avernas, Petersen, and Vandeweyer, 2024; Haddad, Moreira, and Muir, 2024; Hamilton and Wu, 2012
  - Mutual funds, dealers,...: Chaudhary, 2024; Selgrad, 2023; Du, Hébert, and Li, 2022
- Demand-system approach to asset pricing:
  - Application to government bond markets: Koijen, Koulischer, Nguyen, and Yogo, 2017; Cavaleri, 2023; Fang, Hardy, and Lewis, 2022; Jansen, Li, and Schmid, 2024; Zhou, 2023; Eren, Schrimpf, and Xia, 2023; Jansen, Li, and Schmid, 2024; Jiang, Richmond, and Zhang, 2024
  - Methodology: Koijen and Yogo, 2019; Greenwood and Vayanos, 2014, 2014; Gabaix and Koijen, 2024; Qian, 2024; Chodorow-Reich, Gabaix, Koijen, and Viviano, 2024

Roadmap

- Model Framework

- Estimation and Identification

- Understanding macrostructure of the Treasury market:
    1. Quantifying market liquidity
    2. Decomposing yield changes
    3. Zooming into flight-to-safety episodes

The Landscape of U.S. Treasury Market

Data: Financial Accounts +TIC (foreign) + Call Reports (banks)

- Sectors are mutually exclusive + collectively exhaustive of market activity

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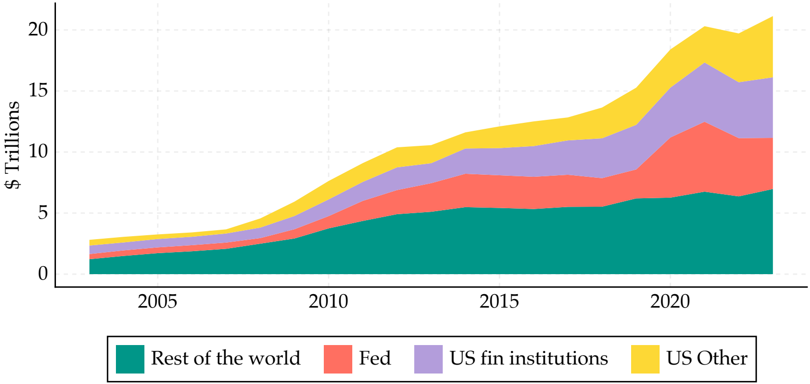
Figure 1: Quarterly sector-level Treasury notes and bonds holdings



Model Demand for Treasuries for Different Investors

Major challenge: different sectors face different portfolio choice problems

- What is the correct objective?
  e.g. mean-variance, bond-in-the-utility, mimizing funding ratio volatility...
- How to model multitude of constraints?
  e.g. benchmarks, capital requirement, internal value-at-risk...

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Solution: first-order log-linearize sector *i*'s portfolio choice:

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Interpretation: ζ_i and $\nu_{i,t}$ are investor-& model-specific

- Elasticity ζ_i:
  expected risk premium, benchmark intensity, learning from price...
- Demand shifter $\nu_{i,t}$:
  changes in risk aversion, short-term rate, private signal...

Modelling demand shifters

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Observed factors: measure with

- Macro-financial: inflation level, and innovations in VIX and dollar indicies
- Policy: Fed fund change, lagged net supply, scheduled Fed purchases
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Unobserved factors: principal components on granular residual flows

Idiosyncratic shocks: e.g., wealth shocks, private info, regulations

General Framework Full specification

Relating equilibrium prices to investor demand

1. Estimate sector-level demand curves: $\Delta q_{i,t} = -\zeta_i \Delta p_t + \bar{q}_i + \boldsymbol{\lambda}_i \boldsymbol{\eta}_t + u_{i,t}$

2. Apply market clearing: total change in holdings (incl. supply) is zero,

$$\sum_{i \in sectors} S_i \Delta q_{i,t} = 0$$

where S_i is the sector i's avg. market share of the Treasury market.

3. Price responds to demand shocks to clear the market:

$$\Delta p_t = \frac{1}{\zeta_S} \sum_{i \in sectors} S_i \left(\bar{q}_i + \lambda_i \boldsymbol{\eta}_t + u_{i,t} \right)$$

where $\zeta_S \equiv \sum S_i \zeta_i$.

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$\Longrightarrow$ we can fully decompose Δp_t into sector-specific demand shifters

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Endogeneity

Classic challenge: $\Delta q_{i,t}$ and Δp_t are endogenous $\Longrightarrow$ instruments needed

Tyipcal instruments: idiosyncratic demand shifters such as,

- Sector-specific regulation changes
- Particular episodes that induced balance sheet shocks
- Institution-specific mechanical rebalancing rules

Such instruments should be:

- **Relevant:** shocks are large enough to move the Treasury price
- **Exogenous:** shocks orthogonal to unobserved demand

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Effective instruments are very rare for the Treasury market

...and we need multi-period instruments for all sectors

Solution: leverage model's idiosyncratic demand shifters

Sector's demand shifters have common and idiosyncratic parts,

$$\Delta q_{i,t} = -\zeta_i \Delta p_t + \bar{q}_i + \boldsymbol{\lambda}_i \boldsymbol{\eta}_t + u_{i,t}$$

Idea: extract sector i's $u_{i,t}$ and instrument for price in sector j's demand.

$$\hat{u}_{i,t}(z_i, \boldsymbol{l}_i) \equiv \Delta q_{i,t} + z_i \Delta p_t + \bar{q}_i + \boldsymbol{l}_i \boldsymbol{\eta}_t$$

Identification assumption: sectors' idiosyncratic shifters are independent,

$$\mathbb{E}\left[\hat{u}_{i,t}\left(\zeta_i, \boldsymbol{\lambda}_i\right) \hat{u}_{j,t}\left(\zeta_j, \boldsymbol{\lambda}_j\right)\right] = 0. \ \ \forall i \neq j$$

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Estimate ζ_i jointly using GMM

- Overidentified system: N elasticities ζ_i and $\frac{N(N-1)}{2}$ moment conditions
- Optimal GIV estimator: weight moment conditions by their influence on price

▸ Optimal GIV ▸ Asymptotic efficiency

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1. Quantifying Sensitivities: Aggregate Elasticity

Aggregate elasticity $\zeta_S = \mathbf{1.03}$. Macro multiplier $M \equiv \frac{1}{\zeta_S} = \mathbf{0.97}$

- 1% flow $\Rightarrow$ **15**bps in yields with average market duration ($\approx$ 6.5 years)

▸ Dynamic price impact ▸ Robustness ▸ Leave-one-out

Elasticity estimates are well in line with the literature:

- More elastic than aggregate equity market ($M \approx 5$) and corporate bond portfolios ($M \approx 3.5$)
- Comparable to individual stocks ($M \approx 1$)

1. Quantifying Sensitivities: Sectoral Price Elasticities

Top contributors:

- Households (Resid.): Small but highly elastic
- Federal Reserve
- RoW: less elastic but large
- Banks

Leave-one-out

Table 1: Elasticity: Top contributors

Sector	$S(\%)$	ζ	ζ **Share (%)**
Aggregate		1.03 (0.77, 1.3)	100.0
Households	5.74	10.54 (5.33, 15.76)	58.55
Fed	22.08	0.42 (0.11, 0.74)	9.28
Rest of World	44.45	0.42 (0.23, 0.61)	17.8
Banks	5.26	0.52 (0.28, 0.76)	2.61

1. Quantifying Sensitivities: Sectoral Price Elasticities

Least contributors:

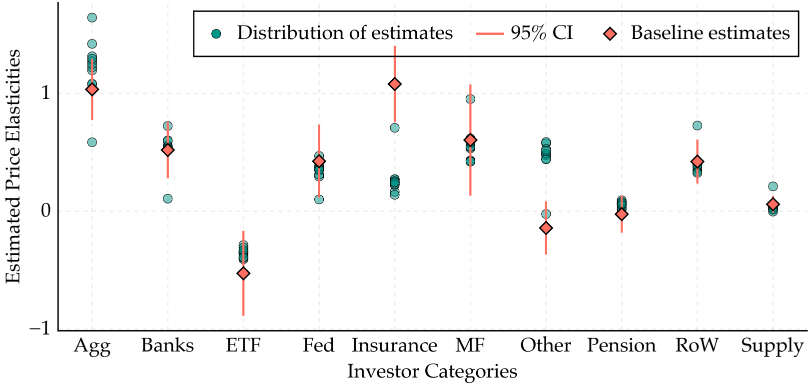
- Supply:
  Inelastic (stated policy)
- Broker-Dealers:
  Elastic but too small
- Pensions
- ETFs

Table 2: Elasticity: Least contributors

Sector	$S(\%)$	ζ	ζ **Share (%)**
Aggregate		1.03 (0.77, 1.3)	100.0
Supply	100.0	0.06 (-0.01, 0.13)	5.74
Broker-dealers	0.81	2.22 (-6.45, 10.88)	1.73
ETF	1.18	-0.53 (-0.89, -0.17)	-0.6
Pension	5.42	-0.02 (-0.18, 0.13)	-0.13

▸ Broker-dealers ▸ Leave-one-out ▸ Case study

1. Quantifying Sensitivities: Leave-one-out Estimates



1. Quantifying Sensitivities: Change Nature of Liquidity Provision

Post-GFC liquidity provision:

Fed: now provide backstop

...stepp-in in bad-times

Foreigners: stepped-back

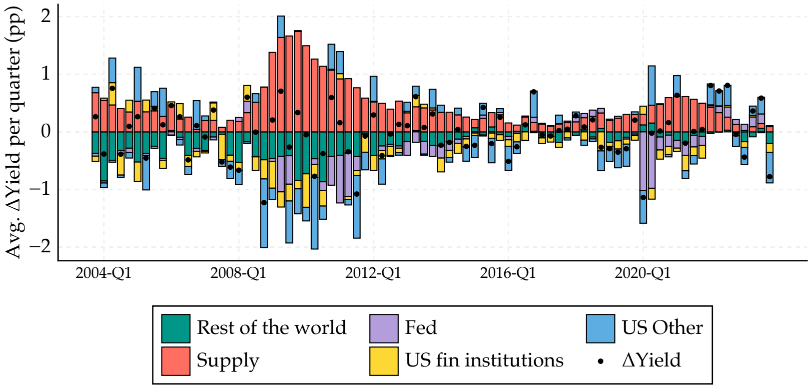
...contrary to big role pre-crisis

U.S. Banks: also stepped-back

...↑regulatory burden

Sector	ζ	ζ **Share (%)**
Fed (03-08)	0.0	-
	-	
Fed (09-23)	0.57	12.53
	(0.32, 0.83)	
Rest of World (03-08)	0.76	30.38
	(0.48, 1.04)	
Rest of World (09-23)	0.3	13.39
	(0.15, 0.46)	
U.S. Banks (03-08)	0.84	3.98
	(0.47, 1.2)	
U.S. Banks (09-23)	0.41	2.13
	(0.21, 0.61)	

2. Decomposition Yields: Sectoral Contributions



▸ Latent shocks by sector

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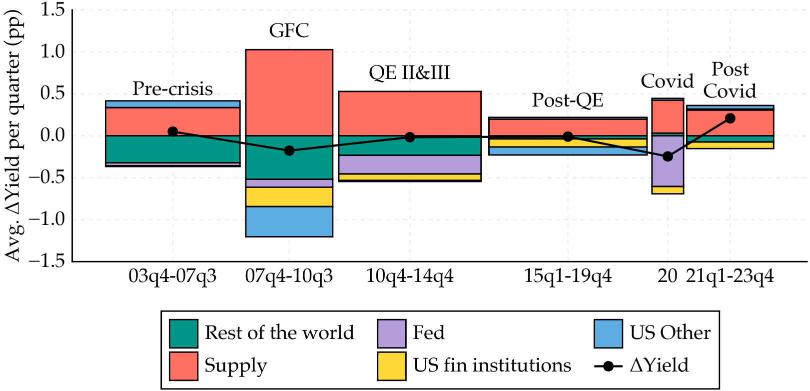
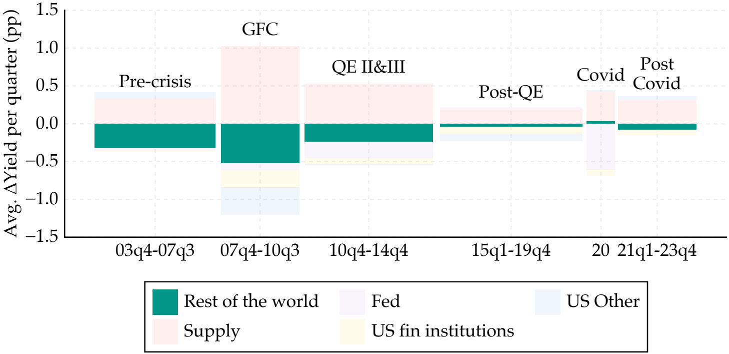


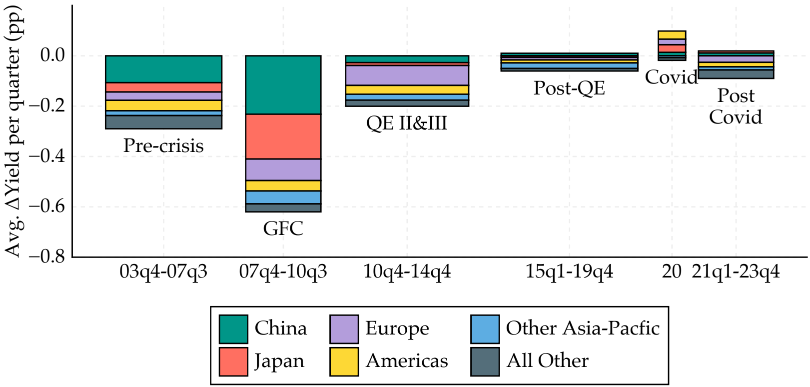
Latent shocks by sector

2. Decomposition Yields: Post-GFC Diminishing Role of Foreigners



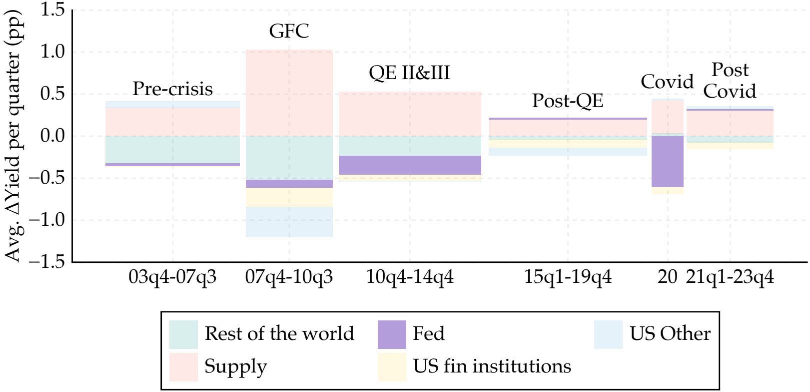
⟹ Pre-GFC consistent with "savings glut" compressing yields...but no longer

2. Decomposition Yields: China and Japan role particularly diminished



Quarter-by-quarter | IIP | Bilateral: China | Bilateral: Japan

2. Decomposition Yields: GFC and Covid, and the Fed



....More on the tranforming role of the Federal Reserve

Table 3: Price elasticity and loadings: Federal Reserve

Period	$S(\%)$	ζ	$\epsilon^{VIX}_{(std.)}$	Δ **FFR**	*Inf.*
09-23	22.08	0.57 (0.32, 0.83)	1.55 (0.74, 2.36)	-9.4 (-12.39, -6.41)	-0.43 (-1.55, 0.7)

- Before GFC: All pre-scheduled and predictable
- After GFC: Treasury purchase as part of the standard central bank toolkit
  - Price elastic: stabilize the Treasury market
  - State-contingent: deployed during market distress
  - Coordination between direct purchase with conventional monetary policy

3. Zooming into flight-to-safety: who increases Treasury demand?

Conventional wisdom: **foreigners**

- Key explanation of "exorbitant privilege"
  e.g, Jiang, Krishnamurthy, and Lustig (2024)

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...not over this period

Sector	$S(\%)$	$\epsilon^{VIX}_{(std.)}$	$\epsilon^{VIX}_{(std.)}$ **Share (%)**
Aggregate (09-)		0.75	100.0
		(0.0, 1.49)	
Households	5.74	16.12	124.11
		(6.12, 26.13)	
Fed (09-)	22.08	1.55	45.94
		(0.74, 2.36)	
Rest of World	44.45	-0.2	-11.69
		(-0.87, 0.48)	
Supply	100.0	-0.19	-25.02
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Mutual Funds	6.75	-1.94	-17.6
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$\Longrightarrow$ Foreigner behavior consistent with using Treasuries as a hedge
...rather domestic investors exhibit flight-to-quality

3. Zooming into flight-to-safety: In fact foreigners sell in bad times

Figure 2: 2003-2023 Quarterly

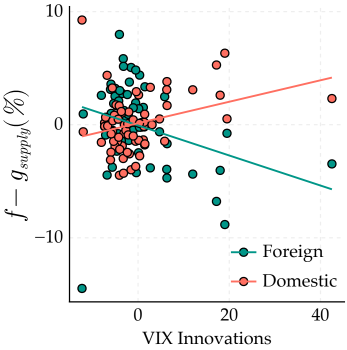
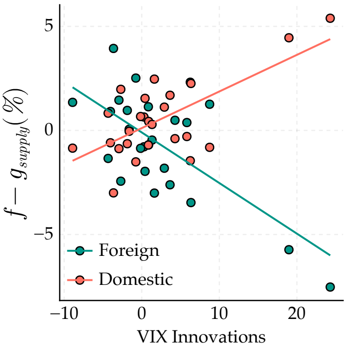


Figure 3: GFC (07-09 Monthly)



Conclusion

An unified equilibrium-pricing framework for the U.S. Treasury market

- A parsimonious yet flexible approach to model different players jointly
- A machinery to decompose changes in yields by macro factors $\times$ investors

Provides machinery to uncover the "macrostucture" of the Treasury market:

- Treasury market is quite inelastic, with large heterogeneity across investors
- Post-GFC, large changes in Treasury market—foreigners, Fed, and banks
- Contrary to the conventional wisdom, the foreigers do not fly-to-safety

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Post-Credit: What if China sold all US Treasuries

- Assuming no political repercussion, no contigent purchase by other sectors, unanticipated and no guidance on the future path

$$\Delta p_t = \underbrace{M}_{1.0} \times \underbrace{\Delta q_{China}}_{-3.5\%} = -3.5\% \implies \Delta y_t = 60bps$$

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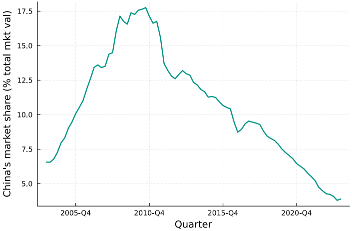
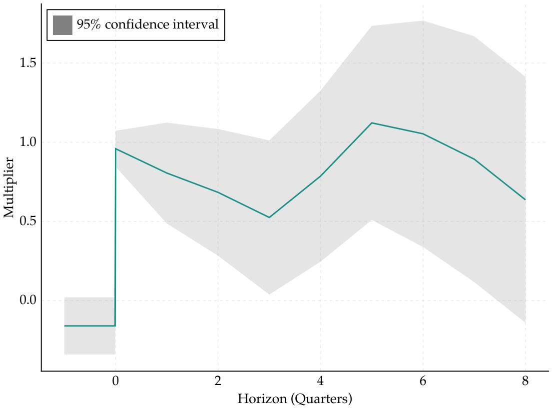


Dynamic Price Impact: Local Projections

Back



The Optimal GIV Estimator ▸ Back

- We propose a new GMM-based estimator, *the optimal GIV estimator*
- In the simplest case, it weights different investors by their sizes and solves (common factors suppressed):

$$\hat{\mathbb{E}}\left[\hat{u}_{i,t}\left(\hat{\zeta}_i\right)\underbrace{\sum_{j\neq i} S_j \hat{u}_{j,t}\left(\hat{\zeta}_j\right)}_{\hat{u}_{S(-i)}(\hat{\zeta})}\right] \equiv \hat{\mathbb{E}}\left[\left(\Delta q_{i,t} + \hat{\zeta}_i \Delta p_t\right)\sum_{j\neq i} S_j \left(\Delta q_{j,t} + \hat{\zeta}_j \Delta p_t\right)\right] = 0$$

Asymptotic Efficiency of the Optimal GIV Estimator

Back

Theorem

The optimal GIV estimator $\hat{\zeta}$ is consistent and asymptotically normal:

$$\sqrt{T}\left(\hat{\zeta}-\zeta\right) \xrightarrow{d} \mathcal{N}\left(0, V^{\zeta}\right),$$

for $T \to \infty$. Moreover, V^{ζ} achieves the semi-parametric efficiency bound

$$V^{\zeta} = \zeta_S^2 \times Inv\left(\begin{bmatrix} \frac{1}{\sigma_1^2}\sum_{i\neq 1} S_i^2\sigma_i^2 & S_1 S_2 & \cdots \\ S_1 S_2 & \frac{1}{\sigma_2^2}\sum_{i\neq 2} S_i^2\sigma_i^2 & \cdots \\ \vdots & \vdots & \ddots \end{bmatrix}\right)$$

General Model

$$\left.\begin{aligned} q_{i,t} &= -p_t \times \mathbf{C}'_{i,t}\zeta + \mathbf{X}'_{i,t}\beta + u_{i,t}, \\ 0 &= \textstyle\sum_i S_{i,t} q_{i,t} \end{aligned}\right\} \implies p_t = \frac{1}{\mathbf{C}'_{S,t}\zeta}\left[\mathbf{X}'_{S,t}\beta + u_{S,t}\right],$$

- Elasticity parameterized by $\mathbf{C}_{i,t}$, entity-specific and time-varying
- Moment conditions become $\mathbb{E}\left[u_{i,t}u_{j,t} \mid \eta_t, \mathrm{C}_t, \mathrm{S}_t\right] = 0$
- $S_{i,t}$ can also be time-varying and do not necessarily sum to 1

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Full Specification

- Financial Account (Z.1) + TIC for foreigners + Call report for banks, 03Q4-23Q4

$$\Delta q_{i,t} = -\zeta_{i,r(t)} \Delta p_t + \boldsymbol{\lambda}_{\text{obs},i,r(t)} \boldsymbol{\eta}_{\text{obs},t} + \boldsymbol{\lambda}_{\text{pc,i}} \boldsymbol{\eta}_{\text{pc},t} + \bar{f}_i + u_{i,t} \quad \forall i$$

- $\Delta q_{i,t}$: Quarterly transaction divided by $S_{i,t}$ (avg. mkt share over sample period)
- $r(t)$: Sector-specific regime shifts in elasticities/loadings (09Q1)
- Consolidate sectors into categories: Composition
  - Impose homogeneous ζ within categories
  - (e.g. close-end & open-end funds; individual banks; China & Japan)

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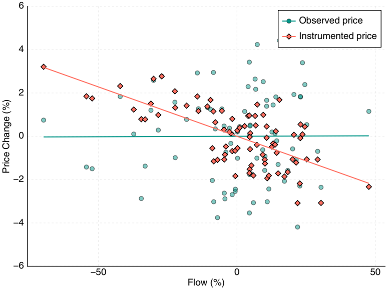
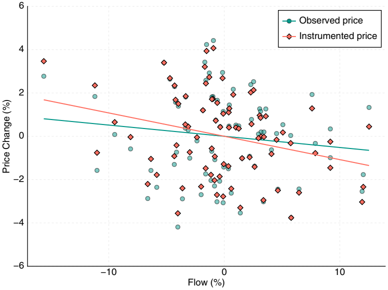
Comparison: Households (left) vs. Mutual Funds (right) ▸ Back





Common Factors

- Factors include both:
  - Observable macro variables
  - Unobservable factors extracted from granular data using PCA
- Three-step approach:
  1. Regress price & quantities on factors η ;
  2. Estimate $\hat{\zeta}_i$ using residuals (no issue with s.e.);
  3. Recover loadings using $\hat{\zeta}_i$ and coefficients in step 1.

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Missing Intercept

- Estimating factor loadings requires consistently estimating price elasticities!
- e.g., A one-factor model without shocks: $q_{i,t} = -\zeta_i p_t + \lambda_i \eta_t$.

$$\lambda_i^q \equiv \frac{\mathbb{E}\left[q_{i,t}\eta_t\right]}{\mathbb{E}\left[\eta_t^2\right]} = \frac{\mathbb{E}\left[\left(-\zeta_i p_t + \lambda_i \eta_t\right)\eta_t\right]}{\mathbb{E}\left[\eta_t^2\right]} = \lambda_i - \frac{\zeta_i}{\zeta_S}\lambda_S.$$

Relation with Standard GIV

- Standard GIV:
  - Assuming ζ_i is homogeneous, i.e., $\boldsymbol{\zeta} = \zeta \boldsymbol{\iota}$.
  - A size-minus-precision weighting scheme to solve ζ analytically
- Define the vector $\mathbf{E}_i = \frac{1/\sigma_i^2}{\sum_i 1/\sigma_i^2}$. GIV shows

$$\mathbf{E}'\mathbb{E}[\mathbf{u}_t\mathbf{u}_t'](\mathbf{S} - \mathbf{E}) = \mathbf{0}$$

Under the homogeneity assumption of ζ, it is equivalent to

$$\mathbb{E}[(q_{E,t} + \zeta p_t)(q_{S,t} - q_{E,t})] = 0$$

It is then implementable by regressing $q_{E,t}$ on p_t instrumented by $q_{S,t} - q_{E,t}$.

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Evolution of Treasury Yields

Figure 4: Average yields and duration

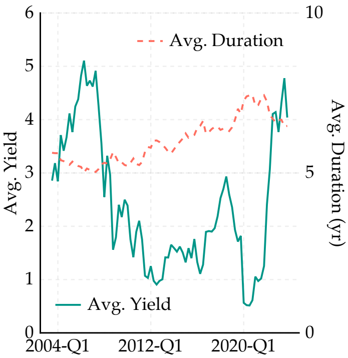
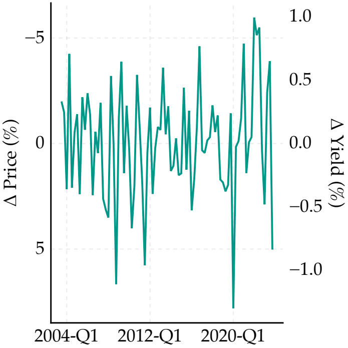


Figure 5: Price change in market portfolio



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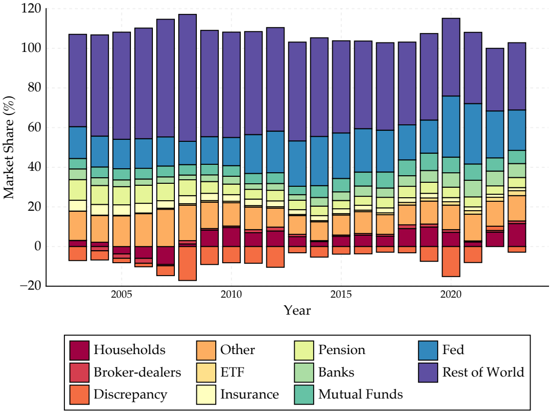
Investor Base of the U.S. Treasury Market



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Robustness: Price Elasticities

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Sector	Baseline	More factors	1970-2023	Including Bills
Aggregate	1.04	1.08	1.3	2.09
	(0.81, 1.27)	(0.83, 1.34)	(1.11, 1.5)	(1.26, 2.91)
Other	-0.24	-0.11	0.19	0.56
	(-0.46, -0.01)	(-0.34, 0.11)	(0.02, 0.36)	(0.26, 0.87)
Households	10.07	11.09	10.5	4.34
	(5.26, 14.88)	(5.71, 16.46)	(7.29, 13.7)	(0.78, 7.9)
Pension	0.2	0.2	-0.23	0.17
	(0.04, 0.36)	(0.04, 0.36)	(-0.39, -0.07)	(-0.07, 0.4)
Insurance	0.51	0.38	-0.67	-0.01
	(0.21, 0.81)	(0.09, 0.66)	(-0.93, -0.41)	(-0.51, 0.49)
Mutual Funds	0.58	0.51	0.47	0.55
	(0.11, 1.05)	(0.03, 1.0)	(0.23, 0.72)	(-0.11, 1.21)
ETF	-0.1	-0.2	0.23	-0.33
	(-0.46, 0.26)	(-0.56, 0.17)	(0.04, 0.42)	(-0.83, 0.17)
Dealers	7.42	7.94	-1.47	1.11
	(-1.49, 16.32)	(-1.22, 17.1)	(-8.37, 5.43)	(-10.11, 12.33)
Fed	0.44	0.49	0.03	0.24
	(0.15, 0.72)	(0.2, 0.79)	(-0.06, 0.13)	(-0.13, 0.6)
Banks	0.53	0.43	1.0	0.63
	(0.35, 0.7)	(0.26, 0.6)	(0.51, 1.49)	(0.42, 0.85)
RoW	0.44	0.39	0.39	0.57
	(0.3, 0.58)	(0.25, 0.53)	(0.27, 0.52)	(0.36, 0.79)
Supply	0.05	0.04	0.26	1.33
	(-0.02, 0.12)	(-0.03, 0.11)	(0.18, 0.33)	(0.32, 2.34)
MMF				2.4
				(0.33, 4.47)

Price Elasticities: Leave-one-out Estimation

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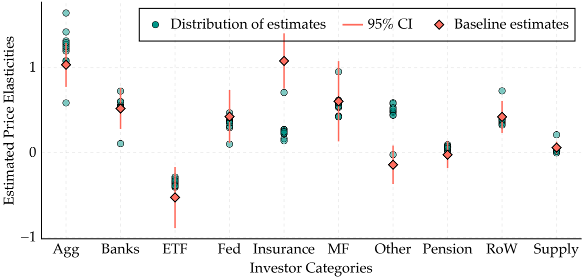


The Role of Broker-Dealers

Figure 6: Raw Dollar Flows

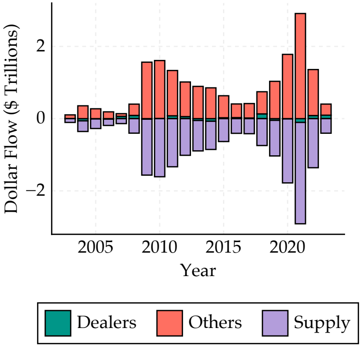
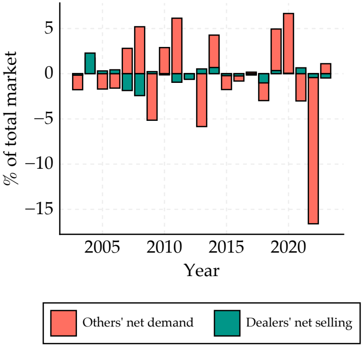


Figure 7: BD Flows vs Net Demand by Others



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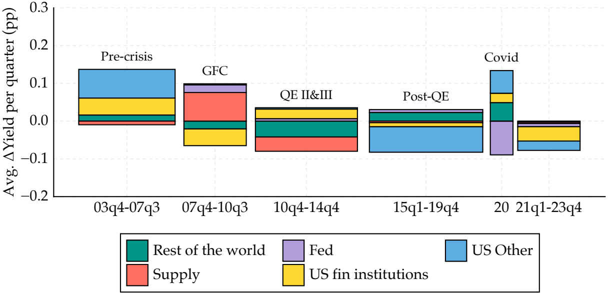
YIELD DECOMPOSITION: CONTRIBUTION OF LATENT SHOCKS



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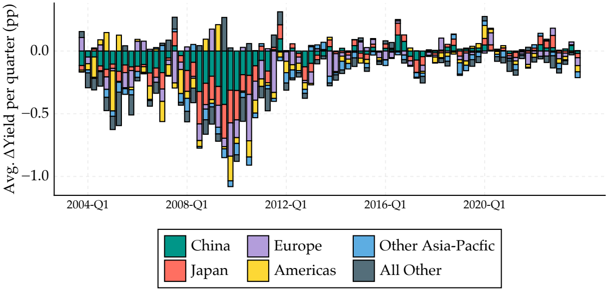
Foreign Demand and Yield: Quarter-by-Quarter Decomposition



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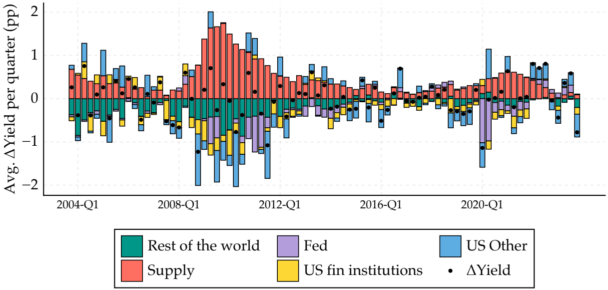
Quarter-by-Quarter Yield Decomposition



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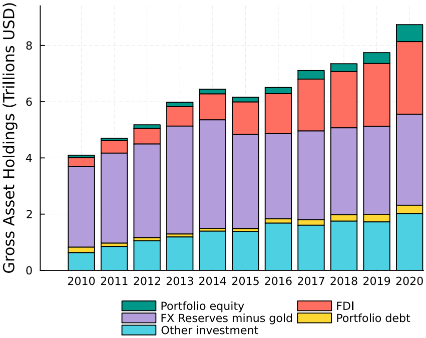
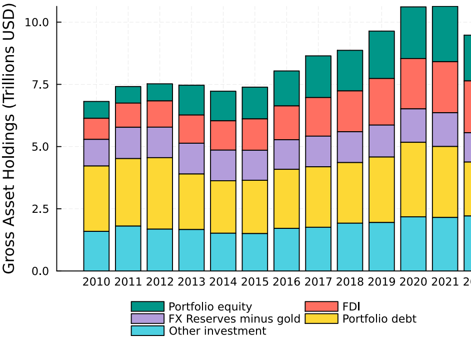
Gross external assets of China and Japan: 2010-2023



China



Japan

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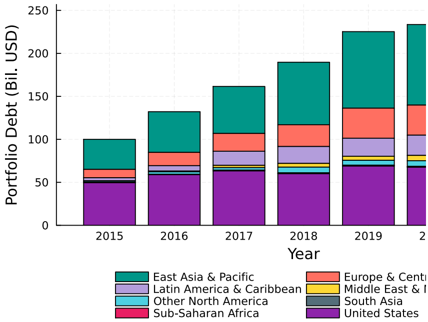
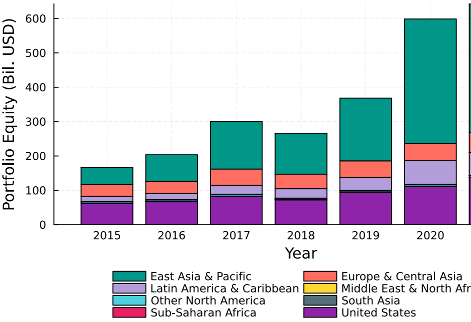
Regional distribution of China's private portfolio investment





Portfolio debt assets (billions USD)

Portfolio equity assets (billions USD)

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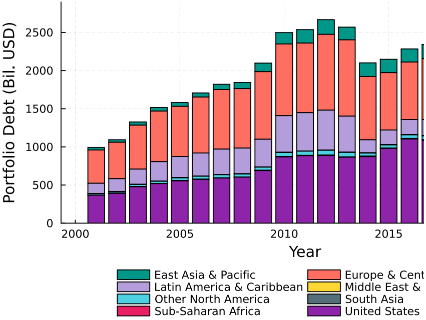
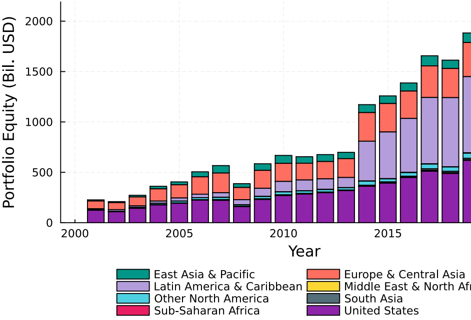
Regional distribution of Japan's private portfolio investment



Portfolio debt assets (billions USD)



Portfolio equity assets (billions USD)

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