Deconstructing debt supply shocks using Treasury auction announcements

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CEMFI

EEA-ESEM 2024

August 25, 2024

Motivation

- Governments issue public debt to fund fiscal deficit
  - Sharp increase in several nations post Covid-19
  - US public debt on 4th June, 2024 at historical high = \$34.67 tln ($\frac{Debt}{GDP} = 122\%$)

- Supply of debt → economy? Not obvious
  1. Jointly determined. US Treasury $\xrightarrow{\text{several determinants}}$ debt supply decisions
  2. Debt funded by bonds with different maturities. Debt supply changes → mix of two distinct phenomena
     - Change in overall *level* of debt
     - Change in issuance across *maturities*, conditional on debt level

- Separately identify shocks to debt level and maturity. Study causal effects
  1. Level
     - Mixed evidence
  2. Maturity
     - Less evidence. Effects? Transmission channels?

Debt dynamics

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Debt dynamics

This paper

1. Identify exogenous changes/shocks to level and maturity structure of public debt supply
   - Combine high-frequency data and features of Treasury auction announcements
   - Key innovation
     i. First to separate level and maturity component of debt supply shocks
     ii. Novel identification strategy. Can be used to separate other series of structural shocks
2. Transmission of shocks to macroeconomy
   - Effects on asset prices and macroeconomic variables
   - Innovation: Test preferred habitat framework predictions
   - Empirical results
     i. $\uparrow$ debt level: $\uparrow$ yield curve. Recession
     ii. $\uparrow$ debt maturity: $\uparrow$ yield curve. Expansion
   - Increase in debt maturity leads to expansions $\rightarrow$ inconsistent with model prediction

Quantifying shocks to debt level and maturity

Treasuries auction announcements

- Treasury issues new debt → periodic uniform price auctions
- Volume offered at auction → announced few days prior. Two types
  1. *Official Financial Remarks (OFRs)*
     - Quarterly
     - Few pages in length
     - Specific auctions. For example, for next 3yr, 10yr, and 30yr auctions
  2. *Intermediate announcements (Inters)*
     - More frequent
     - One page
     - Rest of the auctions in quarter
- Remove Inters that contain no new information
- 348 announcements: Aug 1995 - Dec 2021
- Change in Treasury futures prices around announcements capture new information on debt supply

OFR Inter

Intraday movement in futures price

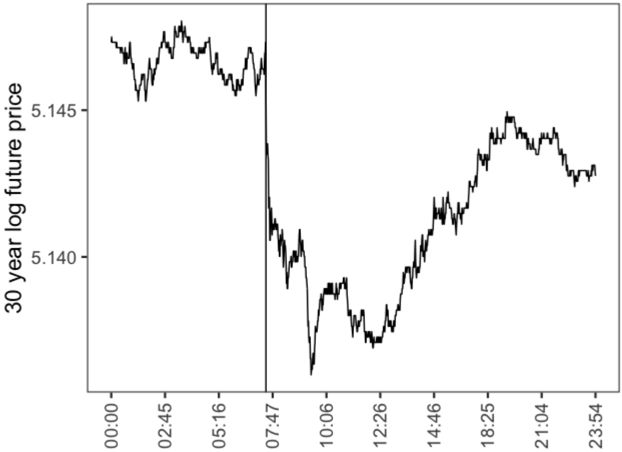

Figure: Intraday movements in futures price on 2020-05-06

Second example

Factors driving futures price changes

- Change in (log) futures prices in a narrow interval around announcements

$$f_t^m = F_{t,post}^m - F_{t,pre}^m \tag{1}$$

- $m \in \{2y, 5y, 10y, 30y, \text{3mo-Eud}\}$
- Interval customized according to nature of the announcement. Typically 30 minutes
- Vector at time t: $D_t = [f_t^{3m} \quad f_t^{2Y} \quad f_t^{5Y} \quad f_t^{10Y} \quad f_t^{30Y}]'$
- Changes in D_t mainly driven by two underlying factors. To get debt level and maturity factors
  1. Estimate principal components F_t and loading matrix Λ in $\underbrace{D_t}_{5\times1} = \underbrace{\Lambda'}_{5\times2} \underbrace{F_t}_{2\times1} + \epsilon_t$
  2. Estimate U such that $\underbrace{\tilde{F}_t}_{\text{true factors}} = U' F_t$. How?
     - Categorize announcements into subsets based on relative information between debt level and maturity
     - Restrictions on factor variances $V(\tilde{F}_t)$ based on subsets

Density | Factor No.Test | Identification

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Restrictions based on subsets

Subset *inter*: Inters + short OFRs. Total offered volume and auction rules (279 obs)

$$V(\tilde{F}_{inter}) = U' V(F_{inter}) U, \qquad V(\tilde{F}_{inter}) = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \tag{2}$$

Subset *level*: OFR. More information on debt level (18 obs)

$$V(\tilde{F}_{level}) = U' V(F_{level}) U, \qquad V(\tilde{F}_{level}) = \begin{bmatrix} \sigma^2_{1,level} & 0 \\ 0 & \sigma^2_{2,level} \end{bmatrix} \tag{3}$$

Subset *mat*: OFR. More information on debt maturity (34 obs)

$$V(\tilde{F}_{mat}) = U' V(F_{mat}) U, \qquad V(\tilde{F}_{mat}) = \begin{bmatrix} \sigma^2_{1,mat} & 0 \\ 0 & \sigma^2_{2,mat} \end{bmatrix} \tag{4}$$

9 restrictions on 5 free parameters $\theta_0 \in \{\theta, \sigma_{1,level}, \sigma_{2,level}, \sigma_{1,mat}, \sigma_{2,mat}\}$

Estimate using 2-step GMM

Effects on asset prices and macroeconomic variables

Effects on asset prices

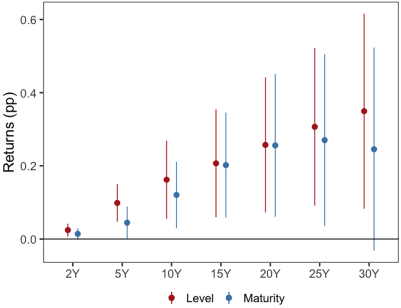
- OLS: $\Delta y_t \rightarrow$ daily change in price of an asset

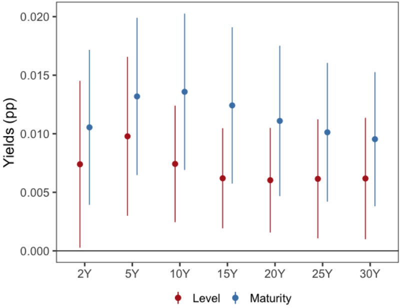
$$\Delta y_t = \alpha + \beta_1 s_{L,t} + \beta_2 s_{M,t} + \epsilon_t \tag{5}$$

- $\beta_1 \rightarrow$ effect of $\uparrow$ debt level
- $\beta_2 \rightarrow$ effect of $\uparrow$ debt maturity
- Nominal bond market effects $\rightarrow$ test Greenwood and Vayanos (2014) predictions

Bond returns and yields

- Dep variable: return $r^{\tau}_{t,t+1} = p^{\tau-1}_{t+1} - p^{\tau}_{t}$, zero coupon yield $y^{\tau}_{t} = -p^{\tau}_{t}/\tau$





- Greenwood and Vayanos (2014) predictions *(intuition)*. ↑ debt level/maturity leads to
  - All returns/yields ↑ *(> premium for > portfolio risk)*
  - Effect size ↑ with τ for returns *(long bonds riskier)*
  - Size ↑ or hump-shaped across τ for yields *(yield = mean ret over τ)*
  - Size larger for returns *(yield = mean ret over τ)*

RA state dependence

Other asset prices

- Indep variable: $s_{L,t}$, $s_{M,t}$ $\rightarrow$ price responses to supply shocks

$$\Delta y_t = \alpha + \beta_1 s_{L,t} + \beta_2 s_{M,t} + \epsilon_t \tag{6}$$

- Strong correlation $\beta_i, i \in \{1,2\}$ suggest (Droste et al, 2021)
  1. Channel of propagation $\rightarrow$ high-grade corp bond yields affected
  2. Jointly determined due to information shocks $\rightarrow$ other asset prices also affected

	Panel A: Level factor	Panel B: Maturity factor	
	Estimate (p-value)	Estimate (p-value)	Sample
Corp bond yields			
Aaa grade	0.001 (0.65)	0.01** (0.003)	1995-2021
Baa grade	0.004 (0.17)	0.01** (0.002)	1995-2021
C grade	-0.004 (0.69)	0.02 (0.2)	1996-2021

Table: Level and maturity factor on corp bond yields. Effects in percentage points.

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Other asset prices

		Panel A: Level factor	Panel B: Maturity factor	
		Estimate (p-value)	Estimate (p-value)	Sample
Equity				
	S&P 500	0.002* (0.07)	-7e-4 (0.44)	1995-2021
	Russell 2000	0.002* (0.09)	0.1e-4 (0.99)	1995-2021
Exchange rates				
	Dollar-Euro	0.003 (0.2)	5e-4 (0.79)	2003-2021
	Dollar-Yen	0.002 (0.12)	4e-4 (0.61)	1996-2021
Commodities				
	GSCI	-5.7e-4 (0.52)	0.14e-4 (0.99)	1995-2021
Uncertainty				
	VIX	-0.006* (0.09)	-5e-4 (0.88)	1995-2021

Table: Level and maturity factor on other asset prices. All effects in percent changes

SVAR-IV impulse responses for asset prices

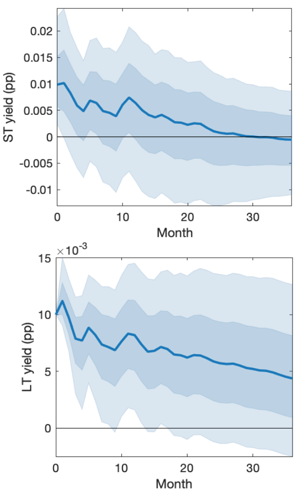


Figure: Level factor

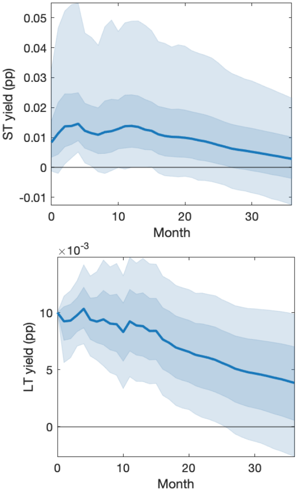


Figure: Maturity factor

Figure: Light and dark blue shaded regions are 68% and 90% confidence bands respectively.

SVAR-IV impulse responses for macro variables

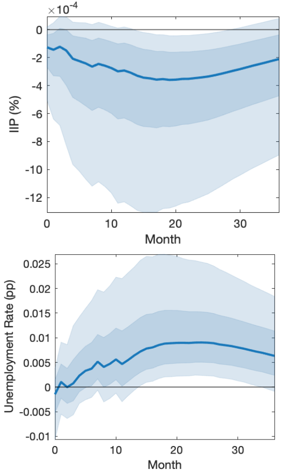
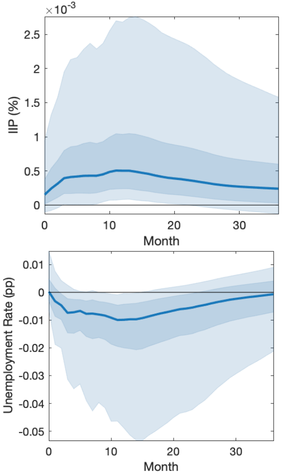


Figure: Level factor



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– ↑ debt level/maturity: ↑ yield curve $\xrightarrow{\text{IS curve}}$ recession (Ray, 2019)

Spec Other vars

Concluding remarks

- Identify shocks to level and maturity structure of public debt supply
  - Novel identification strategy to separate components
  - Readily usable to look at causal effects on variables of interest.
- Non-trivial effects on asset prices and macroeconomy. Transmission $\rightarrow$ Preferred habitat channel
  - $\uparrow$ debt level/maturity $\rightarrow \uparrow$ yield curve (Greenwood and Vayanos, 2014)
  - $\uparrow$ debt level $\rightarrow \downarrow$ output, employment (Ray, 2019)
  - $\uparrow$ debt maturity $\rightarrow \uparrow$ output, employment. Alternative channel.

Thank you !

Appendix

Identification in factor model

- Factor model

$$\underbrace{D_t}_{5\times 1} = \underbrace{\Lambda'}_{5\times 2} \underbrace{F_t}_{2\times 1} + \epsilon_t \tag{7}$$

- Estimate level and maturity factors in two steps

1. Estimate principal components F_t and loading matrix Λ

$$D_t = \Lambda' \underbrace{UU'}_{\mathcal{I}_2} F_t + \epsilon_t = \tilde{\Lambda}' \tilde{F}_t + \epsilon_t \tag{8}$$

$$U \text{ is an orthogonal matrix } \begin{bmatrix} cos\theta & -sin\theta \\ sin\theta & cos\theta \end{bmatrix}$$

2. Estimate $U \rightarrow$ narrative + heteroscedasticity restrictions
   - $\tilde{F}_t = U' F_t$
   - $V(\tilde{F}_t) = U' V(F_t) U$
   - Heteroscedasticity $\rightarrow$ restrictions on factor variances $V(\tilde{F}_t)$ based on subsets
   - Narrative $\rightarrow$ subsets categorized on relative information between debt level and maturity

PCA estimates back

Two-step GMM estimates

- Estimates

	Estimates	Std Errors
θ	28.31	9.97
$\sigma_{1,inter}$	1	–
$\sigma_{2,inter}$	1	–
$\sigma_{1,level}$	0.72	0.20
$\sigma_{2,level}$	0.73	0.15
$\sigma_{1,mat}$	1.42	0.23
$\sigma_{2,mat}$	0.80	0.12
J-test stat	1.64	
p-value	0.80	
Degrees of freedom	4	

Table: Sargan-Hansen J-test. $H_0 : E[g(Y_l, \theta_0)] = 0$

- $U = \begin{bmatrix} 0.88 & -0.47 \\ 0.47 & 0.88 \end{bmatrix}$ Factors of interest $\tilde{F}_t = U' F_t$

- $\frac{\sigma^2_{1,mat}}{\sigma^2_{2,mat}} = 3.12 > \frac{\sigma^2_{1,level}}{\sigma^2_{2,level}} = 0.97$ First factor $\rightarrow$ maturity.

Moment condition back

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Moment condition back

Specification

- Dynamic effect in the macroeconomy due to debt level/maturity shocks $\varepsilon_{1,t}$ (unobserved)
- Impulse responses from SVAR-IV (Mertens and Ravn, 2013; Stock and Watson, 2018)
- Estimated shocks s_t as instrument. Key assumptions
  1. *Relevance.* $E(s_t \varepsilon_{1,t}) = \alpha \neq 0$
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- Variables in SVAR-IV

$$Y_t = [\underbrace{y_t^{(2)}(\%) \quad y_t^{(15)}(\%)}_{\text{Asset price block}} \quad \underbrace{\log(IIP_t) \quad \log(PCE_t) \quad \text{UnRate}_t(\%)}_{\text{Macro block}} \quad \underbrace{\text{FrMD}_t}_{\text{For invertibility}} \quad]' \tag{9}$$

- Effect of $\uparrow$ level/maturity shock $\varepsilon_{1,t}$ that $\uparrow$ $y_t^{(15)}$ by 0.01 pp on impact
- Montiel Olea, Stock and Watson (2021) weak instrument robust confidence intervals

SVAR-IV details | IV relevance test | Model | back

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- Ray (2019) framework predictions
  - $\uparrow$ debt level/maturity: $\uparrow$ yield curve $\xrightarrow{\text{IS curve}}$ recession

SVAR-IV details | IV relevance test | Model | back

Asset price block impulse responses

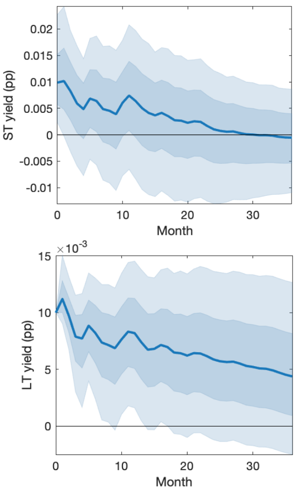
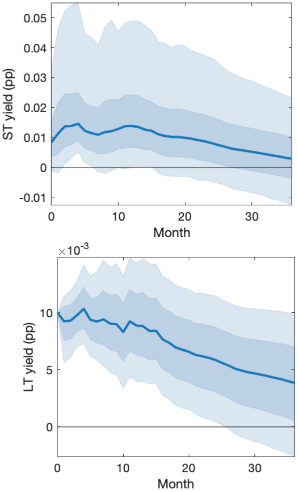


Figure: Level factor



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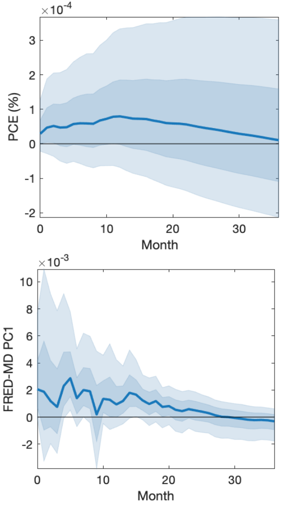
Macro block impulse responses - II



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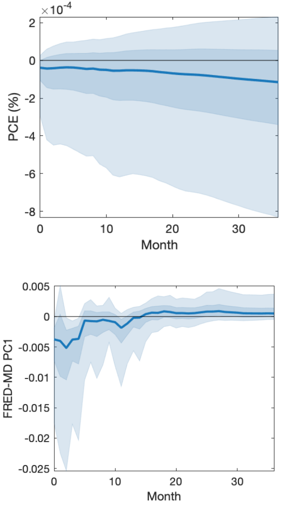

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back

Debt dynamics

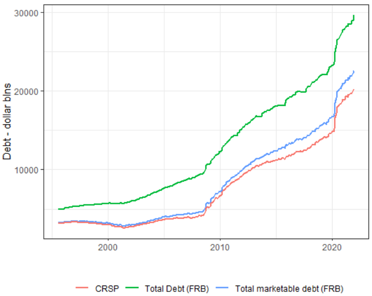
$$Debt_t = \underbrace{\sum_{i \leq t} \text{Debt supply}_i}_{\textit{Inflow}} - \underbrace{\sum_{i \leq t} \text{Debt matured}_i}_{\textit{Outflow}} \tag{10}$$

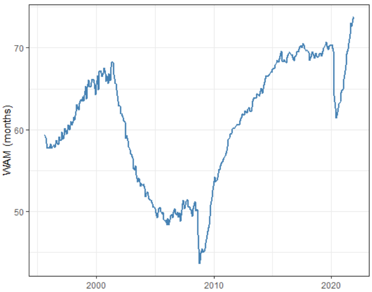
$$Debt_t - Debt_{t-1} = \underbrace{(\text{Debt supply}_t - \text{Debt supply}_{t-1})}_{f(Y_t)} - \underbrace{(\text{Debt matured}_t - \text{Debt matured}_{t-1})}_{\textit{Deterministic}} \tag{11}$$

$$Debt_t - E_{t-1}Debt_t = (\text{Debt supply}_t - E_{t-1}\text{Debt supply}_t) - \underbrace{(\text{Debt matured}_t - E_{t-1}\text{Debt matured}_t)}_{=0} \tag{12}$$

back

Debt dynamics





Issuance frequency

Treasury Issuance Calendar

Nominal Securities	Frequency
4-week bills	Weekly
8-week bills	Weekly
13-week bills	Weekly
17-week bills	Weekly
26-week bills	Weekly
52-week bills	Every 4 weeks
2-year notes	Monthly
3-year notes	Monthly
5-year notes	Monthly
7-year notes	Monthly
10-year notes	Quarterly, with 2 re-openings
20-year bonds	Quarterly, with 2 re-openings
30-year bonds	Quarterly, with 2 re-openings
Treasury Inflation-Protected Securities (TIPS)	
5-year TIPS	Semi-annual, with 1 re-opening
10-year TIPS	Semi-annual, with 2 re-openings
30-year TIPS	Annual, with 1 re-opening
Floating Rate Notes (FRNs)	
2-year FRN	Quarterly, with 2 re-openings

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Figure: Source: US Treasury website

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Auction calendar example

Tentative Auction Schedule of U.S. Treasury Securities					
Security Type			**Announcement Date**	**Auction Date**	**Settlement Date**
3-Year NOTE			**Wednesday, August 02, 2023**	**Tuesday, August 08, 2023**	**Tuesday, August 15, 2023**
10-Year NOTE			**Wednesday, August 02, 2023**	**Wednesday, August 09, 2023**	**Tuesday, August 15, 2023**
30-Year BOND			**Wednesday, August 02, 2023**	**Thursday, August 10, 2023**	**Tuesday, August 15, 2023**
13-Week BILL			Thursday, August 03, 2023	Monday, August 07, 2023	Thursday, August 10, 2023
26-Week BILL			Thursday, August 03, 2023	Monday, August 07, 2023	Thursday, August 10, 2023
52-Week BILL			Thursday, August 03, 2023	Tuesday, August 08, 2023	Thursday, August 10, 2023
17-Week BILL			Tuesday, August 08, 2023	Wednesday, August 09, 2023	Tuesday, August 15, 2023
4-Week BILL			Tuesday, August 08, 2023	Thursday, August 10, 2023	Tuesday, August 15, 2023
8-Week BILL			Tuesday, August 08, 2023	Thursday, August 10, 2023	Tuesday, August 15, 2023
13-Week BILL			Thursday, August 10, 2023	Monday, August 14, 2023	Thursday, August 17, 2023
26-Week BILL			Thursday, August 10, 2023	Monday, August 14, 2023	Thursday, August 17, 2023
17-Week BILL			Tuesday, August 15, 2023	Wednesday, August 16, 2023	Tuesday, August 22, 2023
4-Week BILL			Tuesday, August 15, 2023	Thursday, August 17, 2023	Tuesday, August 22, 2023
8-Week BILL			Tuesday, August 15, 2023	Thursday, August 17, 2023	Tuesday, August 22, 2023
13-Week BILL			Thursday, August 17, 2023	Monday, August 21, 2023	Thursday, August 24, 2023
26-Week BILL			Thursday, August 17, 2023	Monday, August 21, 2023	Thursday, August 24, 2023
2-Year FRN	**R**		**Thursday, August 17, 2023**	**Wednesday, August 23, 2023**	**Friday, August 25, 2023**
20-Year BOND			**Thursday, August 17, 2023**	**Wednesday, August 23, 2023**	**Thursday, August 31, 2023**
30-Year TIPS	**R**	**T**	**Thursday, August 17, 2023**	**Thursday, August 24, 2023**	**Thursday, August 31, 2023**

Figure: Source: TreasuryDirect (US Treasury)

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OFR example

May 6, 2015

(Archived Content)

WASHINGTON – The U.S. Department of the Treasury is offering $64 billion of Treasury securities to refund approximately $67 billion of Treasury notes maturing on May 15, 2015. This will result in a debt pay down of approximately $3 billion. The securities are:

- A 3-year note in the amount of $24 billion, maturing May 15, 2018;
- A 10-year note in the amount of $24 billion, maturing May 15, 2025; and
- A 30-year bond in the amount of $16 billion, maturing May 15, 2045.

The 3-year note will be auctioned on a yield basis at 1:00 p.m. ET on Tuesday, May 12, 2015. The 10-year note will be auctioned on a yield basis at 1:00 p.m. ET on Wednesday, May 13, 2015. The 30-year bond will be auctioned on a yield basis at 1:00 p.m. ET on Thursday, May 14, 2015. All of these auctions will settle on Friday,May 15, 2015.

The balance of Treasury financing requirements will be met with the weekly bill auctions, cash management bills, the monthly note and bond auctions, the May 10-year Treasury Inflation Protected Security (TIPS) reopening auction, the June 30-year TIPS reopening auction, the July 10-year TIPS auction, and the regular monthly 2-year Floating Rate Note (FRN) auctions.

Figure: Source: US Treasury website

Inter example

TREASURY NEWS

Department of the Treasury • Bureau of the Fiscal Service

Embargoed Until 11:00 A.M.
July 23, 2015

CONTACT: Treasury Securities Services
202-504-3550

TREASURY OFFERING ANNOUNCEMENT [1]

Term and Type of Security	2-Year Note
Offering Amount	$26,000,000,000
Currently Outstanding	$0
CUSIP Number	912828XP0
Auction Date	July 28, 2015
Original Issue Date	July 31, 2015
Issue Date	July 31, 2015
Maturity Date	July 31, 2017
Dated Date	July 31, 2015
Series	BD-2017
Yield	Determined at Auction
Interest Rate	Determined at Auction
Interest Payment Dates	January 31 and July 31
Accrued Interest from 07/31/2015 to 07/31/2015	None
Premium or Discount	Determined at Auction
Minimum Amount Required for STRIPS	$100
Corpus CUSIP Number	912820W37
Additional TINT(s) Due Date(s) and CUSIP Number(s)	None None
Maximum Award	$9,100,000,000
Maximum Recognized Bid at a Single Yield	$9,100,000,000
NLP Reporting Threshold	$9,100,000,000
NLP Exclusion Amount	$0
Minimum Bid Amount and Multiples	$100
Competitive Bid Yield Increments [2]	0.001%
Maximum Noncompetitive Award	$5,000,000
Eligible for Holding in TreasuryDirect®	Yes
Estimated Amount of Maturing Coupon Securities Held by the Public	$73,213,000,000
Maturing Date	July 31, 2015
SOMA Holdings Maturing	$1,000,000
SOMA Amounts Included in Offering Amount	No
FIMA Amounts Included in Offering Amount [3]	Yes
Noncompetitive Closing Time	12:00 Noon ET
Competitive Closing Time	1:00 p.m. ET

Figure: Source: TreasuryDirect (US Treasury)

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Intraday movement in futures price

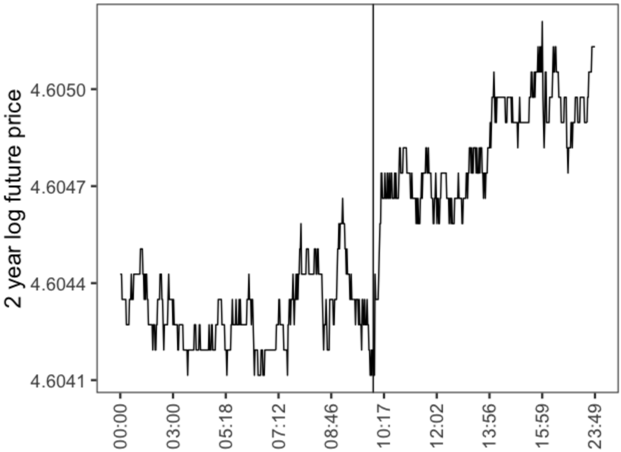

Figure: Intraday movements in futures price on 2009-04-23.

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Kernel density of futures price changes

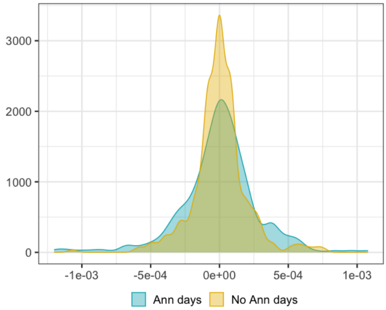

Figure: 2 year futures

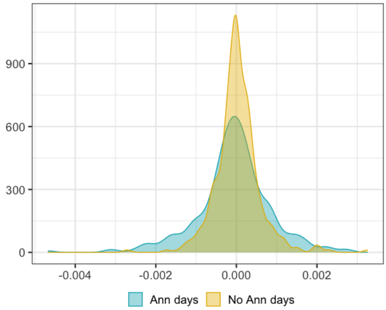

Figure: 5 year futures

- Announcement days → supply shocks
- No Announcement days → no major economic announcements
  - Price changes from 12:20am-12:50am (EST) for randomly chosen dates in sample
- Fatter tails on announcement days driven by major jumps in futures prices

Common factors

- Use intraday price changes D_t to estimate level and maturity shocks $\rightarrow$ factors
- Correlation matrix of D_t

	f_t^{3m}	f_t^{2Y}	f_t^{5Y}	f_t^{10Y}	f_t^{30Y}
f_t^{3m}	1				
f_t^{2Y}	0.42	1			
f_t^{5Y}	0.4	0.84	1		
f_t^{10Y}	0.34	0.72	0.89	1	
f_t^{30Y}	0.28	0.53	0.67	0.81	1

- D_t possibly driven by few common factors

$$\underbrace{D_t}_{5\times 1} = \underbrace{\Lambda'}_{5\times k} \underbrace{F_t}_{k\times 1} + \epsilon_t \tag{13}$$

H_0 : No of factors (k) =	Wald stat	χ^2 crit value	p-value	degree of freedom
0	103.35	18.31	0	10
1	19.11	11.07	0.002	5
2	**1.06**	**3.84**	**0.30**	**1**

Table: Cragg and Donald (1997) test. $H_0 : k_0$ vs $H_1 : k > k_0$.

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Summary statistics of futures price changes

Futures price changes	Mean($\times 10^{-5}$)	Median	SD($\times 10^{-4}$)	Kurtosis	N
Panel A: Ann days					
f_t^{3m}	0.6	0	0.8	3.19	331
f_t^{2Y}	-0.2	0	2.8	3.24	331
f_t^{5Y}	-6	0	9.1	2.72	331
f_t^{10Y}	-17	0	19	3.92	331
f_t^{30Y}	-22	0	33	4.96	331
Panel B: No ann days					
f_t^{3m}	-0.3	0	0.6	3.01	331
f_t^{2Y}	0.2	0	1.9	4.33	331
f_t^{5Y}	3	0	5.7	5.79	331
f_t^{10Y}	3	0	12	4.96	331
f_t^{30Y}	-1.5	0	22	4.67	331

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Kernel density of futures price changes

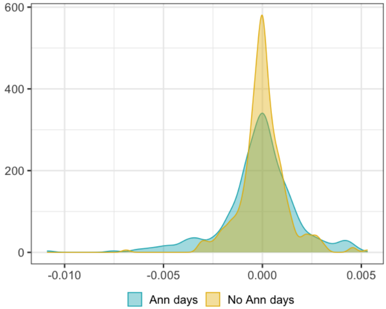

Figure: 10 year futures

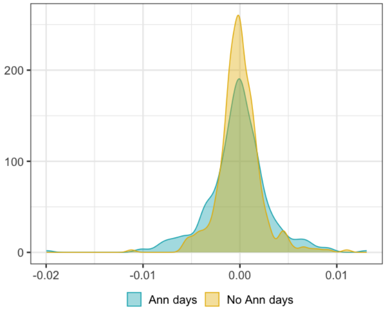

Figure: 30 year futures

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Principal Components

	PC1	PC2	PC3	PC4	PC5
Share of var explained	0.69	0.16	0.09	0.03	0.01
Cumulative share of var explained	0.69	0.85	0.95	0.99	1

Table: Share of variance explained by principal components (PCs).

	2-yr	5-yr	10-yr	30-yr	3-month Eud
PC1	-0.86	-0.94	-0.94	-0.81	-0.53
PC2	0.07	-0.08	-0.20	-0.28	0.83

Table: Matrix of factor loadings Λ'.

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Subset *inter* example I

TREASURY NEWS

Department of the Treasury • Bureau of the Fiscal Service

Embargoed Until 11:00 A.M.
July 23, 2015

CONTACT: Treasury Securities Services
202-504-3550

TREASURY OFFERING ANNOUNCEMENT [1]

Term and Type of Security	2-Year Note
Offering Amount	$26,000,000,000
Currently Outstanding	$0
CUSIP Number	912828XP0
Auction Date	July 28, 2015
Original Issue Date	July 31, 2015
Issue Date	July 31, 2015
Maturity Date	July 31, 2017
Dated Date	July 31, 2015
Series	BD-2017
Yield	Determined at Auction
Interest Rate	Determined at Auction
Interest Payment Dates	January 31 and July 31
Accrued Interest from 07/31/2015 to 07/31/2015	None
Premium or Discount	Determined at Auction
Minimum Amount Required for STRIPS	$100
Corpus CUSIP Number	912820W37
Additional TINT(s) Due Date(s) and CUSIP Number(s)	None
CUSIP Number(s)	None
Maximum Award	$9,100,000,000
Maximum Recognized Bid at a Single Yield	$9,100,000,000
NLP Reporting Threshold	$9,100,000,000
NLP Exclusion Amount	$0
Minimum Bid Amount and Multiples	$100
Competitive Bid Yield Increments [2]	0.001%
Maximum Noncompetitive Award	$5,000,000
Eligible for Holding in TreasuryDirect®	Yes
Estimated Amount of Maturing Coupon Securities Held by the Public	$73,213,000,000
Maturing Date	July 31, 2015
SOMA Holdings Maturing	$1,000,000
SOMA Amounts Included in Offering Amount	No
FIMA Amounts Included in Offering Amount [3]	Yes
Noncompetitive Closing Time	12:00 Noon ET
Competitive Closing Time	1:00 p.m. ET

Figure: Source: TreasuryDirect (US Treasury)

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Subset *inter* example II

- OFRs with no significant information on either debt level or debt maturity.
  - Release on 2007-10-31 only contains a section announcing the conversion to the TAAPS automatic system for the auctions, and another section mentioning a lowering of the minimum purchase amounts for Treasury auctions.
- Releases that mention no change in upcoming announcements.

> "*Based on recent forecasts, Treasury is announcing* **no increase** *to nominal coupon and FRN auction sizes over the upcoming quarter, and currently anticipates no further changes in issuance sizes for nominal coupon and FRNs for the remainder of the 2019 calendar year. Treasury plans to address any seasonal or unexpected variations in borrowing needs over the next quarter through changes in regular bill auction sizes and/or cash management bills.*"

– OFR release on 2019-07-31

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Subset *level* example

- A change in total level of debt to be issued in the near future
- Buyback announcements with no information on the maturity of buying

> "*The fiscal year 2008 outlook, even absent the enactment of a fiscal stimulus package,* **potentially calls for a higher net marketable borrowing requirement** *resulting from larger base line deficit projections and potential reductions in issuance of non-marketable securities to states and local municipalities. Consequently, in addition to expected increases in bill issuance,* **Treasury may raise nominal coupon issuance in the coming months** *to address these larger net marketable borrowing needs*"

– OFR release on 2008-01-30

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Subset *mat* example

- Change in issuance as Treasury plans to change the maturity of outstanding debt
- Introduction or discontinuity of maturity points
- Change to existing auction setup - frequency of auctions at a particular maturity, introducing re-openings for certain bonds, etc.

> " *Our first announcement concerns* **reductions in the issuance sizes of longer-maturity debt**. *This reduces our funding, takes into consideration the longer-term fiscal forecasts, and helps us* **manage the average maturity of our debt**. *In this regard, we plan to reduce the issuance of 5-year, 10-year and 30-year debt, both fixed rate and inflation-indexed securities. Consistent with the Committees recommendations, we will maintain the regular monthly auctions of our two-year notes at the present time. We plan, however, to cut modestly the size of individual auctions of two-year notes.*"

– OFR release on 2000-02-02

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Moment condition

- Moment condition

$$\mathbb{E}[g(Y_l, \theta_0)] = 0, \qquad l \in \{inter, level, mat\} \tag{14}$$

$$\text{where} \quad g(Y_l, \theta_0) = \left[vech(V(\tilde{F}_l)) - vech(U'V(F_l)U)\right], \quad vech \equiv \text{vector-half} \tag{15}$$

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Summary statistics of factors

Factors	Mean	Median	SD	N	Correlations	
					$s_{M,t}$	$s_{L,t}$
Maturity factor $s_{M,t}$	0	-0.05	1	331	1	
Level factor $s_{L,t}$	0	-0.06	1	331	0	1

Table: Summary statistics of factors

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Factors aggregated to monthly

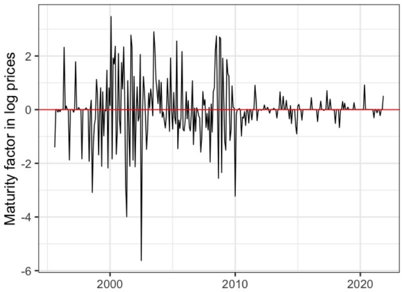

Figure: Maturity factor

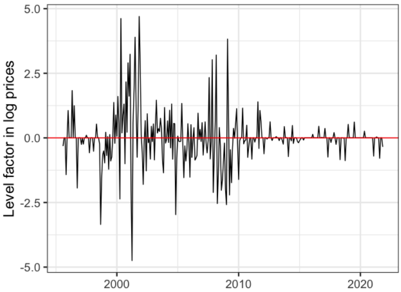

Figure: Level factor

Factors	Mean	Median	SD	N	Correlations S_t^{mat}	S_t^{level}
Maturity factor S_t^{mat}	0	0	1.00	316	1	
Level factor S_t^{level}	0	0	1.01	316	0.09	1

Table: Summary statistics of monthly aggregated factors

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Autocorrelation function

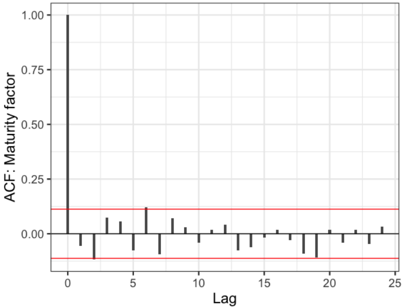

Figure: Maturity factor

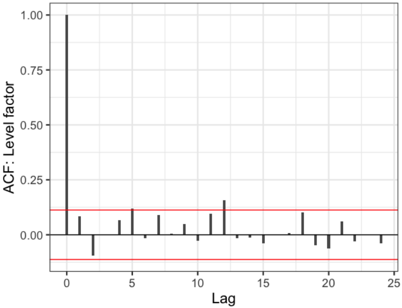

Figure: Level factor

Figure: Auto-correlation function for maturity and level factor. Red lines are critical values at 5% level of significance given by $\pm 2/\sqrt{N}$

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Granger causality test

- Granger causality test (lag order=12, differenced wherever needed)
  - H_0 : Lagged values of X are **not** useful to predict shocks
  - H_A : Lagged values of X are useful to predict shocks

Variable (X)	p-value	
	Level	Maturity
Output growth	0.99	0.70
PCE inflation	0.44	0.27
Unemployment rate	0.99	0.99
Fed Funds rate	**0.01**	**0.01**
S&P 500 diff	0.19	0.87

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Correlation with other proxies

- (Pearson) correlation coefficient with other proxies
  - $H_0 : \rho = 0$
  - $H_A : \rho \neq 0$

Shock	Source	Level		Maturity	
		ρ	p-value	ρ	p-value
Monetary policy	JK (2021)	**0.14**	**0.02**	**0.17**	**0.01**
Information	JK (2021)	**0.12**	**0.07**	-0.04	0.52
Oil supply	Kanzig (2021)	0.001	0.98	0.04	0.47
Oil supply news	Kanzig (2021)	-0.05	0.40	-0.05	0.35
Uncertainty	Baker, Bloom and Davies (2016)	0.07	0.21	0.04	0.43
Govt exp	Ramey (2011)	0.03	0.81	-0.14	0.22
Productivity news	Barsky and Sims (2011)	0.14	0.32	-0.11	0.46

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Factor properties

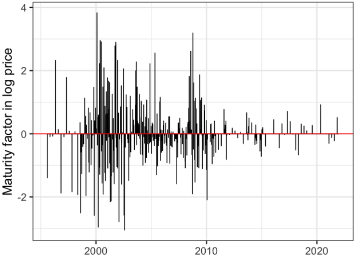

Figure: Maturity factor

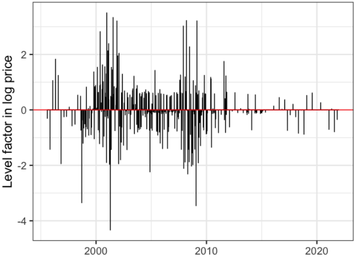

Figure: Level factor

- Not autocorrelated. Details
- Not predictable by other macro variables. Details
- No correlation with other available proxies. Details

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Summary statistics Monthly series

State dependence on risk aversion

- Dep variable: y_t^τ
- High RA $\rightarrow RA_t >$ median (RA_t). RA_t from Bekaert, Engstrom and Xu (2022).
- Split sample into two based on RA_t. Run for each subsample

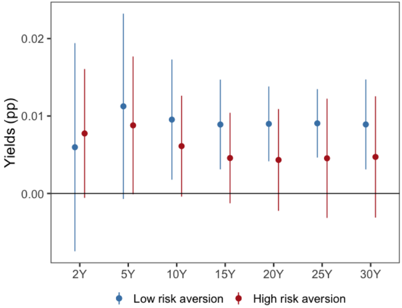

Figure: Level factor

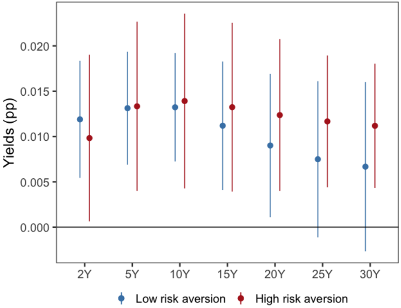

Figure: Maturity factor

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State dependence on risk aversion

- Dep variable: p_t^τ
- High RA $\rightarrow RA_t >$ median (RA_t). RA_t from Bekaert, Engstrom and Xu (2022).
- Split sample into two based on RA_t. Run for each subsample

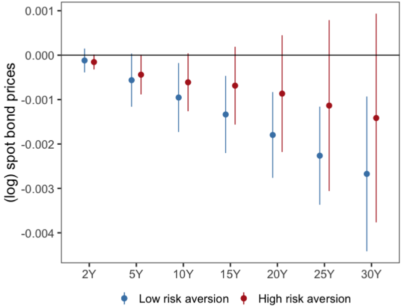

Figure: Level factor

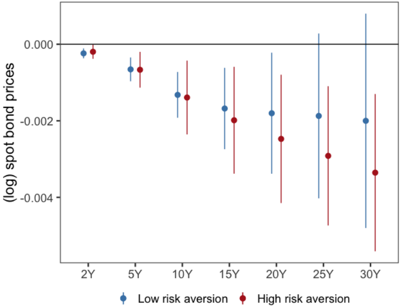

Figure: Maturity factor

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State dependence on risk aversion

- Dep variable: $r^{\tau}_{t,t+1}$
- High RA $\rightarrow RA_t >$ median (RA_t). RA_t from Bekaert, Engstrom and Xu (2022).
- Split sample into two based on RA_t. Run for each subsample

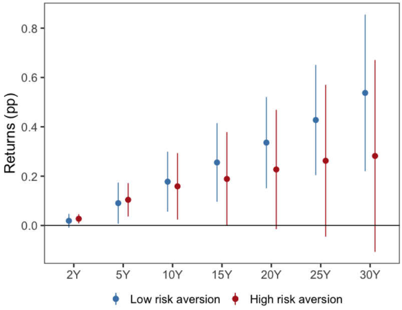

Figure: Level factor

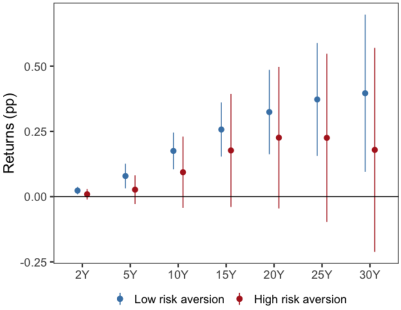

Figure: Maturity factor

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SVAR-IV details

Reduced form VAR(p)

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + ... + A_p Y_{t-p} + \eta_t, \quad Var(\eta_t) = \Sigma \tag{16}$$

$$\eta_t = \Theta_0 \varepsilon_t, \quad V(\varepsilon_t) = diag(\sigma_1^2, \sigma_2^2, ..., \sigma_n^2) \tag{17}$$

MA representation in terms of structural shocks

$$Y_t = \sum_{k=0}^{\infty} C_k(A)\Theta_0 \varepsilon_{t-k} \tag{18}$$

Impulse response to a variable i at horizon $t+k$ due to a unit change in $\varepsilon_{1,t}$

$$\lambda_{k,i} = \partial Y_{i,t+k} / \partial \varepsilon_{1,t} = e_i' C_k(A)\Theta_{0,1} \tag{19}$$

To estimate $\Theta_{0,1}$, use factor s_t and relevance and exogeneity conditions to write

$$E(s_t \eta_t) = \alpha \Theta_{0,1}, \quad E(s_t \eta_{1,t}) = \alpha \Theta_{0,11} \tag{20}$$

Under the normalisation $\Theta_{0,11} = x$.

$$\Theta_{0,1} = [x; \tilde{\phi}_0 . x]', \text{ where } \tilde{\phi}_0 = \frac{E(s_t \eta_t)}{E(s_t \eta_{1,t})} \tag{21}$$

I set $x = 0.01$ (pp)

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First-stage tests for instrument relevance

Test type	Test statistic		Critical value	
	Level	Maturity		
Robust F-test	2.72	1.70	23.10 ($\alpha = 5\%, \tau = 10\%$)	
MSW Wald test	5.57	3.95	0.99 ($\chi^2_{1,1-0.68}$)	2.71 ($\chi^2_{1,1-0.90}$)

Table: Tests for instrument relevance.

- Null hypothesis for the robust F -test (Olea and Pflueger, 2013) is the Nagar bias exceeds $\tau = 10\%$ of a worst case benchmark, which corresponds to presence of weak instruments
- MSW Wald test (Montiel Olea, Stock and Watson, 2021) tests the null hypothesis that $E(s_t \eta_{1,t}) = 0$, that is, the instrument relevance condition does not hold

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