The Effect of Primary Dealer Constraints on Intermediation in the Treasury Market

Falk Bräuning and Hillary Stein

Federal Reserve Bank of Boston

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Motivation and Research Question

- Treasury market is one of the most important markets globally
  - investment asset
  - collateral (e.g., repos)
  - risk-free benchmark
  - safe haven asset (hedge)
  - monetary policy implementation
  - financing federal deficit

Motivation and Research Question

- Treasury market is one of the most important markets globally
- **Primary dealers** are designated securities dealers that are crucial intermediaries
  - Largest primary dealers are owned by BHCs (banks)
  - Participate in Treasury auctions (primary market)
  - Act as market makers in secondary market
  - Direct counterparties in Fed operations

Motivation and Research Question

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- **Primary dealers** are designated securities dealers that are crucial intermediaries
  - Largest primary dealers are owned by BHCs (banks)
  - Participate in Treasury auctions (primary market)
  - Act as market makers in secondary market
  - Direct counterparties in Fed operations
- **Research question**: given their special role, what are the effects of primary dealers' constraints on liquidity and pricing of Treasuries?
  - Policy relevance given post-GFC regulatory constraints
  - Large theoretical literature on asset pricing with constrained intermediaries...
  - But, given data and identification limitation, empirical evidence is scarce

Our paper in a nutshell

- **Key takeaway**: We empirically show that tighter constraints:
  1. reduce dealers' positions,
  2. reduce turnover and liquidity,
  3. amplify price movements after net demand shifts, and
  4. impair auction outcomes.

Our paper in a nutshell

- **Key takeaway**: We empirically show that tighter constraints:
  1. reduce dealers' positions,
  2. reduce turnover and liquidity,
  3. amplify price movements after net demand shifts, and
  4. impair auction outcomes.

- Our analysis is based on two merged key confidential micro datasets on primary dealers' trading activity (FR 2004) and their risk limits (FR VV-1)

Roadmap

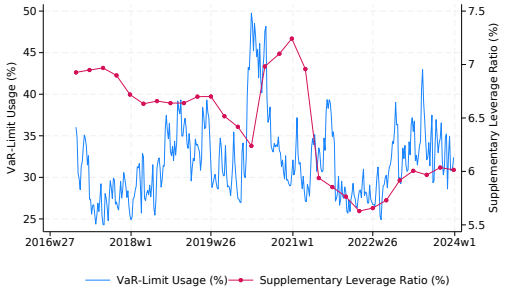
1. Introduction
2. Conceptual Framework
3. Data
4. SLR Change
5. VaR Limit Changes
6. Costs of Constraints
7. Conclusion

Roadmap

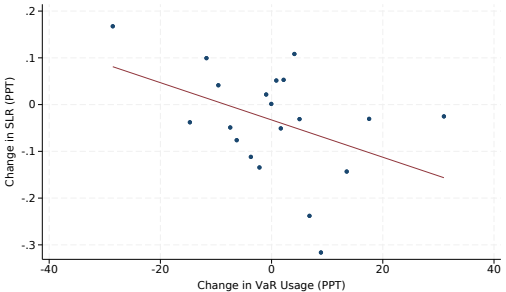
How are dealers constrained?

- Banks are composed of multiple organizational layers
  - E.g. Markets Unit > Fixed Income Sales and Trading > individual trading desks
- Bank regulation can target the overall bank or individual business units
- We focus on two different types of regulatory constraints:
  1. Basel III: leverage capital requirements
  2. Volcker Rule: limits the risk of individual trading desks; includes reporting requirements of internal risk limits and usage to the supervisors
- We exploit exogenous changes in these constraints and estimate their effects on the Treasury market
  1. Temporary adjustment to Supplementary Leverage Ratio (SLR) during COVID
  2. Granularly (desk level) identified Value-at-Risk limit changes (Barbiero et al. 2024)

Dealer Constraint Utilization: Leverage Ratio and Value-at-Risk



(a) Time Series of Means



(b) Binned Bank-Quarter Data

Notes: Panel (a) shows the average SLR and the average percentage VaR-limit usages of dealers in our sample based on a constant sample of dealers. A lower SLR means higher utilization of equity capital. For VaR-limit utilization, a higher percentage represents higher usage of the set limit. In Panel (b), using variation at the dealer-quarter level, we show a binned scatter plot and linear fit between quarterly SLR changes and quarterly VaR usage changes. *Sources*: FR VV-1, FR Y-9C, authors' calculations.

Roadmap

Two key supervisory micro datasets

- **FR 2004** (primary dealer activity): Weekly dealer-level Treasury positions and turnover (=transactions) by maturity buckets
  ▸ Aggregates
- **FR VV-1** (Volcker data): Daily desk-level internal risk limits and usage; *all* desks of BHCs with large trading book
  - 14 banks in the VV-1 data are affiliated with primary dealers
- Sample: 2016w1-2023w52; merged data captures 75% of total dealer activity (in terms of turnover and positions) because largest dealers owned by BHCs
- Additionally: FR Y-9C, Treasury auction data, CRSP, Bloomberg, Haver

Roadmap

Analysis #1 focuses on change in Supplementary Leverage Ratio

- SLR = Equity/Total Exposure, where exposure includes trading assets and liabilities
  - BHCs with assets $\geq$ \$250B required to have at least 3% SLR

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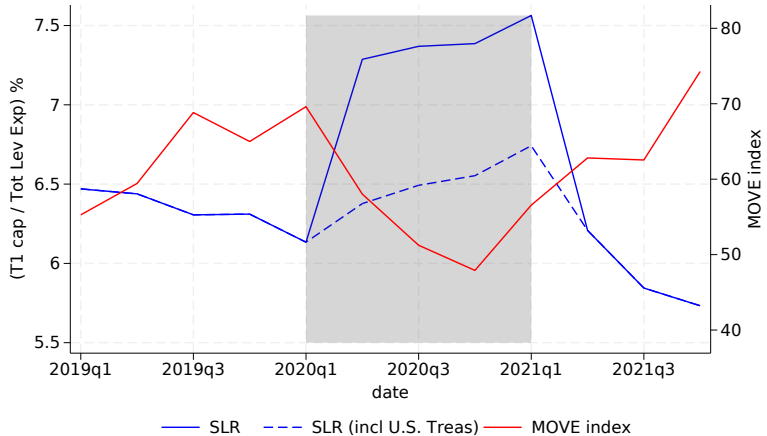
- SLR = Equity/Total Exposure, where exposure includes trading assets and liabilities
  - BHCs with assets $\geq$ \$250B required to have at least 3% SLR
- On April 1, 2020, Fed Board announced change to SLR: Treasuries and reserves were temporarily exempt from exposure measure (until April 1, 2021).
- The stated objective of temporary and surprise policy change was "*to ease strains in the Treasury market resulting from the coronavirus [...].*"

Figure: SLR and Treasury Market Volatility



Notes: This figure shows the effect of the exemption of exposure in Treasury securities and reserves on the SLR. Reported are the average SLR (blue line) and the hypothetical SLR that would prevail without the exemption. The sample is restricted to BHCs that own a primary dealer. The MOVE index, reported on the right-hand side scale, is a market-implied measure of bond market volatility. The shaded area indicates the period when the exemption was in effect. *Sources*: FR Y-9C, Haver, authors' calculations.

Empirical strategy: difference-in-differences

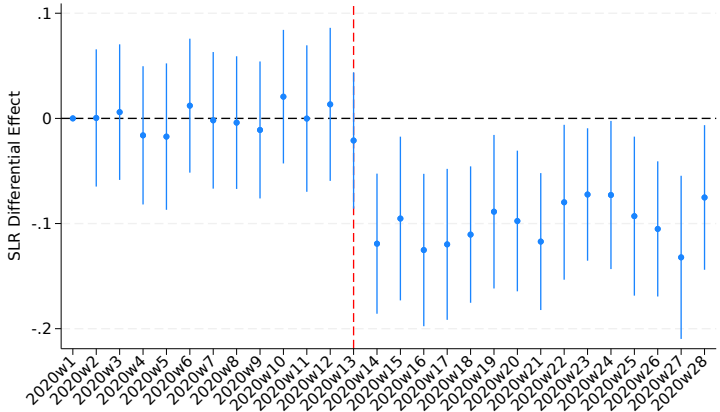
$$\text{Log(Position)}_{i,t} = \beta \text{Post-Change}_t \times \text{SLR}_i^{2019q4} + \alpha_i + \alpha_t + \epsilon_{i,t}$$

- Post-Change_t: dummy, equals one as of week 14, 2020 (when the policy change was announced and became effective)
- SLR_i^{2019q4}: continuous treatment variable
  - Results are similar using 2020:Q1
- Note fixed effects also absorb the level (uninteracted) effects of SLR and Post-Change
- Standard errors clustered at the week level
- At the time of the SLR change, no other policy changes occurred More info

Sum Stats

Differential Effect of SLR Change on Dealers' Positions

After SLR was relaxed, low SLR dealers increased Gross Positions



Notes: Positions are gross positions, in line with gross notionals entering the SLR exposure measure. The SLR change was announced on April 1, 2020 (week 14), and became effective immediately. The vertical red line indicates the last week before the change. The bars represent 90 percent confidence intervals based on robust standard errors. *Sources*: FR 2004, FR Y-9C, authors' calculations.

Differential Effect of SLR Change on Dealers' Positions

After SLR was relaxed, low SLR dealers increased Gross Positions

	$\text{Log}(\text{Position}_{i,t})$	$\text{Log}(\text{Position}_{i,m,t})$	
	(1)	(2)	(3)
$\text{Post-Change}_t \times \text{SLR}_i^{2019q4}$	-0.102***	-0.091***	
	(0.009)	(0.007)	
$\text{Post-Change}_t \times \Delta\text{SLR}_i$			0.672***
			(0.096)
Week FE	Yes		
Bank FE	Yes		
Week*Maturity FE		Yes	Yes
Bank*Maturity FE		Yes	Yes
R^2	0.969	0.940	0.940
R^2 within	0.224	0.064	0.063
N	171	1,026	1,026

Notes: The table reports the differential effects of the SLR policy on primary dealers' net positions, depending on their SLR. In column (1), the data are at the bank-week level, and the dependent variable is the logarithm of total gross position in Treasury securities of dealer i in week t. In columns (2) and (3), the data are at the bank-maturity-week level, and the dependent variable is the logarithm of gross position in Treasury securities in maturity bucket m of dealer i in week t. Post-SLR is an indicator that equals one as of week 14, 2020, and zero otherwise. SLR is the 2019:Q4 SLR ratio as a percentage. ΔSLR is the (hypothetical) increase in the 2019:Q4 SLR if the policy enacted on week 14 of 2020 applied. The sample period covers 2020:W8 through 2020:W28. Fixed effects are included as indicated in the bottom of the table. Robust standard errors are clustered at the week level and reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. *Sources*: FR 2004, FR Y-9C, authors' calculations.

Differential Effect of SLR Change on Liquidity

After SLR was relaxed, in addition to increasing positions, affected dealers also increase turnover and margins decline → liquidity improved

	$\text{Log}(\text{Turnover}_{i,t})$	$\text{Log}(\text{Turnover}_{i,m,t})$	$\text{Margin}_{i,t}$	$\text{Log}(\text{Margin}_{i,t})$
	(1)	(2)	(3)	(4)
$\text{Post-Change}_t \times \text{SLR}_i^{2019q4}$	-0.050**	-0.069***	0.081**	0.098*
	(0.020)	(0.023)	(0.039)	(0.050)
Week FE	Yes		Yes	Yes
Bank FE	Yes		Yes	Yes
Week*Maturity FE		Yes		
Bank*Maturity FE		Yes		
R^2	0.977	0.944	0.667	0.833
R^2 within	0.073	0.041	0.013	0.011
N	171	1,026	171	147

Notes: In column (1), the data are at the bank-week level, and the dependent variable is the logarithm of total turnover in Treasury securities of dealer i in week t. In columns (2) and (3), the data are at the bank-maturity-week level. In column (2), the dependent variable is the logarithm of turnover in Treasury securities in maturity bucket m of dealer i in week t. In column (3), the dependent variable is the total weekly profits of dealers' trading desks (retrieved from VV-1 data) relative to the preceding week's position (margin) and expressed as a ratio of its standard deviation. In column (4), similar results are obtained with the dependent variable being the logarithm of the intermediation margin. Post-SLR is an indicator that equals one as of week 14 of 2020 and zero otherwise. SLR is the 2019:Q4 SLR ratio as a percentage. The sample period covers 2020:W8 through 2020:W28. Robust standard errors are clustered at the week level and reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. *Sources*: FR 2004, FR Y-9C, FR VV-1, authors' calculations.

Roadmap

Analysis #2 focuses on Value-at-Risk (VaR) constraints

- Volcker Rule generally prohibits proprietary trading of BHCs (Treasuries exempt)
- VV-1 data also monitors internal risk limits and usage at desk-day level to assess compliance, common metric is VaR
  - E.g., Treasury portfolio loss not to exceed X$ with probability 95%.
  - VaR constraints are risk-sensitive (unlike SLR constraint)
- We identify the US Treasury desk(s) at each primary dealer in the VV-1 data from desk names and descriptions
- Application of Gabaxi and Koijen (2024) GIV to identify exogenous aggregate limit changes of dealers. ▸ Details

Identification of Effect of Limit Shocks on Treasury Market

$$\Delta y_{m,t} = \beta_1 \text{Limit Shock}_{m,t} + \gamma' X_{m,t} + \alpha_m + \alpha_t + u_{m,t}$$

- $y_{m,t}$ is one of three outcome variables:
  1. log aggregate net positions in maturity bucket m
  2. log aggregate turnover in maturity bucket m
  3. log bid–ask spread associated with maturity bucket m
- Controls include 4 lags of y
- Robust standard errors are clustered at week level
- Sample: 2016:W1 through 2023:W52 (robust to excluding 2020:Q1–2021:Q1)
- Baseline sample: bonds and notes, not bills

Sum stats

After tightening limit shocks, dealers' positions decline

	Log(Position)		
	(1)	(2)	(3)
Limit Shock	-0.021***	-0.021**	
	(0.007)	(0.008)	
Raw Limit Change			-0.008
			(0.007)
Lagged LHS	Yes	Yes	Yes
Maturity FE	Yes	Yes	Yes
Week FE	Yes	Yes	Yes
Excl. COVID	No	Yes	No
R^2	0.945	0.942	0.945
R^2 within	0.733	0.725	0.732
N	2,075	1,815	2,075

Notes: The table reports the effects of a one-standard-deviation tightening limit shock on primary dealers' net positions. The dependent variable is the logarithm of the absolute value of dealers' net position in Treasury securities. The data are at the maturity-bucket and week level. The sample period covers 2016:W1 through 2023:W52. The COVID-19 period is excluded or not, as indicated in the fixed effects panel. Robust standard errors are clustered at the week level and reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. *Sources*: FR 2004, FR VV-1, authors' calculations.

▸ Robustness: alternative shocks ▸ Robustness: sample period

Heterogeneous Effects Depending on Return Variability

	Log(Position$_{m,t}$)		
	(1)	(2)	(3)
Non-Bills × Limit Shock$_{m,t}$	-0.0154**		
	(0.008)		
Bills × Limit Shock$_{m,t}$	0.00153		
	(0.010)		
Limit Shock$_{m,t}$		-0.00987	-0.0201***
		(0.006)	(0.007)
Return Variability$_{m,t}$		0.00989**	0.00875**
		(0.004)	(0.004)
Return Variability$_{m,t}$ × Limit Shock$_{m,t}$		-0.0184**	-0.0171**
		(0.008)	(0.009)
Lagged LHS	Yes	Yes	Yes
Maturity FE	Yes	Yes	Yes
Week FE	Yes	Yes	Yes
Excl. Bills	No	No	Yes
R^2	0.944	0.944	0.950
R^2 within	0.749	0.749	0.740
N	2,696	2,696	2,281

▸ Return by maturity bucket

Tightening limit shock $\Longrightarrow$ turnover decreases and bid-ask spreads increase

	Log(Turnover$_{m,t}$)		Log(Bid-Ask$_{m,t}$)	
	(1)	(2)	(3)	(4)
Limit Shock$_{m,t}$	-0.017	-0.021**	0.024***	0.027***
	(0.011)	(0.010)	(0.007)	(0.008)
Lagged LHS	Yes	Yes	Yes	Yes
Maturity FE	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes
Excl. COVID	No	Yes	No	Yes
R^2	0.866	0.872	0.943	0.938
R^2 within	0.017	0.013	0.564	0.571
N	2,075	1,815	2,061	1,803

▸ Liquidity index

Roadmap

Model-based estimation of cost of constraints

- Dealer optimization problem:

$$\max_{\{s,\lambda\}} \mathcal{L} = s \cdot t(s) + r \cdot \delta(s) - \lambda \cdot \left(\delta(s) - \bar{\delta}\right)$$

- FOC: the marginal return from charging a spread (intermediation income) has to equal the marginal cost of holding a position

$$t + st' = (\lambda - r)\delta' \quad \Rightarrow \quad \frac{1 + \epsilon_t}{\epsilon_\delta} = \frac{\lambda - r}{\mu}$$

  - $\mu \equiv \frac{s \cdot t}{\delta}$: a margin measure equal to spread income relative to position
  - r: repo rate at which positions are financed
  - ϵ_t: spread elasticity of turnover
  - ϵ_δ: spread elasticity of position

- Estimate cost of constraint by backing out spread elasticities from identified limit-shock elasticities of turnover, position, and the spread

$$\epsilon_t \equiv \frac{dt}{ds}\frac{s}{t} = e_t/e_s \quad \text{and} \quad \epsilon_\delta \equiv \frac{d\delta}{ds}\frac{s}{\delta} = e_\delta/e_s.$$

Estimated Elasticities and Shadow Cost of Constraints

	Bid-Ask Spread Elasticity of		Constraint Shadow Cost (% of Margin)
	Turnover, ϵ_t	Position, ϵ_δ	
	(1)	(2)	(3)
VaR estimates	-0.71	-0.87	8.7
SLR estimates	-0.76	-0.93	6.3

Note: The table reports the spread elasticity of turnover and position as implied by our estimates from the analysis of either VaR limits or the SLR policy change.

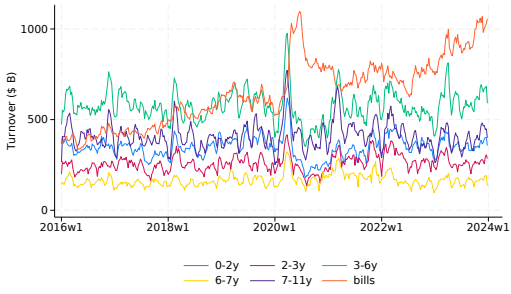
Roadmap

Conclusion

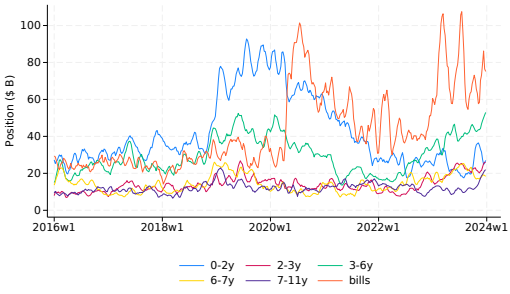
- Intermediary constraints matter for pricing and liquidity of Treasuries
  1. reduce dealers' positions,
  2. reduce turnover and liquidity,
  3. amplify price movements after net demand shifts, and
  4. impair auction outcomes.
- This is true for two types of constraints: SLR and desk-level VaR constraints
- Understanding the forces that can impair US Treasury market functioning is critical both for US Government financing as well as overall capital market functioning, given Treasuries' central importance.

APPENDIX

Aggregate Turnover and Net Positions of Primary Dealers



(a) Turnover $B



(b) Net position $B

Notes: Four-week moving averages based on weekly FR 2004 data. *Sources*: FR 2004, FR VV-1, authors' calculations.

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Table: Summary Statistics of Bank-Week-Level Data

	Mean	SD	p25	p50	p75	Obs.
$\text{Turnover}_{i,t}$ ($B)	212.45	125.27	130.40	208.28	280.95	171
$\text{Net Position}_{i,t}$ ($B)	16.31	18.27	3.70	11.88	18.35	171
$\text{Gross Position}_{i,t}$ ($B)	34.27	27.62	14.36	27.65	45.93	171
$\text{Margin}_{i,t}$ (P&L over Gross Position, %)	0.08	0.12	0.00	0.04	0.12	171
SLR_i (%)	7.13	1.85	6.21	6.36	7.07	171
SLR Diff_i (%)	0.57	0.25	0.47	0.66	0.73	171

Notes: Data are at the bank-week frequency, and summary statistics are reported for the baseline sample from 2020:W8 through 2020:W28. The margin is computed as primary dealers' trading-desk profits and losses reported in the VV-1 data as a percentage of their gross position reported in the 2004 data. SLR is the 2019:Q4 SLR ratio, and SLR Diff is the hypothetical change in the 2019:Q4 SLR if Treasuries and reserves were exempt from the exposure. *Sources*: FR 2004, FR Y-9C, authors' calculations.

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Federal Reserve Responses to COVID-19 Crisis

Facility	Sector targeted	Funding	Date announced	Date opened	Date closed	Maximum capacity ($ bil.)	Peak assets ($ bil.)	Assets as of 12/8/21 ($ bil.)	Treasury backstop ($ bil.)
Commercial Paper Funding Facility (CPFF)	Commercial paper market	Fed, Treasury (ESF)	3/17/20	4/14/20	3/31/21	Unlimited	4.2	0.0	10.0
Main Street Lending Program (MSLP)*	Small and mid-sized businesses, non-profits	Fed, Treasury (CARES Act)	4/9/20	7/6/20†	1/8/21	600.0	16.6	13.4	75.0
Money Market Mutual Fund Liquidity Facility (MMLF)	Money market mutual funds	Fed, Treasury (ESF)	3/18/20	3/23/20	3/31/21	Unlimited	53.2	0.0	10.0
Municipal Liquidity Facility (MLF)*	State and local governments	Fed, Treasury (CARES Act)	4/9/20	5/26/20	12/31/20	500.0	6.4	4.2	35.0
Paycheck Protection Program Liquidity Facility (PPPLF)*	Small businesses	Fed	4/9/20	4/16/20	7/30/21	953.0‡	90.6	39.9	-
Primary Dealer Credit Facility (PDCF)	Broker-dealers	Fed	3/17/20	3/20/20	3/31/21	Unlimited	33.4	0.0	-
Primary Market Corporate Credit Facility (PMCCF)*	Large businesses	Fed, Treasury (CARES Act)	3/23/20	6/29/20	12/31/20	750.0	0.0	0.0	50.0
Secondary Market Corporate Credit Facility (SMCCF)*	Large businesses, exchange-traded funds	Fed, Treasury (CARES Act)	3/23/20	5/12/20†	12/31/20	Combined with PMCCF	14.3	0.0	25.0
Term Asset-Backed Securities Loan Facility (TALF)	Securities markets (e.g. student, auto, & credit card loans)	Fed, Treasury (CARES Act)	3/23/20	6/17/20	12/31/20	100.0	4.1	1.4	10.0

Notes: Key Federal Reserve programs to support the economy at the onset of the COVID-19 crisis.

Source: https://www.brookings.edu/articles/fed-response-to-covid19/.

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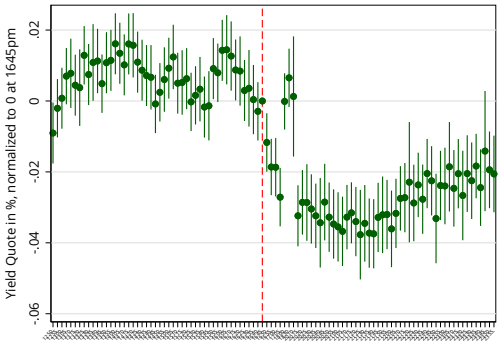
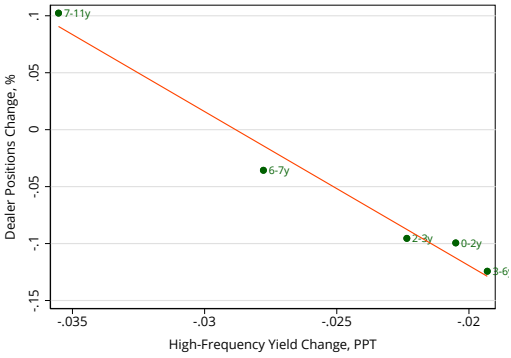
Intraday evidence

Figure: High-Frequency Yield Change around SLR announcement and Dealers' Position Change





Notes: This figure plots, for different maturity bucket, the US Treasury yield changes around the SLR announcement on 4:45pm on April 1, 2020 against the change in dealer positions. ... *Sources*: Refinitiv, authors' calculations.

Identification of Granular Limit Shocks

- Two insights from Gabaix and Koijen (2020):
  1. Isolate bank-level idiosyncratic risk limit changes (orthogonal to general market conditions)
  2. Granularity of dealer-centric market $\implies$ these exogenous, idiosyncratic limit changes affect aggregate quantities

- Idiosyncratic limit changes identified from regression at the desk-day (d, τ) level:

$$\Delta \log \text{Limit}_{i,\tau} = \sum_{\substack{h=-20 \\ h\neq 0}}^{20} \gamma_h \log \text{Limit}_{i,\tau-h} + \sum_{\substack{h=-20 \\ h\neq 0}}^{20} \omega_h \text{Usage}_{i,\tau-h} + \alpha_i + \alpha_\tau + e_{i,\tau}$$

  - α_d is desk fixed effects, and $\alpha_{b,\tau}$ is bank-day fixed effects
  - ‣ Kurtosis in changes
  - Risk limits tend to change due to recalibration of VaR methodology, changes in business strategy, and regulatory compliance (Barbiero et al. 2024)

‣ Back

Aggregation to Maturity-Time Level Shocks

- Construct the limit shock variable at the bank-week level:

$$\text{Limit Shock}_{i,t} = -\sum_{\tau \in t} \hat{e}_{i,\tau}$$

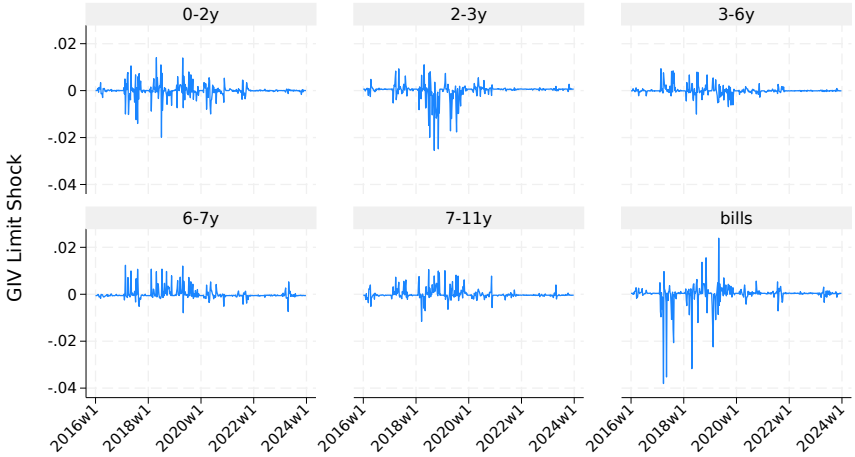
  - The summation aggregates daily bank level shocks to the weekly frequency.
  - **Note**: multiplied by -1 $\implies$ an increase in the limit shock variable means banks are *more* constrained

- Maturity-week limit shocks are constructed with (net) exposure weights:

$$\text{Limit Shock}_t^m = \sum_i \left(\frac{\text{abs}(\text{Net Position}_{i,t-1}^m)}{\sum_i \text{abs}(\text{Net Position}_{i,t-1}^m)} \right) \text{Limit Shock}_{i,t}$$

Limit shocks by maturity bucket | Back

Limit Shocks by Maturity Bucket



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Summary Statistics of Baseline Maturity-Week-Level Data

	Mean	SD	p25	p50	p75	Obs.
Turnover$_{m,t}$ ($B)	359.91	175.55	217.76	345.93	475.60	2080
Net Position$_{m,t}$ ($B)	22.53	15.75	11.80	16.88	28.08	2080
Gross Position$_{m,t}$ ($B)	65.79	37.42	36.05	45.91	93.74	2080
Bid-Ask Spread$_{m,t}$ (% Mid Point)	0.05	0.03	0.03	0.04	0.08	2073
Margin$_{m,t}$ (Income over Net Position, %)	1.23	1.31	0.41	0.71	1.45	2073
Margin$_{m,t}$ (Income over Gross Position, %)	0.38	0.36	0.12	0.24	0.50	2073
Limit Shock$_{m,t}$ (%)	-0.14	0.52	-0.04	-0.01	-0.01	2080
Raw Limit Change$_{m,t}$ (%)	-0.07	0.51	-0.04	0.00	0.03	2080
Yield-to-Maturity$_{m,t}$ (%)	2.02	1.27	1.07	1.81	2.78	2080
Adj. MBS Duration$_t$	4.18	1.28	3.07	4.51	5.20	1935
EURIBOR Change$_t$ (bps)	1.96	5.98	-0.42	0.00	0.66	2070

Notes: Positions are aggregate net positions computed as the sum of net positions across all dealers by maturity and week. Income = Spread*Turnover. MBS duration in years. EURIBOR Changes represent two-week changes. *Sources*: FR 2004, FR VV-1, CRSP, Bloomberg, authors' calculations.

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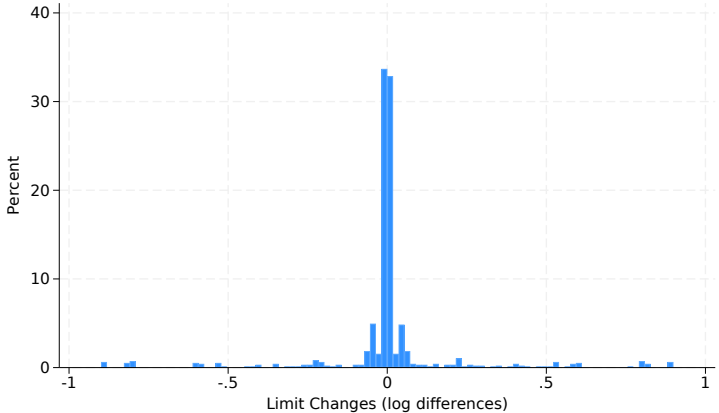
Distribution of VaR-Limit Changes



Notes: This figure shows the distribution of the log difference of VaR limits at the bank-day level. Only nonzero changes are included, and they are trimmed at top and bottom 2.5 percent. *Sources*: FR VV-1, authors' calculations.

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Baseline Results Using Alternative Shocks

	Log(Position$_{m,t}$)				
	(1)	(2)	(3)	(4)	(5)
Limit Shock (w/o leads)$_{m,t}$	-0.017***				
	(0.006)				
Limit Shock (w/ FR 2004 controls)$_{m,t}$		-0.022***			
		(0.008)			
Limit Shock (w/ PCA)$_{m,t}$			-0.012**		
			(0.006)		
Limit Shock (excl. Holidays)$_{m,t}$				-0.010*	
				(0.005)	
Limit Shock (excl. dealers w/ foreign desks)$_{m,t}$					-0.009**
					(0.004)
Lagged LHS	Yes	Yes	Yes	Yes	Yes
Maturity FE	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	Yes
R^2	0.945	0.945	0.945	0.945	0.945
R^2 within	0.733	0.733	0.732	0.732	0.732
N	2,075	2,075	2,075	2,075	2,075

Notes: In column (1), we exclude leads of limits and percent utilization from our calculation of the Limit Shock variable. In column (2), we control for the primary dealer's *past* positions in Treasuries as reported in the FR 2004 data, in addition to the past limit utilization that we include in our baseline specification. In column (3), we incorporate a factor analysis of the desk-day-level limit innovations and remove the first principle component. In column (4), we remove foreign holidays from the estimation sample of the idiosyncratic desk innovations. In column (5), we remove primary dealers with foreign desks from the sample. *Sources*: FR VV-1, FR 2004, authors' calculations.

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Baseline Results Using Alternative Sample Periods

	Log(Position$_{m,t}$)			
	$t < 2019$	$t \geq 2019$	$t \geq 2020$	All
	(1)	(2)	(3)	(4)
Limit Shock$_{m,t}$	-0.028**	-0.014*	-0.005	
	(0.012)	(0.008)	(0.005)	
Year 2016 × Limit Shock$_{m,t}$				-0.041
				(0.068)
Year 2017 × Limit Shock$_{m,t}$				-0.020**
				(0.009)
Year 2018 × Limit Shock$_{m,t}$				-0.021*
				(0.012)
Year 2019 × Limit Shock$_{m,t}$				-0.020*
				(0.012)
Year 2020 × Limit Shock$_{m,t}$				-0.041*
				(0.022)
Year 2021 × Limit Shock$_{m,t}$				0.040
				(0.051)
Year 2022 × Limit Shock$_{m,t}$				0.307
				(0.233)
Year 2023 × Limit Shock$_{m,t}$				0.011
				(0.045)
Lagged LHS	Yes	Yes	Yes	Yes
Maturity FE	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes
R^2	0.933	0.950	0.941	0.945
R^2 within	0.505	0.794	0.799	0.733
N	775	1,300	1,040	2,075

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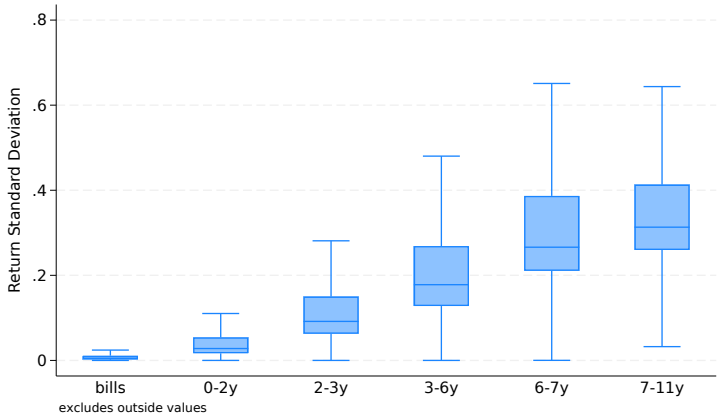
Return Variability by Maturity Bucket



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Limit shock effect on liquidity index

	Liquidity Index$_{m,t}$	
	(1)	(2)
Limit Shock$_{m,t}$	-0.089*	-0.096
	(0.051)	(0.058)
Lagged LHS	Yes	Yes
Maturity FE	Yes	Yes
Week FE	Yes	Yes
Excl. COVID	No	Yes
R^2	0.653	0.648
R^2 within	0.314	0.333
N	2,040	1,780

Notes: The liquidity index is based on the average yield errors of US Treasury bonds from a fitted Treasury curve. *Sources*: FR VV-1, FR 2004, Bloomberg, authors' calculations.

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Summary Statistics on Treasury Auctions

	2-Year	3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
Total Accepted$_{m,t}$ ($ B)	44.68	44.41	48.06	41.54	32.81	20.20	20.91
Primary Dealer Accepted$_{m,t}$ (%)	27.87	29.30	22.00	17.91	21.62	16.33	20.13
Bid-to-Cover$_{m,t}$	2.66	2.62	2.44	2.47	2.47	2.52	2.33
High Yield$_{m,t}$ (%)	1.87	1.93	2.06	2.21	2.31	2.79	2.76
Number of Auctions	95.00	96.00	95.00	95.00	97.00	44.00	96.00

Notes: The first four rows correspond to means conditional on the respective maturity indicated in the columns. The sample excludes T-bills auctions. For the 10-, 20-, and 30-year buckets, we include the few securities with one or two months shorter maturity in those buckets. For example, we consider a security with a maturity of nine years and 10 months equivalent to a 10-year Treasury. *Sources*: Treasury Securities Auctions Data, authors' calculations.

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