Measuring the Effects of Federal Reserve Forward Guidance and Asset Purchases on Financial Markets

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University of California, Irvine

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Cambridge, MA
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In December 2008, U.S. Federal Reserve/FOMC lowered federal funds rate essentially to 0

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FOMC began to pursue “unconventional monetary policy” to try to lower longer-term interest rates and stimulate the economy:

- **Forward guidance**: information about the future path of the federal funds rate
- **Large-scale asset purchases (LSAPs)**: purchases of hundreds of billions of $ of longer-term Treasury and mortgage-backed securities
Background
The Committee will maintain the target range for the federal funds rate at 0 to 1/4 percent and anticipates that economic conditions are likely to warrant exceptionally low levels of the federal funds rate for an extended period. To provide greater support to mortgage lending and housing markets, the Committee decided today to increase the size of the Federal Reserve’s balance sheet further by purchasing up to an additional $750 billion of agency mortgage-backed securities, bringing its total purchases of these securities to up to $1.25 trillion this year, and to increase its purchases of agency debt this year by up to $100 billion to a total of up to $200 billion. Moreover, to help improve conditions in private credit markets, the Committee decided to purchase up to $300 billion of longer-term Treasury securities over the next six months.
<table>
<thead>
<tr>
<th>Date</th>
<th>Announcement</th>
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</thead>
<tbody>
<tr>
<td>Mar. 18, 2009</td>
<td>FOMC announces it expects to keep the federal funds rate between 0 and 25 basis points (bp) for “an extended period”, and that it will purchase $750B of mortgage-backed securities, $300B of longer-term Treasuries, and $100B of agency debt (a.k.a. “QE1”)</td>
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<td>Nov. 3, 2010</td>
<td>FOMC announces it will purchase an additional $600B of longer-term Treasuries (a.k.a. “QE2”)</td>
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<td>Aug. 9, 2011</td>
<td>FOMC announces it expects to keep the federal funds rate between 0 and 25 bp “at least through mid-2013”</td>
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<td>Sep. 21, 2011</td>
<td>FOMC announces it will sell $400B of short-term Treasuries and use the proceeds to buy $400B of long-term Treasuries (a.k.a. “Operation Twist”)</td>
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<td>Jan. 25, 2012</td>
<td>FOMC announces it expects to keep the federal funds rate between 0 and 25 bp “at least through late 2014”</td>
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Unconventional Monetary Policy Announcements

Sep. 13, 2012  FOMC announces it expects to keep the federal funds rate between 0 and 25 bp “at least through mid-2015”, and that it will purchase $40B of mortgage-backed securities per month for the indefinite future.

Dec. 12, 2012  FOMC announces it will purchase $45B of longer-term Treasuries per month for the indefinite future, and that it expects to keep the federal funds rate between 0 and 25 bp for at least as long as unemployment remains above 6.5 percent and inflation expectations remain subdued.

Dec. 18, 2013  FOMC announces it will start to taper its purchases of longer-term Treasuries and mortgage-backed securities to paces of $40B and $35B per month, respectively.

Dec. 17, 2014  FOMC announces that “it can be patient in beginning to normalize the stance of monetary policy.”
Motivation

Important Questions:

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**Problem:** It’s difficult to distinguish FG from LSAPs in the data:

- Many FOMC announcements contain elements of both forward guidance and LSAPs
- One way LSAPs can affect the economy is by signaling FOMC commitment to a future path for the federal funds rate
- Only surprise component of announcement should affect asset prices, but we don’t have good data on what markets expected
<table>
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<th>Methods</th>
<th>Results</th>
<th>Persistence</th>
<th>Uncertainty</th>
<th>Conclusions</th>
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Summary of This Paper

1. Adapt and extend the methods of Gürkaynak, Sack, and Swanson (2005) to **separately identify** the forward guidance and **LSAP** components of every FOMC announcement from January 2009 to October 2015.

Use high-frequency regressions around those FOMC announcements to estimate effects of each type of unconventional monetary policy on asset prices. Also look at the persistence of these effects, the effects of these policies on uncertainty, etc.
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Collect 30-minute asset price responses into a $T \times N$ matrix of asset price responses $X$
GSS (2005): Testing the Rank of the Matrix X

GSS tested the rank of $X$ over 1990–2004 period using matrix rank test of Cragg and Donald (1997):

$$\begin{align*}
X_{T \times N} &= F_{T \times n} \Lambda_{n \times N} + \epsilon_{T \times N} \\
\text{Clearly rejected } H_0 \text{ of } n = 0 \text{ (white noise responses)} \\
\text{Clearly rejected } H_0 \text{ of } n = 1 \text{ (one-dimensional responses)} \\
\text{Did not reject } H_0 \text{ of } n = 2 \text{ factors} \\
\text{Results consistent with idea that there were two dimensions of monetary policy during this period: changes in the current federal funds rate target and changes in forward guidance.}
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This chooses the 2 columns of $F$ so as to explain the greatest share of variation in $X$
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For example:

- Let \( U \) be any \( 2 \times 2 \) orthogonal matrix \((U'U = I)\)
- Let \( \tilde{F} \equiv FU' \), \( \tilde{\Lambda} \equiv U\Lambda \)
- Then \( F\Lambda = \tilde{F}\tilde{\Lambda} \), so

\[ X = \tilde{F}\tilde{\Lambda} + \varepsilon \]
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This identifies factors $\tilde{F}$ and loadings $\tilde{\Lambda}$ that have the structural interpretation we want
GSS: Effects of Funds Rate and Forward Guidance

Check the results of this identification to see if they make sense:
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July 1991–Dec. 2008:
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GSS also show changes in forward guidance factor correspond to notable, market-moving FOMC statements
This Paper

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- Let $N$ index different assets
- Collect 30-minute asset price responses in $T \times N$ matrix $X$
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$p$-value for $H_0$ of:

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Clear evidence of at least 2 factors; Possible evidence of a third factor, but 3rd principal component explains only 2.5–6% of variation in $X$.

As in GSS, estimate factors $F$ using principal components $X \subset T \times N = F \subset T \times 2 \Lambda \subset 2 \times N + \epsilon \subset T \times N$.
This Paper

Test for the number of factors in $X$ over Jan. 2009–Oct. 2015 sample:

$p$-value for $H_0$ of:

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Clear evidence of at least 2 factors;

Possible evidence of a third factor, but 3rd principal component explains only 2.5–6% of variation in $X$

As in GSS, estimate factors $F$ using principal components

$$
X_{T \times N} = F_{T \times 2} \Lambda_{2 \times N} + \varepsilon_{T \times N}
$$
This Paper: Rotation and Identification

\( F \) is only a statistical decomposition (no structural interpretation)
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$F$ is only a statistical decomposition (no structural interpretation)

Search for a rotation matrix $U$ that makes first column of $\tilde{F} \equiv FU'$ look like forward guidance
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Search for a rotation matrix \( U \) that makes first column of \( \tilde{F} \equiv FU' \) look like forward guidance

**Identifying assumption**: effects of forward guidance on asset prices **after** Dec. 2008 look like the effects of forward guidance on asset prices **before** Dec. 2008
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\( F \) is only a statistical decomposition (no structural interpretation)

Search for a rotation matrix \( U \) that makes first column of \( \tilde{F} \equiv FU' \) look like **forward guidance**

**Identifying assumption**: effects of forward guidance on asset prices **after** Dec. 2008 look like the effects of forward guidance on asset prices **before** Dec. 2008

- Choose rotation matrix \( U \) so that effects of first column of \( \tilde{F} \) post-2008 look like estimated effects of forward guidance factor pre-2008 (estimated previously)

- Interpret first column of \( \tilde{F} \) as **forward guidance**
This Paper: Rotation and Identification

$F$ is only a statistical decomposition (no structural interpretation)

Search for a rotation matrix $U$ that makes first column of $\tilde{F} \equiv FU'$ look like forward guidance

**Identifying assumption**: effects of forward guidance on asset prices after Dec. 2008 look like the effects of forward guidance on asset prices before Dec. 2008

- Choose rotation matrix $U$ so that effects of first column of $\tilde{F}$ post-2008 look like estimated effects of forward guidance factor pre-2008 (estimated previously)
- Interpret first column of $\tilde{F}$ as forward guidance
- Second column of $\tilde{F}$ is all other aspects of FOMC statements that systematically moved asset prices during the ZLB period
- Interpret second column of $\tilde{F}$ as LSAPs
Estimated Effects of Forward Guidance and LSAPs

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**Effect of forward guidance is hump-shaped**

**Effect of LSAPs increases with maturity**

**LSAPs are much more important for the longest-maturity yields**
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- Effect of **forward guidance** is hump-shaped
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Forward Guidance and LSAP Factors, 2009–2015

Estimated forward guidance factor
Estimated LSAP factor
Forward Guidance and LSAP Factors, 2009–2015

- Estimated forward guidance factor
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"QE1"
Forward Guidance and LSAP Factors, 2009–2015

- "Operation Twist"
- "taper tantrum"
- FOMC decides not to taper
- "QE1"
- Estimated forward guidance factor
- Estimated LSAP factor
Forward Guidance and LSAP Factors, 2009–2015

- "Operation Twist"
- "taper tantrum"
- "mid-2013"

- FOMC decides not to taper
- FOMC extends LSAP end date from 2009Q4 to 2010Q1
- FOMC signals caution in raising rates

- Estimated forward guidance factor
- Estimated LSAP factor
Effects of Fwd Guidance, LSAPs on Treasury Yields

Run high-frequency regressions on FOMC announcement days:

\[ \Delta y_t = \alpha + \beta \tilde{F}_t + \epsilon_t \]

from Jan. 2009–Oct. 2015
Effects of Fwd Guidance, LSAPs on Treasury Yields

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from Jan. 2009–Oct. 2015

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Regression \( R^2 \)
- 0.49
- 0.94
- 0.95
- 0.97
- 0.78

# Observations
- 55
- 55
- 55
- 55
- 55
Results from regressions

\[ \Delta \log x_t = \alpha + \beta \tilde{F}_t + \varepsilon_t \]
### Effects on Stocks and Exchange Rates

Results from regressions

\[
\Delta \log x_t = \alpha + \beta \widetilde{F}_t + \varepsilon_t
\]

<table>
<thead>
<tr>
<th></th>
<th>S&amp;P 500</th>
<th>$/euro</th>
<th>$/yen</th>
</tr>
</thead>
<tbody>
<tr>
<td>change in forward guidance</td>
<td>$-0.19^{***}$</td>
<td>$-0.28^{***}$</td>
<td>$-0.19^{***}$</td>
</tr>
<tr>
<td>[t-stat.]</td>
<td>$[-2.82]$</td>
<td>$[-6.96]$</td>
<td>$[-5.43]$</td>
</tr>
<tr>
<td>change in LSAPs</td>
<td>$0.19^{***}$</td>
<td>$0.32^{***}$</td>
<td>$0.36^{***}$</td>
</tr>
<tr>
<td>[t-stat.]</td>
<td>$[3.55]$</td>
<td>$[6.60]$</td>
<td>$[7.59]$</td>
</tr>
<tr>
<td>Regression $R^2$</td>
<td>.27</td>
<td>.68</td>
<td>.79</td>
</tr>
<tr>
<td># Observations</td>
<td>55</td>
<td>55</td>
<td>55</td>
</tr>
</tbody>
</table>
Effects on Corporate Bond Yields and Spreads

Results from regressions

\[ \Delta y_t = \alpha + \beta \tilde{F}_t + \varepsilon_t \]
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Results from regressions

\[ \Delta y_t = \alpha + \beta \tilde{F}_t + \epsilon_t \]

<table>
<thead>
<tr>
<th>Change in forward guidance</th>
<th>Corporate Yields</th>
<th>Spreads</th>
</tr>
</thead>
<tbody>
<tr>
<td>change in forward guidance</td>
<td>0.71</td>
<td>–0.06</td>
</tr>
<tr>
<td>change in LSAPs</td>
<td>–4.57***</td>
<td>–5.05***</td>
</tr>
<tr>
<td>[t-stat.]</td>
<td>[–12.55]</td>
<td>[–8.45]</td>
</tr>
</tbody>
</table>

Regression \( R^2 \)

<table>
<thead>
<tr>
<th>Regression ( R^2 )</th>
<th>.44</th>
<th>.49</th>
<th>.54</th>
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Are the Effects of Fwd Guidance, LSAPs Persistent?

Interesting question whether one-day effects of forward guidance and LSAPs are persistent.

"Slow-moving capital" view (Duffie 2010; Fleckenstein, Longstaff, Lustig 2014):
many examples in finance of pricing anomalies that fade over time (from minutes to months)
takes time for potential arbitrageurs to reallocate capital

Wright (2012) estimates effects of unconventional monetary policy have half-life of 2–3 months

Run daily regressions forecasting $h$-day change in yields:

$$y_t + h = \alpha_h + \beta_h y_t + \gamma_h \tilde{F}_t + \epsilon_t(h)$$

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Persistence of Forward Guidance Effects (on 10y Tr.)

Effect of Forward Guidance on 10-Year Treasury Yield

horizon $h$ (days)

coefficient $\gamma_h$ (bp/sd)

0 20 40 60 80 100 120

-20 -15 -10 -5 0 5 10 15
Persistence of LSAP Effects (on 10y Treasury)

Effect of LSAPs on 10-Year Treasury Yield

horizon $h$ (days)

coefficient $\gamma_h$ (bp/sd)
Is the Attenuation Significant?

Impose functional form
\[ \gamma_h = a + b e^{c h} \]
and reestimate regressions for the different horizons \[ h \] using NLS.
Is the Attenuation Significant?

Impose functional form

\[ \gamma_h = a + be^{ch} \]

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Effect of LSAPs on 10-Year Treasury Yield
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<td></td>
<td>( a )</td>
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<td>( c )</td>
</tr>
<tr>
<td>2-year Treasury yield</td>
<td>(-18.7)</td>
<td>(21.7)</td>
<td>(-0.0004)</td>
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<td>( t\text{-stat.} )</td>
<td>(-0.01)</td>
<td>(0.11)</td>
<td>(-0.10)</td>
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<td>10-year Treasury yield</td>
<td>(-21.4)</td>
<td>(28.2)</td>
<td>(-0.0048)</td>
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<td>( t\text{-stat.} )</td>
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But Significance is Entirely Due to One Obs.: 3/18/09
Persistence of LSAP Effects on 10Y Tr., incl. 3/18/09
Persistence of LSAP Effects on 10Y Tr., excl. 3/18/09

Effect of LSAPs on 10-Year Treasury Yield (excl. 3/18/09)
How Does Unconvent. Mon. Pol. Affect Uncertainty?

Many have argued FOMC’s forward guidance reduced uncertainty about future path of monetary policy (e.g., Bernanke 2013)
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Forward guidance and LSAPs could increase or decrease uncertainty about long-term bond yields

- Are these policies adding or removing variance from long-term bond yields?
Measuring Monetary Policy Uncertainty

We can measure monetary policy uncertainty using options data:
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Effect of Forward Guidance on Monetary Policy Uncertainty

Effect of Forward Guidance on Monetary Policy Uncertainty
Effect of LSAPs on Monetary Policy Uncertainty

Horizon $h$ (days)

Coefficient $\gamma_h$ (bp/sd)
Effect of Forward Guidance on MOVE Index

Effect of Fwd Guidance on Long-Term Bond Yield Uncertainty

- coefficient $\gamma_h$ (index pts./sd)
- horizon $h$ (days)
- $0$ $20$ $40$ $60$ $80$ $100$ $120$
- $-15$ $-10$ $-5$ $0$ $5$ $10$ $15$
Effect of LSAPs on MOVE Index

Effect of LSAPs on Long-Term Bond Yield Uncertainty

horizon \( h \) (days)

\[
\begin{array}{c|c|c|c|c|c|c|c}
\hline
h & 0 & 20 & 40 & 60 & 80 & 100 & 120 \\
\hline
\text{coefficient} \gamma_h & 0 & -5 & 0 & 5 & 10 & 15 & \\
\end{array}
\]
Effect of Forward Guidance on VIX
Effect of LSAPs on VIX
Conclusions

1. Unconventional monetary policy was effective (on financial markets)
   - suggests Fed does not need to raise its inflation target

2. Both forward guidance and LSAPs were effective:
   - FG and LSAPs about equally effective for medium-term Treasury yields, stocks, and exchange rates
   - Forward guidance had larger effects on short-term Treasury yields
   - LSAPs had larger effects on long-term Treasury yields, corporate bond yields, and interest rate uncertainty

3. There is some evidence these effects were not persistent, particularly for LSAPs, but that evidence depends entirely on the very influential 3/18/2009 QE1 announcement