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.
- At ZLB (late 2008): Fed resorts to balance sheet policy (BSP), including Treasury QE


- Supply/scarcity channel:
  - imperfect asset substitutability  \(\Longrightarrow\)
  - stable demand for certain assets  \(\Longrightarrow\)
  - available supply DOWN  \(\Longrightarrow\) excess demand cannot be satiated by substitution
  - prices UP  \(\Longrightarrow\) 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 $= \frac{\Delta \text{yield (bps)}}{\text{surprise ($)}}$
  - 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 $\implies$ Supply effects remain powerful over time
  - During QT are at least as large as during QE $\implies$ Supply effects do not diminish during period of market calm and away from ZLB
  - Are amplified by interest-rate uncertainty prevailing before announcement $\implies$ Turning points in BSP elicit larger reactions

- These findings pose challenges to existing macro-finance models of QE
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:

\[
\frac{\partial rp_t^\tau}{\partial S} = a_t \sigma^2_{r_t} A_t^{\tau} \int_0^T A_t^s ds
\]

- \(a_t\), arbitrageurs' risk aversion
- \(\sigma^2_{r_t}\), interest-rate volatility
- \(A_t^{\tau} \approx \int_0^\tau e^{-ks} Pr (r_{t+s} > 0) ds\), 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 \(A_t^{\tau}\) and \(\sigma^2_{r_t}\) (at the ZLB)
- During QT: lower \(a_t\) but higher \(A_t^{\tau}\) and \(\sigma^2_{r_t}\) (away from ZLB)
- Which factor dominates is ultimately an empirical question
Events: 8 FOMC Meetings

<table>
<thead>
<tr>
<th>QE Events</th>
<th>QT Events</th>
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<tbody>
<tr>
<td>Mar 2009 FOMC: LSAP1</td>
<td>Jun 2013 FOMC: Taper tantrum continues</td>
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<tr>
<td>Aug 2010 FOMC: Reinvestment</td>
<td>Sept 2013 FOMC: Tapering delayed</td>
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<tr>
<td>Sep 2011 FOMC: MEP1</td>
<td>Jun 2017 FOMC: Normalization Addendum</td>
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- Span diverse macroeconomic/financial environments → 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

Aug 2010: Reinvestment

Sept 2011: MEP1

June 2012: MEP2
- 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

Basis Points

0 5 10

Years to Maturity

0 5 10 15 20 25 30

2:30-3pm Reaction

Sept 2013 FOMC

Basis Points

0 -5 -10 -15 -20

Years to Maturity

0 5 10 15 20 25 30

2:4pm Reaction

June 2017 FOMC

Basis Points

0 1 2 3 4

Years to Maturity

0 5 10 15 20 25 30

2-3pm Reaction

March 2019 FOMC

Basis Points

0 -5 -10

Years to Maturity

0 5 10 15 20 25 30

2:4pm Reaction
Measures of BSP Surprises

- For fixed-size program: \( E_{t-\delta} [BSP_t] = Pr_{t-\delta} \cdot E_{t-\delta} [Q|\text{announcement}] \)

- For open-ended programs:

\[
E_{t-\delta} [BSP_t] = Pr_{t-\delta} \cdot E_{t-\delta} [q_m|\text{announcement}] \cdot E_{t-\delta} [M|\text{announcement}] 
\]

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

\[
E_{t-\delta} [BSP_t] = Pr_{t-\delta} \cdot [S_m^e - E_{t-\delta} (\text{cap}_m|\text{announcement})] \cdot E_{t-\delta} [M|\text{announcement}] 
\]

- The unexpected (U) component: \( BSP^U_t = BSP_t - E_{t-\delta} [BSP_t] \)

- If pre- and post-FOMC SPD are available: \( BSP^U_{t+\delta} = E_{t+\delta} [BSP_t] - E_{t-\delta} [BSP_t] \)
First reduction in pace of purchases (highlighted) shifts up 3 months

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<td>-12.5</td>
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<td>10</td>
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<td>0</td>
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<td>∆MBS</td>
<td>-5</td>
<td>-7</td>
<td>-11</td>
<td>-5</td>
<td>-5</td>
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<td>-5</td>
<td>+5</td>
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- FOMC slows down balance sheet reduction more quickly than markets anticipated (reinvesting more at auctions)

- $51bn dovish Treasury surprise

- Yields go down, kink around 5Y maturity
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
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 \( \Delta t \) around announcement
- \( \tau_i \): 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 \( \tau_i > K \)
- \( \beta_2 \): change in slope at kink, \textbf{independent} of BSP surprise measurement.

- It captures whether on average 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**

<table>
<thead>
<tr>
<th></th>
<th>LSAP1</th>
<th>Reinvest</th>
<th>MEP1</th>
<th>MEP2</th>
<th>Tantrum</th>
<th>Feint</th>
<th>Addendum</th>
<th>QT Taper</th>
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<tbody>
<tr>
<td>$\beta_2$</td>
<td>2.28***</td>
<td>1.13***</td>
<td>-4.70***</td>
<td>-1.57***</td>
<td>-2.97***</td>
<td>3.35***</td>
<td>-2.28***</td>
<td>1.39***</td>
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<tr>
<td>Total Surprise (bn$)</td>
<td>$143</td>
<td>$186</td>
<td>$147</td>
<td>$175</td>
<td>27.5</td>
<td>$95.0</td>
<td>$78.2</td>
<td>$50.8</td>
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<tr>
<td>Local Surprise (bn$)</td>
<td>$74.7</td>
<td>77.5</td>
<td>$127</td>
<td>$117</td>
<td>$11.3</td>
<td>$39.2</td>
<td>$12</td>
<td>$5.6</td>
</tr>
<tr>
<td>Sensitivity (LB)</td>
<td>1.59</td>
<td>0.61</td>
<td>3.21</td>
<td>0.90</td>
<td>10.8</td>
<td>3.53</td>
<td>2.91</td>
<td>2.73</td>
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<tr>
<td>Sensitivity (UB)</td>
<td>3.05</td>
<td>1.46</td>
<td>3.71</td>
<td>1.34</td>
<td>26.2</td>
<td>8.56</td>
<td>19</td>
<td>24.6</td>
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<tr>
<td>Adj $R^2$</td>
<td>0.783</td>
<td>0.712</td>
<td>0.869</td>
<td>0.748</td>
<td>0.946</td>
<td>0.450</td>
<td>0.720</td>
<td>0.801</td>
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<tr>
<td>$N$</td>
<td>27</td>
<td>70</td>
<td>97</td>
<td>94</td>
<td>138</td>
<td>106</td>
<td>170</td>
<td>159</td>
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</table>

- Yield sensitivity at kink in bps per $100bn = |(\beta_2 \div \text{surprise}) \times 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

<table>
<thead>
<tr>
<th>Max Horizon</th>
<th>LSAP1</th>
<th>Reinvest</th>
<th>MEP1</th>
<th>MEP2</th>
<th>Jun2013</th>
<th>Sep2013</th>
<th>Jun2017</th>
<th>Mar2019</th>
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<tr>
<td>5-year</td>
<td>0.096</td>
<td>-0.203</td>
<td>0.018</td>
<td>-0.092</td>
<td>0.149</td>
<td>0.306</td>
<td>-0.136</td>
<td>-0.129</td>
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<tr>
<td>10-year</td>
<td>0.095</td>
<td>-0.199</td>
<td>0.019</td>
<td>-0.093</td>
<td>0.146</td>
<td>0.299</td>
<td>-0.133</td>
<td>-0.128</td>
</tr>
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</table>

- 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 ⇒ numbers bigger than 0 indicate high uncertainty relative to previous year.
## Impact of Uncertainty on Yield Sensitivity

<table>
<thead>
<tr>
<th></th>
<th>Intercept</th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
<th>$\beta_3$</th>
<th>$\beta_4$</th>
<th>Adj$R^2$</th>
<th>N</th>
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<tr>
<td>Point Est</td>
<td>9.718</td>
<td>1.311</td>
<td>-2.344</td>
<td></td>
<td></td>
<td></td>
<td>818</td>
</tr>
<tr>
<td>T-Stat</td>
<td>(67.9)</td>
<td>(26.6)</td>
<td>(-26.9)</td>
<td></td>
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<td>0.980</td>
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<td>Point Est</td>
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<td>2.998</td>
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<td>T-Stat</td>
<td>(59.3)</td>
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<td>(-28.7)</td>
<td>(11.7)</td>
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<td>Point Est</td>
<td>8.891</td>
<td>1.283</td>
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<td>3.061</td>
<td>-5.617</td>
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- Pool together all 8 events and augment baseline specification interacting regressors with proxy of BSP uncertainty

- $\beta_2$ indicates that average supply effect of BSP announcement is about -2.34 bps per $110bn$

- $\beta_4$ indicates that average supply effect increases to -7.8 bps per $110bn$ if investor uncertainty about 10-year rate is unusually elevated.
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
  - Supply effect of each QE program = average yield sensitivity per $1bn * size of the program
  - Found to account for about half of overall QE effect estimated 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