Measuring the Effect of the Zero Lower Bound on Medium- and Longer-Term Interest Rates

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Federal Reserve Bank of San Francisco

Macroeconomics Seminar
UC Davis
May 15, 2013
Three Motivating Observations

1. New Keynesian IS curve:

\[ y_t = E_t y_{t+1} - \alpha r_t + \varepsilon_t \]

\[ = -\alpha E_t \sum_{j=0}^{\infty} r_{t+j} + \varepsilon_t \]
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3. The zero lower bound is not a substantial constraint on monetary policy if the central bank can affect longer-term interest rates:
   - Gürkaynak, Sack, and Swanson (2005): 60–90% of the response of 2- to 10-year Treasury yields to FOMC announcements is due to statement, not funds rate
2-Year Treasury Yield $\gg 0$ for Much of 2008–10
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Questions We Address

- Was the ZLB a substantial constraint on monetary policy? —e.g., was the 2-year Treasury yield constrained?
- If so, when?
- And how severely?
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Implications for fiscal as well as monetary policy:

- Several papers show fiscal multiplier larger when ZLB binds (Christiano-Eichenbaum-Rebelo 2011, Erceg-Lindé 2010, Eggertsson-Krugman 2011)
- But did ZLB constrain yields that matter for private-sector spending?
What We Do

Empirical:

1. We compute the sensitivity of interest rates of various maturities to macroeconomic news in normal times (1990–2000).
2. And compare it to the sensitivity of those yields to news when the ZLB may have been a constraint.
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   - Shows ZLB able to explain all of our results.
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Modeling:

- Simple NK model with ZLB motivates empirical specification
- Shows ZLB able to explain all of our results

The level of yields alone is not a good measure of ZLB constraint:

- No way to measure severity or statistical significance —e.g., is a 50 bp 2-year Treasury yield constrained or not?
- Crowding out, fiscal multiplier determined by response of yields to fiscal policy, not level of yields
- Effective lower bound may be $\gg 0$, e.g. 50bp in the UK
Illustrative Macro Model

**IS curve:**

\[ y_t = E_t y_{t+1} - \alpha (i_t - E_t \pi_{t+1} - r_t^*) \]

**Phillips curve:**

\[ \pi_t = \beta E_t \pi_{t+1} + \gamma y_t + \mu_t \]

**Taylor rule with ZLB:**

\[ i_t = \max\{0, \pi_t + r_t^* + 0.5y_t + 0.5(\pi_t - \pi^*)\} \]

**Initial condition:** \( r_t^* < 0 \), so that ZLB binds
Illustrative Macro Model

shadow interest rate path
Illustrative Macro Model

feasible interest rate path

shadow interest rate path
Illustrative Macro Model

Use model to illustrate three main points:

1. When short-term rates are constrained by ZLB, all yields respond less to news; attenuation is greatest for shortest maturities.

2. Dampening effect of ZLB on yields is essentially symmetric for positive and negative shocks.

3. Attenuation is roughly the same for different types of shocks (as long as shock persistences are similar).
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Symmetric Response to Positive, Negative Shocks

\[ i \]

feasible interest rate path

shadow interest rate path

\[ -i_0 \]

\[ 0 \]

\[ t \]
Symmetric Response to Positive, Negative Shocks

vertical axis: i  
horizontal axis: t

feasible interest rate path
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- Symmetric response
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- Negative economic surprise

Motivation
Illustrative Model
Empirical Framework
Main Results
Discussion
Conclusions
Symmetric Response to Positive, Negative Shocks

Illustrative Model

Symmetric response to positive, negative shocks feasible interest rate path

feasible interest rate path

symmetric response

shadow interest rate path

positive economic surprise

negative economic surprise
Symmetric Response to Positive, Negative Shocks

In simple NK model with ZLB, graph absolute value of response to large positive, negative shocks, relative to baseline path:

expected short-term rate

yield curve

(a) Impulse Response of Short-term Interest Rate to Output Shock

(b) Initial Response of Yields to Output Shock
Measuring Treasury Yield Sensitivity to News

Measure Treasury yield sensitivity to news in normal times using a high-frequency regression:

\[ \Delta y_t = \alpha + \beta X_t + \varepsilon_t \]
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- regression is at daily frequency
- $\Delta y_t$ denotes one-day change in Treasury yield on date $t$
- $X_t$ is a vector of surprises in macroeconomic data releases (GDP, CPI, nonfarm payrolls, etc.) on date $t$
- $\varepsilon_t$ denotes effects of other news and other factors on yields
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Surprise component of data release: \( x_t - E_{t-1} x_t \).

Market expectation of macroeconomic data releases measured by Money Market Services, Bloomberg surveys.
Measuring Time-Varying Sensitivity to News

Time-varying sensitivity version:

\[ \Delta y_t = \alpha^i + \delta^i \beta X_t + \varepsilon_t \]

where \( \delta^i \) scalar, \( i \in 1990, 1991, \ldots, 2012 \).
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\[ \Delta y_t = \alpha^i + \delta^i \beta X_t + \varepsilon_t \]

where \( \delta^i \) scalar, \( i \in 1990, 1991, \ldots, 2012 \).

- Assumption: *relative* responses \( \beta \) constant over time
- Estimate \( \delta^i, \beta \) by nonlinear least squares
- Normalize \( \delta^i \) so that average \( \delta^i \) from 1990–2000 is 1
## Nonlinear Regression Results for $\beta$, 1990–2012

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| # Observations       | 2829    | 2829   | 2829    |
| $R^2$                | .08     | .17    | .10     |
| $H_0 : \beta = 0$, $p$-value | $< 10^{-16}$ | $< 10^{-16}$ | $< 10^{-16}$ |
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Rolling Regressions

\[ \Delta y_t = \alpha^i + \delta^i \beta X_t + \varepsilon_t \]  \hspace{2cm} (\ast)
To study time-varying $\delta$ in finer detail, run daily rolling regressions:

- Use $\hat{\beta}$ from (*) to define “generic surprise” regressor $\hat{\beta} X_t$
- Estimate:
  \[
  \Delta y_t = \alpha^\tau + \delta^\tau \hat{\beta} X_t + \varepsilon_t
  \]
  where sample is 1-year rolling window centered around date $\tau$
- When $\tau =$ midpoint of year $i$, then $\delta^\tau$ agrees with $\delta^i$
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Account for 2-stage sampling uncertainty in rolling regressions:

- Use standard errors for \( \delta^i \) in (*) as benchmarks
- Interpolate between them using estimates for \( \delta^\tau \)
Time-Varying Sensitivity $\delta^\tau$, 3-month Treasury

(a) 3-Month Treasury Yield Sensitivity to News
Time-Varying Sensitivity $\delta^\tau$, 6-month Treasury

(b) 6-Month Treasury Yield Sensitivity to News
Time-Varying Sensitivity $\delta^\tau$, 1-year Treasury

(c) 1-Year Treasury Yield Sensitivity to News
Time-Varying Sensitivity $\delta^\tau$, 2-year Treasury

(d) 2-Year Treasury Yield Sensitivity to News
Time-Varying Sensitivity $\delta^\tau$, 5-year Treasury

(e) 5-Year Treasury Yield Sensitivity to News
Time-Varying Sensitivity $\delta^\tau$, 10-year Treasury

(f) 10-Year Treasury Yield Sensitivity to News
Private-Sector Expectations of Funds Rate “Liftoff”

Why were 1- and 2-year Treasury yields so responsive to news from 2008–2010?
Why were 1- and 2-year Treasury yields so responsive to news from 2008–2010?

Look at private sector expectations of funds rate “liftoff”:
- Blue Chip survey
- interest rate options
- Eurodollar futures
Private-Sector Expectations of Funds Rate “Liftoff”

Blue Chip Consensus expectation, time until first funds rate increase:
Private-Sector Expectations of Funds Rate “Liftoff”

One-year-ahead implied probability distribution for federal funds rate, derived from options, on November 2, 2011:
Private-Sector Expectations of Funds Rate “Liftoff”

Probability of funds rate < 50bp in 5 quarters, from options:
Monetary Policy Expectations from Eurodollar Futures
Federal Reserve Forward Guidance

Can the Fed manage expectations of future monetary policy?
Federal Reserve Forward Guidance

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To manage expectations, FOMC must have some ability to commit.
Federal Reserve Forward Guidance

Can the Fed manage expectations of future monetary policy?
To manage expectations, FOMC must have some ability to commit.
Theory:
- Discretion (Kydland-Prescott 1977) is a limiting, extreme case
Federal Reserve Forward Guidance

Can the Fed manage expectations of future monetary policy?

Empirics:

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Can the Fed manage expectations of future monetary policy?

Empirics:

- Gürkaynak-Sack-Swanson (2005): 60–90% of the response of 2- to 10-year Treasury yields to FOMC announcements is due to *statement*, not funds rate.

Three recent examples:

<table>
<thead>
<tr>
<th></th>
<th>3-month</th>
<th>6-month</th>
<th>1-year</th>
<th>2-year</th>
<th>5-year</th>
<th>10-year</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOMC drops “considerable period” language on Jan. 28, 2004</td>
<td>3</td>
<td>2</td>
<td>12.5</td>
<td>16.6</td>
<td>13.9</td>
<td>10.3</td>
</tr>
<tr>
<td>change (bp)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>FOMC projects zero funds rate “at least through mid-2013” on Aug. 9, 2011</td>
<td>–2</td>
<td>–1</td>
<td>–4.3</td>
<td>–9.9</td>
<td>–20.5</td>
<td>–22.9</td>
</tr>
<tr>
<td>change (bp)</td>
<td></td>
<td></td>
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<tr>
<td>FOMC projects zero funds rate “at least through late 2014” on Jan. 25, 2012</td>
<td>0</td>
<td>0</td>
<td>–0.2</td>
<td>–3.7</td>
<td>–9.4</td>
<td>–8.0</td>
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<td>change (bp)</td>
<td></td>
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</tbody>
</table>
Federal Reserve Long-Term Bond Purchases

Why are 5-, 10-year Treasuries so sensitive to news in 2010–12?
Federal Reserve Long-Term Bond Purchases

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(e) 5-Year Treasury Yield Sensitivity to News

(f) 10-Year Treasury Yield Sensitivity to News
Federal Reserve Long-Term Bond Purchases

Why are 5-, 10-year Treasuries so sensitive to news in 2010–12?

In the illustrative model, all yields are attenuated by the ZLB (although longer-term yields are attenuated less)
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Federal Reserve Long-Term Bond Purchases

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Forward Guidance:
- Eggertsson-Woodford (2003), Reifschneider-Williams (2000)
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- 11/3/10: $600B Treasuries
- 9/21/11: $400B “Operation Twist”
- 6/20/12: $270B extension of “Operation Twist”
- 9/13/12: $40B/mo MBS
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Theoretical and empirical studies:
Implications for the Fiscal Multiplier

(A) Liftoff expected sooner

(B) Liftoff expected later

This paper: 2008–10 look like scenario A
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A) liftoff in 4 qtrs. $\rightarrow$ multiplier same as normal (CER 2011)
B) liftoff in 8 qtrs. or more $\rightarrow$ large multiplier (CER 2011)
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This paper: 2008–10 look like scenario A
Other Explanations for Time-Varying Sensitivity?

Natural candidates are level of yields and monetary policy uncertainty:

(a) $\delta^i$ for 2-Year Treasury Yield and Fitted Values

(b) 80th-20th Percentile Eurodollar Rate 1 Year Ahead, from Options
Conclusions

What we do:

- Test whether interest rates are responding normally to news.
- Measure the degree to which interest rates are attenuated.

What we find:

- 1- and 2-year Treasury yields were surprisingly responsive to news throughout much of 2008–10.

What we conclude:

- Effectiveness of monetary and fiscal policy likely close to normal throughout 2008–10.
- Zero lower bound a more severe constraint since mid-2011.
ZLB Attenuates All Yields, But Short Yields Most

(a) Impulse Response of Short-term Interest Rate to Output Shock

(b) Initial Response of Yields to Output Shock

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- **No zero bound**
- **Zero bound initially binding**
Yield Curve Response to Output, Inflation Shocks

(c) Initial Response of Yields to Output Shock

(d) Initial Responses of Yields to Inflation Shock

Degree of attenuation related to persistence of shock. For shocks with similar persistence, attenuation effects are similar.
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