Unexpected Supply Effects of Quantitative Easing and Tightening

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The views expressed here do not necessarily reflect the position of the Federal Reserve Bank of Chicago or the Federal Reserve System.

Background

- At ZLB (late 2008): Fed resorts to balance sheet policy (BSP), including Treasury QE
- QE (2008-2014): Fed buys assets, expanding balance sheet size
- QT (2017-2019): Fed slowly runs off assets, shrinking balance sheet size
- Supply/scarcity channel:
  - imperfect asset substitutability $\implies$
  - stable demand for certain assets $\implies$
  - available supply DOWN $\implies$ excess demand cannot be satiated by substitution
  - prices UP $\implies$ yields DOWN, also for similar assets
  - ample evidence that this QE's channel works

Main Questions

- Are the supply/scarcity effects of BSP state dependent?
  - Investigate how Treasury yield sensitivity to supply shocks changes across different economic and financial market conditions
  - Earlier QE vs. later QE or QT vs. QE

- *Why does it matter? Because it helps us understand whether*
  - BSP has diminishing returns across subsequent programs
  - BSP works in periods of market calm and away from ZLB
  - Impacts of QT and QE are asymmetric
  - Predictions of macro-finance models of QE are correct

Previous Event Studies

- For each program, total impact is computed combining high-frequency yield changes across selected events
  - Approach becomes increasingly more problematic after first QE, as Fed signaled it intentions well before formal announcements and strengthened conditionality of QE to macroeconomic outcomes
  - Identification of the relevant events becomes extremely hard, as any economic news and data releases can alter BSP expectations
- If the set of relevant events selected for each program is not exhaustive
- Evolution of investor expectations about BPS is not properly tracked
- Asset price impact is not estimated correctly

Our Innovations

- Focus on the BSP **surprise** (i.e., asset supply shock): Unexpected amount and distribution of asset purchases/reinvestments
  - Use NY Fed Survey of Primary Dealers (SPD) to measure BSP surprises
  - Treasury yield sensitivity $= \frac{\Delta yield \text{ (bps)}}{surprise \text{ (\$)}}$
  - Our Premise: **Size** of the **BSP surprise** and **not necessarily** the **yield sensitivity** that **changes over time**

- Exploit **kinks** in yield curve **reaction** to retrieve causal effect of BSP surprise on yields
  - For each program, no need to combine yield changes from multiple events
  - No need to control for security-level proxies of any BSP channels

- Control for interaction between BSP surprise and BSP **uncertainty**

What We Find

- Well-identified supply shocks lead to conclusions quite different from previous studies, as Treasury yield sensitivities
  - Do not fall monotonically across subsequent announcements $\Longrightarrow$ Supply effects remain powerful over time
  - During QT are at least as large as during QE $\Longrightarrow$ Supply effects do not diminish during period of market calm and away from ZLB
  - Are amplified by interest-rate uncertainty prevailing before announcement $\Longrightarrow$ Turning points in BSP elicit larger reactions
- These findings pose challenges to existing macro-finance models of QE

Common Macro Models of QE

- Imperfect asset substitutability matters if market frictions restrict arbitrage: capital constraints, limited risk-bearing capacity, large transactions costs...
  - E.g., Curdia and Woodford (2011), Chen et al. (2012), He and Krishnamurthy (2013), Gertler and Karadi (2011, 2013), and Caballero and Farhi (2016)

- In normal times, as market frictions and distortions wane, arbitrage becomes more efficient and QE less potent

- This mechanism is used to justify both QE's diminishing returns and asymmetry of QE and QT's supply effects

- However, there is limited evidence on the evolution of supply effects across subsequent QE programs, and no evidence on those effects during QT

Factors Affecting State Dependence

- In equilibrium term-structure models accounting for the ZLB (King, 2019), the risk premium (rp) response to changes in supply (S) is an increasing function of:

$$\frac{\partial rp_t^\tau}{\partial S} = a_t \sigma_{r_t}^2 A_t^\tau \int_0^T A_t^s ds$$

  - a_t, arbitrageurs' risk aversion
  - $\sigma_{r_t}^2$, interest-rate volatility
  - $A_t^\tau \approx \int_0^\tau e^{-ks} Pr\left(r_{t+s} > 0\right) ds$, the discounted stream of probabilities that r will be above the ZLB over the life of the bond

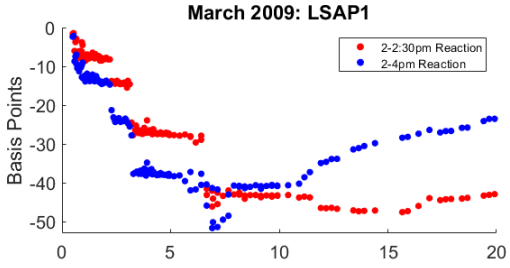
- During QE: higher a_t but lower A_t^τ and $\sigma_{r_t}^2$ (at the ZLB)
- During QT: lower a_t but higher A_t^τ and $\sigma_{r_t}^2$ (away from ZLB)
- Which factor dominates is ultimately an empirical question

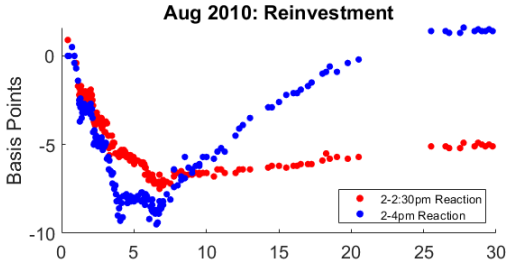
Events: 8 FOMC Meetings

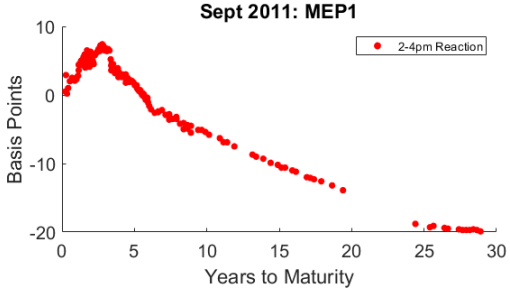
QE Events	*QT Events*
Mar 2009 FOMC: **LSAP1**	Jun 2013 FOMC: **Taper tantrum continues**
Aug 2010 FOMC: **Reinvestment**	Sept 2013 FOMC: **Tapering delayed**
Sep 2011 FOMC: **MEP1**	Jun 2017 FOMC: **Normalization Addendum**
Jun 2012 FOMC: **MEP2**	Mar 2019 FOMC: **Phasing Out of QT**

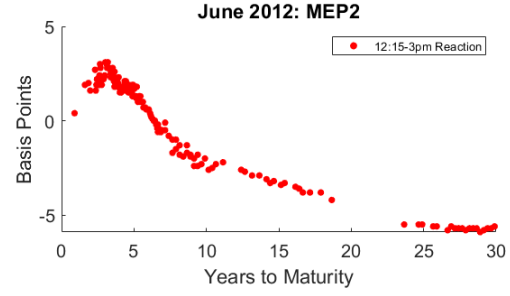
- Span diverse macroeconomic/financial environments $\rightarrow$ examine state-dependence of supply channel
- Include all major QT events, and all QE events with sufficiently granular info on BSP changes to form a sharp kink in the yield curve reaction

QE Events

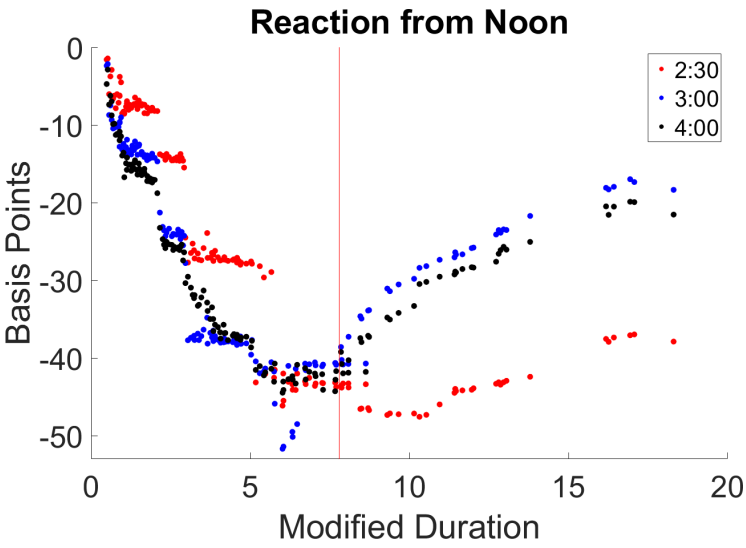

March 2009: LSAP1
2-2:30pm Reaction
2-4pm Reaction
Basis Points
0
-10
-20
-30
-40
-50
0
5
10
15
20


Aug 2010: Reinvestment
2-2:30pm Reaction
2-4pm Reaction
Basis Points
0
-5
-10
0
5
10
15
20
25
30


Sept 2011: MEP1
2-4pm Reaction
Basis Points
10
0
-10
-20
0
5
10
15
20
25
30
Years to Maturity

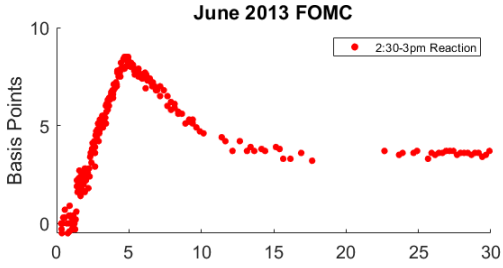

June 2012: MEP2
12:15-3pm Reaction
Basis Points
5
0
-5
0
5
10
15
20
25
30
Years to Maturity

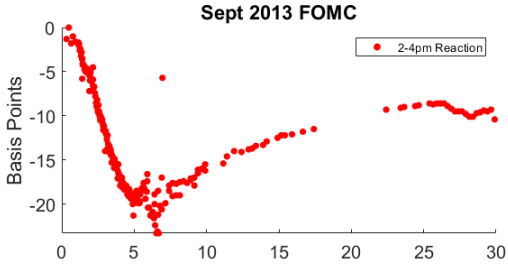
LSAP1, March 18, 2009: 12-4PM

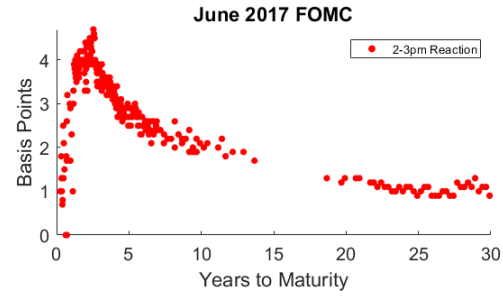


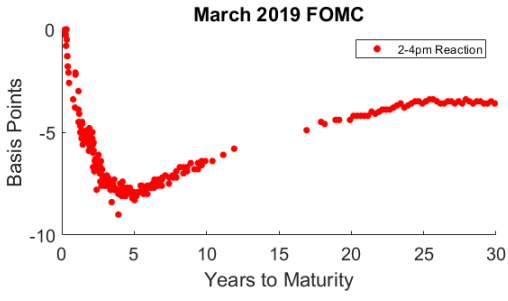
- 12:15PM: FOMC announces additional purchases, more aggressive than expected
- $143bn dovish Treasury surprise according to SPD
- 2:44PM: NY Desk announces purchases concentrated in 2-10Y Treasuries $\rightarrow$ yield reversal in LT Treasuries
- Kink at 7.8-year modified duration (10Y maturity)

QT Events


June 2013 FOMC
2:30-3pm Reaction
Basis Points
10
5
0
0
5
10
15
20
25
30


Sept 2013 FOMC
2-4pm Reaction
Basis Points
0
-5
-10
-15
-20
0
5
10
15
20
25
30


June 2017 FOMC
2-3pm Reaction
Basis Points
4
3
2
1
0
0
5
10
15
20
25
30
Years to Maturity


March 2019 FOMC
2-4pm Reaction
Basis Points
0
-5
-10
0
5
10
15
20
25
30
Years to Maturity

Measures of BSP Surprises

- For fixed-size program: $E_{t-\delta}[\Delta BSP_t] = Pr_{t-\delta} * E_{t-\delta}[Q|announcement]$
- For open-ended programs:

$$E_{t-\delta}[\Delta BSP_t] = Pr_{t-\delta} * E_{t-\delta}[q_m|announcement] * E_{t-\delta}[M|announcement]$$

- For QT (only the amount exceeding the caps get reinvested)

$$E_{t-\delta}[\Delta BSP_t] = Pr_{t-\delta} * [S_m^e - E_{t-\delta}(cap_m|announcement)] * E_{t-\delta}[M|announc.]$$

- The unexpected (U) component: $\Delta BSP_t^U = \Delta BSP_t - E_{t-\delta}[\Delta BSP_t]$
- If pre- and post-FOMC SPD are available:
  $\Delta BSP_{t+\delta}^U = E_{t+\delta}[\Delta BSP_t] - E_{t-\delta}[\Delta BSP_t]$

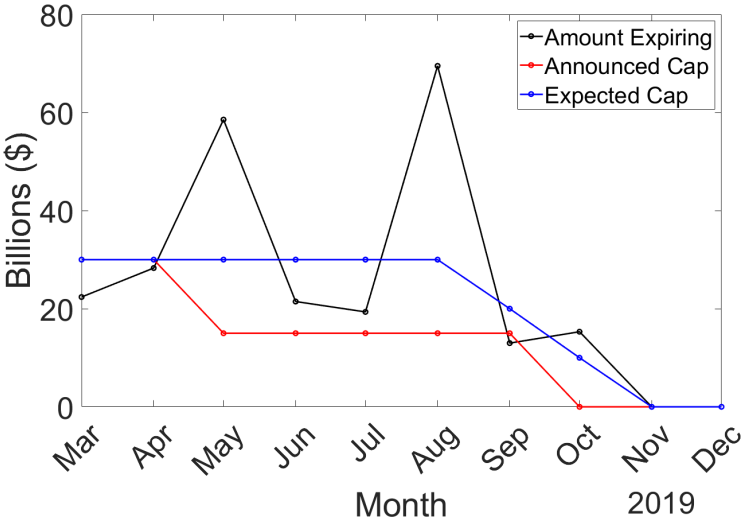
June 2013 Surprise (Survey of Primary Dealers)

First reduction in pace of purchases (highlighted) shifts up 3 months

Month	Jun13	Jul13	Aug13	Sep13	Oct13	Nov13	Dec13	Jan14	Feb14	Mar14	Apr14	May14	Jun14
Jun10	45	45	45	45	45	45	30	25	20	15	10	5	0
Jun24	45	45	45	40	35	32.5	30	25	20	15	10	5	0
ΔTr's				-5	-10	-12.5							

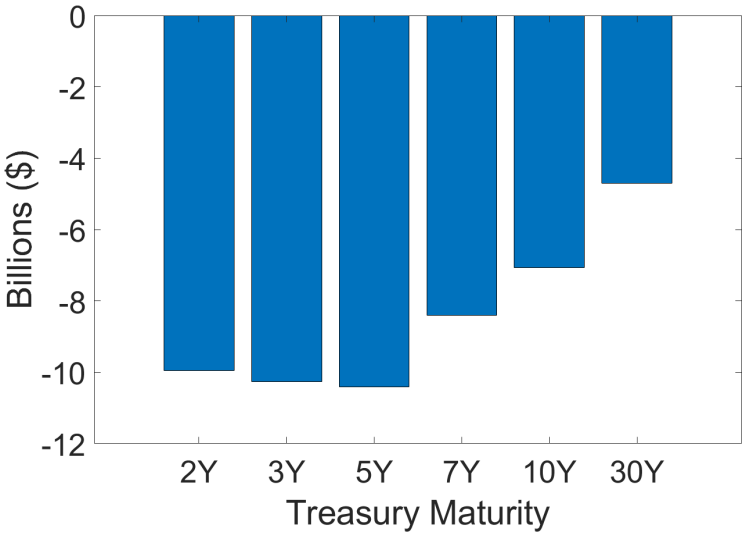
Month	Jun13	Jul13	Aug13	Sep13	Oct13	Nov13	Dec13	Jan14	Feb14	Mar14	Apr14	May14	Jun14
Jun10	40	40	40	40	40	40	30	25	20	15	0	0	0
Jun24	40	40	40	35	33	29	25	20	15	10	5	0	0
ΔMBS				-5	-7	-11	-5	-5	-5	-5	+5		

March 2019 Surprise



- FOMC slows down balance sheet reduction more quickly than markets anticipated (reinvesting more at auctions)
- $51bn dovish Treasury surprise ▸ Surprise Computation
- Yields go down, kink around 5Y maturity ▸ Surprise Distribution

March 2019 Surprise Distribution



- Computed using Survey of Primary Dealers and NY Fed reinvestment rule: negative sign denotes dovish surprise (more purchases)
- Surprise peak: 5Y maturity
- Yield decrease peak: 5Y maturity

Kink's Location

- Kinks tend to form when detailed information about maturity distribution of purchases/sales is released
- Seem the result of trading of well informed investors
- Kink's location should be related to edges of auction sectors with largest local supply surprises
- But location is affected by degree of market segmentation and width of auction sector
  - high segmentation $\implies$ almost exact correspondence btw kink location and edge of sector characterized by largest surprise
  - wide sector $\implies$ securities within not all close subs $\implies$ kink towards edge
- In extreme cases discontinuities rather than kinks, but scarcity channel interacts with liquidity channel

Empirical Strategy

- Slope change in yield curve reaction around kink retrieves causal effect of supply shock:
  - Only the unexpected change in asset supply (BSP surprise) with respect to maturity exhibits a discrete jump;
  - Other channels of BSP (e.g., signaling and duration-risk) change smoothly across similar maturities.

- Relative to previous studies our methodology does not require us to:
  - Combine yield changes across selected events;
  - Control for proxies of other channels;
  - Compute surprises for each individual security (Cahill et al.t, 2013).

Regression Kink Design

- Restrict sample to Treasuries within +/-3 years of kink $\rightarrow$ similar maturity:

$$\Delta y_{i,\Delta t} = \alpha + \beta_1(\tau_i - K) + \beta_2 D_i(\tau_i - K) + \epsilon_{i,\Delta t}$$

  - $\Delta y_{i,\Delta t}$: yield change for security i within narrow time-window Δt around announcement
  - τ_i: maturity of security i
  - K: the kink location in the maturity range (peak of yield curve reaction)
  - D_i: dummy variable: 1 if security i has $\tau_i > K$
  - β_2: change in slope at kink, **independent** of BSP surprise measurement.

- It captures whether shift is larger or smaller to the right of the kink

Bounds of BSP Surprise

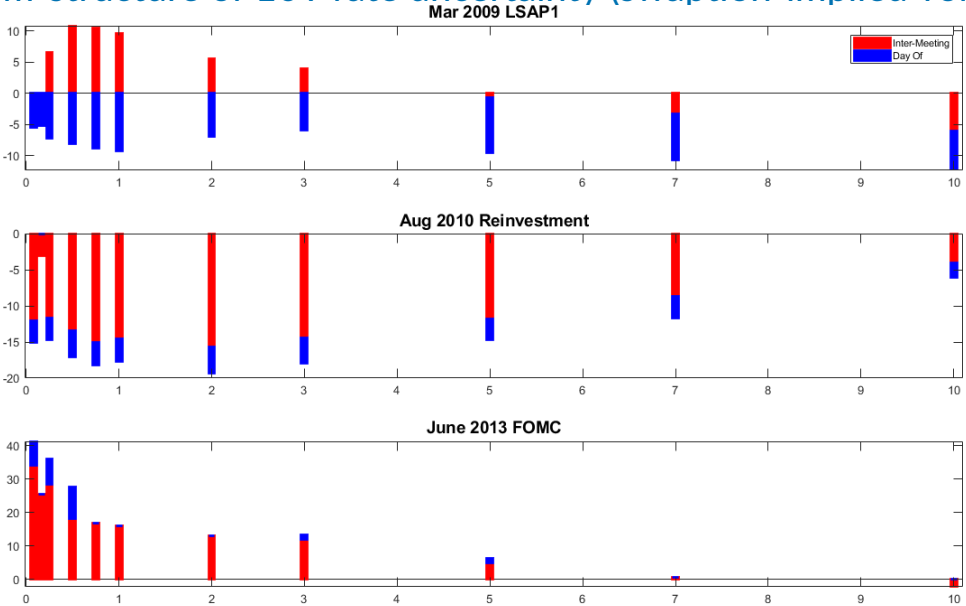
- We provide a lower and upper bound for the yield sensitivity using two opposite assumptions about degree of market segmentation
- 1) Local surprise size equals relative supply changes only in adjacent maturity buckets bracketing the kink
  - Implying high segmentation, which gives upper bound for yield sensitivity
- 2) Local surprise size (around the kink) equals total surprise at announcement
  - No stance on segmentation, which gives lower bound for yield sensitivity
- Each has its own limitations.

Treasury Yield Sensitivity

	LSAP1	Reinvest	MEP1	MEP2	Tantrum	Feint	Addendum	QT Taper
β_2	2.28***	1.13***	-4.70***	-1.57***	-2.97***	3.35***	-2.28***	1.39***
Total Surprise (bn)	$143	$186	$147	$175	$27.5	$95.0	$78.2	$50.8
Local Surprise (bn)	$74.7	$77.5	$127	$117	$11.3	$39.2	$12	$5.6
Sensitivity (LB)	1.59	0.61	3.21	0.90	10.8	3.53	2.91	2.73
Sensitivity (UB)	3.05	1.46	3.71	1.34	26.2	8.56	19	24.6
Adj R^2	0.783	0.712	0.869	0.748	0.946	0.450	0.720	0.801
N	27	70	97	94	138	106	170	159

- Yield sensitivity at kink in bps per $100bn = $|(\beta_2 \div \text{surprise}) * 100|$
- Yield sensitivity does not decrease monotonically and is not smaller in QT

Term-structure of 10Y rate uncertainty (swaption-implied vol)



Measure of BSP Uncertainty

Max Horizon	LSAP1	Reinvest	MEP1	MEP2	Jun2013	Sep2013	Jun2017	Mar2019
5-year	0.096	-0.203	0.018	-0.092	0.149	0.306	-0.136	-0.129
10-year	0.095	-0.199	0.019	-0.093	0.146	0.299	-0.133	-0.128

- Measure whether market uncertainty about 10-year rate is unusually elevated ahead of each FOMC meeting
  - 1) at each horizon compute average uncertainty over 10 days prior to FOMC;
  - 2) take weighted sum of those averages using weights inversely related to length of forecasting horizon;
  - 3) normalize it dividing by the average uncertainty in the year prior to FOMC and subtracting one $\implies$ numbers bigger than 0 indicate high uncertainty relative to previous year.

Impact of Uncertainty on Yield Sensitivity

	Intercept	β_1	β_2	β_3	β_4	$AdjR^2$	N
Point Est	9.718	1.311	-2.344				861
T-Stat	(67.9)	(26.6)	(-26.9)			0.980	
Point Est	8.893	1.281	-2.373	2.998	-5.489		861
T-Stat	(59.3)	(27.7)	(-28.7)	(11.7)	(-10.8)	0.983	
Point Est	8.891	1.283	-2.377	3.061	-5.617		861
T-Stat	(59.3)	(27.8)	(-28.8)	(11.7)	(-10.9)	0.983	

- Pool together all 8 events and augment baseline specification interacting regressors with proxy of BSP uncertainty
- β_2 indicates that average supply effect of BSP announcement is about -2.34 bps per $110bn
- β_4 indicates that average supply effect increases to -7.8 bps per $110bn if investor BSP uncertainty is unusually elevated

Total Impact of Scarcity/Supply channel

Supply effect of each QE program = avg. yield sensitivity per $1bn * size of program

LSAP Policies	Our Supply Effects	Other Studies	Average Tot
LSAP1 ($300bn)	21	Gagnon et al (2011) KVJ (2011) D'Amico et al (2012) DK (2013) Bonis et al (2017)	37
LSAP2 ($600bn)	13	KVJ (2011), Meaning and Zhu (2012); Swanson (2011) D'Amico et al (2012) Bonis et al (2017)	24
MEP ($667bn)	14	Meaning and Zhu (2012) Hamilton and Wu (2012) Bonis et al (2017)	22
LSAP3 ($790bn)	17	Engen et al (2015) Bonis et al (2017)	45.5
Total Estimate	**65**		**129.5**

Takeaway

- Results pose challenge to current macro-finance models of QE
- Suggest supply effect is not just due to temporary market segmentation arising from limits to arbitrage
- Instead, supply risk might be systemic risk factor, amplified by novelty and uncertainty about BSP
- Supply effects are a significant share of the total BSP impact, as estimated to account for about half of overall QE effect found in the literature

Implications for BSP

- Controlling for expectations and uncertainty about BSP is important for assessing its impact
- Careful forward guidance about BSP can help control financial market effects by calibrating the size of the supply shock
- BSP can still affect Treasury yields away from the ZLB and during normal market conditions $\implies$ Perhaps BSP should not be limited to extraordinary circumstances
- Since supply effects are found to be sizable and can be localized, then likely through supply channel a CB could control specific segments of the yield curve