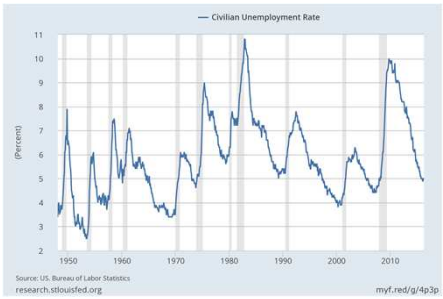
Monetary policy at the zero lower bound: Empirical evidence

A. Brief summary of 2007-2014
B. Event studies
   1. Emergency lending
   2. Large-scale asset purchases
   3. Forward guidance

1

Slow recovery from worst downturn since Great Depression



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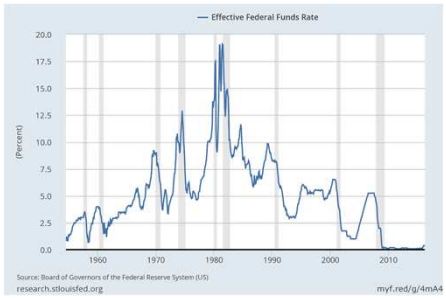
Traditional tool of lowering fed funds rate won't work



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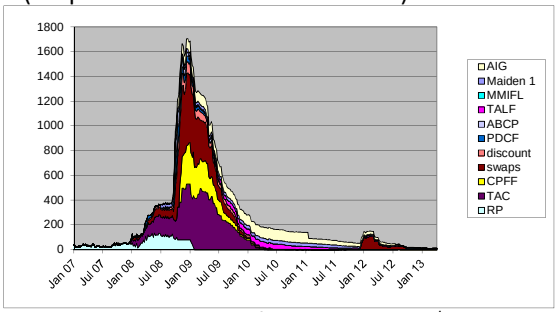
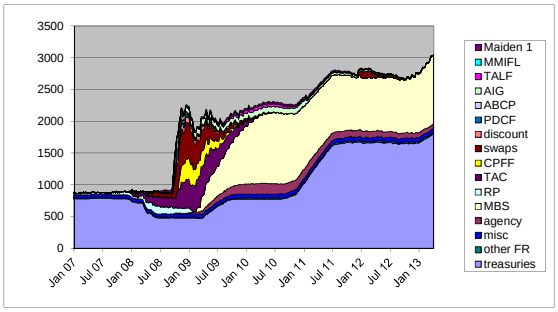
Phase I: Emergency Fed lending (Sept 2008 – March 2009)



Outstanding Fed loans as of Dec 31, 2008: TAC $450 B; swaps $554 B; CPFF $334 B ; total assets: $2,276 B

4

Phase II: Loans repaid but Fed bought huge amounts of Treasuries, MBS



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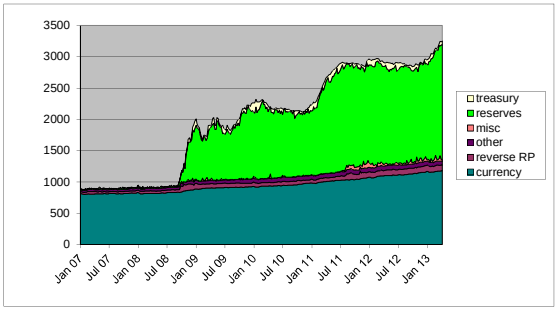
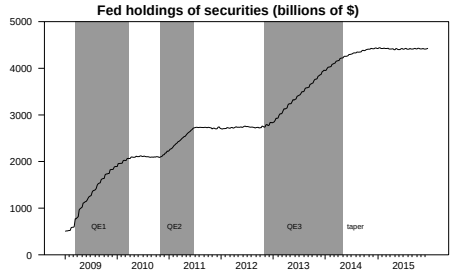
Paid for these by creating new Fed deposits (liabilities in billions)



6

Three phases of "Quantitative Easing" (QE) or "Large-Scale Asset Purchases" (LSAP)



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- LSAP: Fed buys $100 B in securities
- Pays for it by creating $100 B in new deposits with Fed (pay interest)
- If purchased securities were 3-month Tbill, banks have just swapped one asset (safe 3-month Tbill paying very low interest) for another (overnight deposits with Fed paying very low interest)
- No reason this should change interest rate

8

- Deposits with Federal Reserve are essentially equivalent to 3-month treasury bills
- Pay about the same interest
- Are both short-term liabilities of the U.S. government
- Nothing special about Fed deposits now that they are far beyond what banks need to meet requirements or have adequate liquidity
- So Fed is buying something other than Tbills (emergency loans in Phase I, long-term bonds in II)

9

B. Event studies

1. Emergency lending (Commercial Paper Lending Facility)
2. Large-scale asset purchases
3. Forward guidance

10

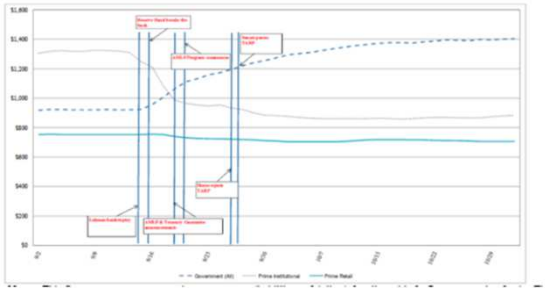
B. Event studies

1. Emergency lending

- Money market mutual funds
  - Accept deposits from customers
  - Invest in Treasury securities or prime commercial paper
- Reserve Primary Fund
  - Historically had been very conservative
  - Later took more risks to offer higher yield (e.g. loans to Lehman)
  - Lehman bankrupt Sept 15, 2008
  - Reserve Primary Fund "broke the buck" Sept 16

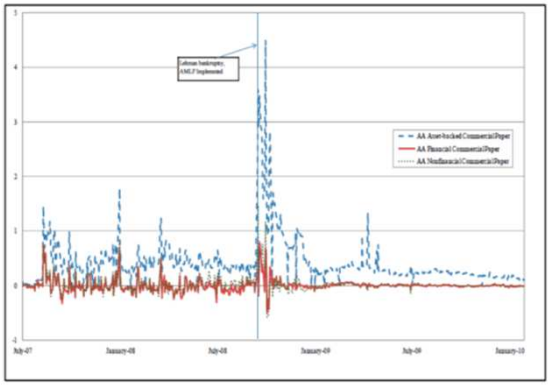
11

Figure 1: Total assets under management, prime and government-only money market mutual funds, September-October 2008



12

Figure 4: Spreads on overnight commercial paper over the effective fed funds rate



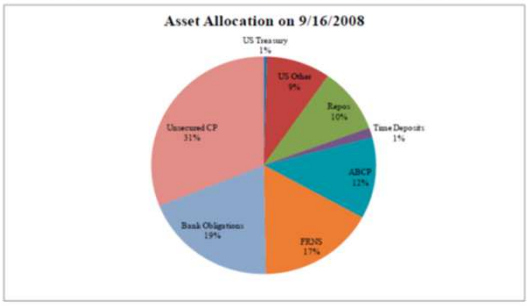
13

Commercial Paper Lending Facility

- Fed announced Sept 19 it would lend to banks that purchased asset-backed commercial paper (ABCP) from eligible money market mutual funds (MMMF), accepting the ABCP as collateral for loans

14

Figure 3: Asset allocation of prime money market mutual funds, September 16, 2008



15

Event study methodology

- Time series: do we see a change on the day of the announcement?
- Cross-section: is change bigger for those MMMF with more ABCP exposure?

16

We first look at how asset flows responded to the announcement of the AMLF. Using a panel of daily observations encompassing one week before and one week after the announcement of the AMLF (September 12-26, 2008), we estimate the following equation:

$$\Delta A_{it} = \beta_0 + \beta_1 AMLF_{\bar{t}} + \beta_2 S_{it}^{ABCP} + \beta_3 AMLF_{\bar{t}} * S_{it}^{ABCP} + \beta_4 S_{it}^{L} + \beta_5 Liq_{it} + \beta_6 Inst_i + \varepsilon_{it} \quad (3)$$

where ΔA_{it} is the change in total AUM of fund i between t -1 and t; $AMLF_{\bar{t}}$ is an indicator variable that equals 1 after September 19, 2008 (we denote the announcement date of the AMLF by $\bar{t}$)). S_{it}^{ABCP} is the share of ABCP holdings in fund i's portfolio on September 9, 2008 (one week before Lehman's bankruptcy, which we denote by $\bar{t}$)); S_{it}^{L} is the share of "liquid" assets defined as repos, Treasuries, and other U.S. agency notes of fund i at time $\bar{t}$, $Inst_i$ is a dummy variable for institutional MMMFs; and Liq_{it} is the 7-day liquidity of the fund, defined as the percent of assets in fund i's portfolio that are scheduled to reach maturity within 7 days from $\bar{t}$. We also estimate equation (3) including fund and time (day) fixed effects.

17

Assets under management of vulnerable MMF increased

Table 10: Impact of the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF) on money market mutual fund asset flows

Dependent variable – Percentage change in assets under management

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
AMLF Program Indicator	-0.002	-0.010**	-0.002	-0.002	-0.002	-0.010**	-0.002	-0.011**
	[0.003]	[0.005]	[0.003]	[0.003]	[0.003]	[0.005]	[0.003]	[0.004]
AMLF Program Indicator X Fraction of ABCP (on 16 September 2008)	0.083***	0.083***	0.081***	0.081***	0.083***	0.083***	0.081***	0.081***
	[0.030]	[0.030]	[0.029]	[0.029]	[0.030]	[0.030]	[0.029]	[0.029]
Fraction of ABCP (on 16 September 2008)	-0.087***	-0.087***			-0.074***	-0.074***		
	[0.025]	[0.025]			[0.022]	[0.022]		
Fraction Maturing in 7 Days (on 16 September 2008)					-0.003	-0.003		
					[0.025]	[0.025]		
Fraction of Liquid Assets (on 16 September 2008)					0.023	0.023		
					[0.028]	[0.028]		
Institutional Fund Indicator					-0.014***	-0.014***		
					[0.003]	[0.003]		
Day Fixed Effects	No	Yes	No	Yes	No	Yes	No	Yes
Fund Fixed Effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	2644	2644	2644	2644	2644	2644	2644	2644
R-squared	0.013	0.025	0.009	0.020	0.027	0.038	0.009	0.020

18

CPLF reduced ABCP yield spread

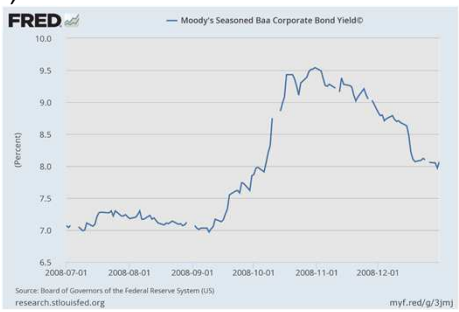
Table 11: Impact of the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF) on asset-backed commercial paper (ABCP) yields

Dependent variable – Yield on ABCP minus yield on commercial paper issued by the sponsor

	(1)	(2)	(3)	(4)	(5)	(6)
Post-AMLF Indicator	-0.787***	0.777**	-0.987***	-0.881***	-0.336	
	[0.218]	[0.278]	[0.275]	[0.271]	[0.273]	
Sponsor CDS Spread		0.122	-0.259**	0.059	0.025	-0.269
		[0.072]	[0.098]	[0.128]	[0.106]	[0.462]
AMLF Participant Indicator					-0.842	-0.899
					[0.676]	[0.603]
Post-AMLF Indicator X AMLF Participant Indicator					-0.685**	-0.873**
					[0.265]	[0.271]
Constant	2.752***	2.437***	1.522***	1.462***	2.295***	2.390***
	[0.151]	[0.091]	[0.277]	[0.231]	[0.585]	[0.677]
Conduit Fixed Effects	No	Yes	No	No	No	No
ABCP Program Type Fixed Effects	No	No	Yes	Yes	Yes	Yes
Sponsor Fixed Effects	No	No	No	Yes	Yes	Yes
Time Fixed Effects	No	No	No	No	No	Yes
Observations	201	185	185	185	185	185
R-squared	0.135	0.723	0.304	0.458	0.548	0.642

19

Baa continued to rise through Oct 31, 2008



20

- The Fed began scaling down emergency lending in January 2009 and today these programs are essentially all shut down.
- Fed ended up making a profit on these loans.
- Widespread financial failures did not happen.

21

B. Event studies

2. LSAP

- Nov 25, 2008: LSAP announced
- Dec 1, 2008: Bernanke: "could purchase longer-term Treasury… in substantial quantities"
- Dec 16, 2008: FOMC "stands ready to expand its purchases of agency debt and mortgage-backed securities"
- Mar 18, 2009: Announced new purchases of MBS and agency debt

22

Table 1. Treasury, Agency and Agency MBS yields on QE1 event dates

Two-day changes (in basis points)

Date	Event	Treasuries yields (constant maturity)					Agency yields			Agency MBS yields	
		30 year	10 year	5 year	3 year	1 year	10 year	5 year	3 year	30 year	15 year
11/25/2008	Initial announcement	-24	-36	-23	-15	-2	-76	-57	-42	-75	-147
12/1/2008	Bernanke speech	-27	-25	-28	-15	-13	-67	-50	-28	-10	58
12/16/2008	FOMC statement	-32	-33	-15	-4	-5	-39	-26	-28	-30	-7
1/28/2009	FOMC statement	31	28	28	19	4	28	27	16	6	16
3/18/2009	FOMC statement	-21	-41	-36	-24	-9	-45	-44	-38	-19	-18
Above 5 dates	Above 5 events	-73*	-107**	-74	-39	-25*	-199***	-150**	-120***	-128**	-98

23

Table 3. Inflation Swaps, TIPS, and Implied Interest Rate Volatility on QE1 Event Dates

Two-day changes (in basis points)

Date	Event	Inflation swaps				TIPS real yields (constant maturity)			Interest rate volatility
		30 year	10 year	5 year	1 year	20 year	10 year	5 year	
11/25/2008	Initial Announcement	1	-6	-28	48	-22	-43	5	1
12/1/2008	Bernanke speech	15	27	11	-40	-38	-34	-51[28]	-7
12/16/2008	FOMC Statement	4	37	35	-17	-45	-57	-83	-20
1/28/2009	FOMC Statement	14	15	-6	5	15	6	13	0
3/18/2009	FOMC Statement	2	22	24	45	-45	-59	-43	-11
Above 5 dates	Above 5 events	36**	95**	36	41	-135***	-187***	-144***	-37***

24

Table 5. Treasury, Agency and Agency MBS Yields on QE2 Event Dates
One and two-day changes (in basis points)

Date	Event	Changes	Treasuries yields (constant maturity)					Agency yields		Agency MBS yields	
			30 year	10 year	5 year	3 year	1 year	10 year	5 year	30 year	15 year
8/10/2010	FOMC meeting	1-day	-1	-7	-8	-3	-1	-7	-9	1	-5
		2-day	-8	-14	-10	-3	-1	-13	-9	-8	-4
9/21/2010	FOMC meeting	1-day	-8	-11	-9	-5	0	-11	-9	-7	1
		2-day	-13	-16	-10	-5	-1	-16	-10	4	5
11/3/2010	FOMC meeting	1-day	16	4	-4	-2	0	5	-5	-5	-2
		2-day	11	-10	-11	-6	-1	-10	-14	-13	-3
8/10 and 9/21		1-day	-9*	-18***	-17***	-8***	-1	-18***	-18***	-6	-4
		2-day	-21***	-30***	-20***	-8***	-2	-29***	-19***	-4	1

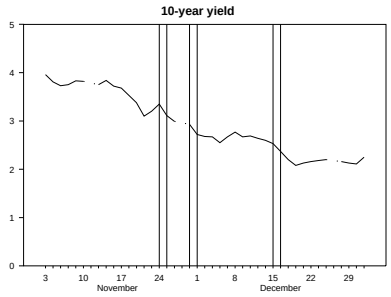
25

Table 8. Inflation Swaps, TIPS, and Implied Interest Rate Volatility on QE2 Event Dates
One and two-day changes (in basis points)

Date	Event	Changes	Inflation swaps				TIPS real yields (constant maturity)			10 year interest rate volatility
			30 year	10 year	5 year	1 year	20 year	10 year	5 year	
8/10/2010	FOMC meeting	1-day	5	-1	-3	0	-10	-9	-8	-2
		2-day	-2	0	-3	-4	-6	-9	-5	-3
9/21/2010	FOMC meeting	1-day	6	6	6	-1	-14	-16	-14	-1
		2-day	6	4	7	9	-17	-20	-18	-2
11/3/2010	FOMC meeting	1-day	6	-3	2	1	4	1	-6	-2
		2-day	1	-10	4	14	2	-5	-14	-3
8/10 and 9/21		1-day	11***	5	3	-1	-24***	-25***	-22***	-3***
		2-day	4	4	4	5	-23***	-29***	-23***	-5***

26

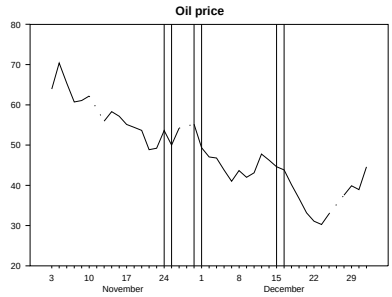
10-year yield fell 170 bp Nov 3 - Dec 31



fell 61 bp on 3 indicated dates

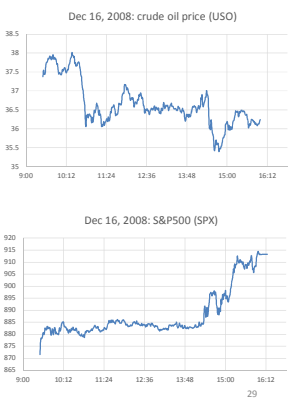
27

Oil price declined 30% Nov 3 - Dec 31



fell 19% on 3 indicated dates

28



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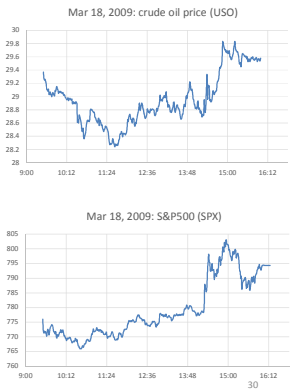

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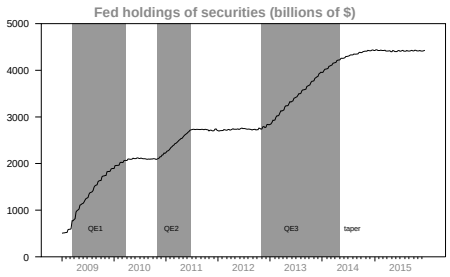
Study	Sample	Method	Estimated Effect of $600B LSAP (±2 std errors if avail.)[a]
Modigliani-Sutch (1966, 1967)	Operation Twist	time series	0 bp (±20 bp)
Bernanke-Reinhart-Sack (2004)	Japan, U.S.	event study	400 bp (±370 bp), 40 bp (±60 bp)
Greenwood-Vayanos (2008)	post-War U.S. (pre-crisis)	time series	14 bp (±7 bp)
Krishnamurthy-Vissing-Jorgensen (2011, 2012)	post-War U.S., QE1, and QE2	time series	15 bp (±5 bp)
Gagnon-Raskin-Remache-Sack (2011)	QE1	event study, time series	30 bp (±15 bp), 18 bp (±7 bp)
D'Amico-King (2013)	QE1 Treasury purchases	security-specific event study	100 bp (±80 bp)
Hamilton-Wu (2011)	U.S., 1990 - QE2	affine no-arbitrage model	17 bp
Hancock-Passmore (2011)	QE1 MBS purchases	time series	depends, roughly 30 bp
Swanson (2011)	Operation Twist	event study	15 bp (±10 bp)
Joyce-Lasaosa-Stevens-Tong (2011)	U.K. LSAPs	event study, time series	40 bp
Neely (2013)	effect of U.S. QE1 on foreign bond yields	event study	17 bp (±13 bp)
Christensen-Rudebusch (2012)	QE1, QE2, and U.K. LSAPs	event study, affine no-arbitrage model	10 bp
D'Amico-English-Lopez-Salido-Nelson (2012)	U.S., pre-crisis	weekly time series	depends, roughly 45 bp
Bauer-Rudebusch (2013)	QE1, QE2	event study, affine no-arbitrage model	16 bp
Li-Wei (2013)	U.S., pre-crisis	affine no-arbitrage model	26 bp

Source: Williams (2013)

31



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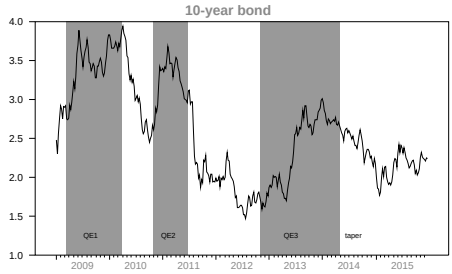
But longer-term evidence is in opposite direction



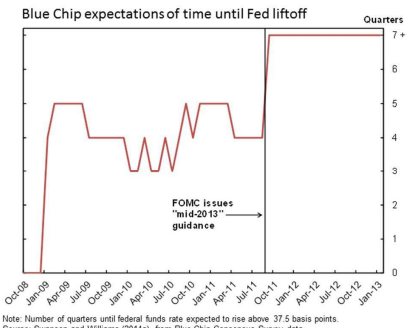
33

B. Event studies

3. Forward guidance

- FOMC statement Aug 9, 2011:
  - "The Committee currently anticipates that economic conditions–including low rates of resource utilization and a subdued outlook for inflation over the medium run–are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013."

34



Note: Number of quarters until federal funds rate expected to rise above 37.5 basis points.
Source: Swanson and Williams (2014a), from Blue Chip Consensus Survey data.

35

Swanson (2017) collected observations on $j = 1, \ldots, n$ changes in the price of $n = 8$ different assets in 30-minute interval around Fed communication for $t = 1, \ldots, T = 213$ different communications over July 1991 to Oct 2015.

$\mathbf{x}_t$ = Kuttner change in current and 2-month fed funds futures, change in 2-, 3- and 4-quarter-ahead Eurodollar futures and 2-, 5-, and 10-year Treasury yields.

J6

Method 1:

◦ Estimate 2 principal components for the July 1991 to Dec 2008 subsample, and a different 2 principal components ξ_{1t} and ξ_{2t} for the second subsample.

◦ Find rotation $\boldsymbol{\xi}_t^* = \mathbf{Q}\boldsymbol{\xi}_t$ and loadings $\mathbf{x}_t \simeq \mathbf{H}^*\boldsymbol{\xi}_t^*$ such that column 2 of $\mathbf{H}^*$ is as close as possible as loadings of these 5 assets on the GSS "path" factor $\tilde{\xi}_{2t}$ on pre-ZLB data.

◦ Interpret ξ_{2t}^* as ZLB "forward guidance" factor and ξ_{1t}^* as contribution of LSAP over and above forward guidance.

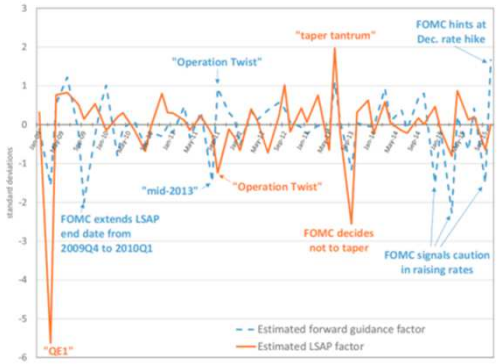
Method 2:

◦ Estimate 3 principal components $\xi_{1t}, \xi_{2t}, \xi_{3t}$ over the full 1991-2015 sample

◦ Find rotation of $\xi_{1t}, \xi_{2t}, \xi_{3t}$ that could be interpreted as target, forward guidance, and LSAP shocks

◦ FG and LSAP have no effect on current fed funds rate

◦ Make sum of squares of LSAP factor as small as possible prior to 2008 (pins down third element of rotation matrix)



39

FOMC Dec 18, 2013 announcement:

- LSAP decrease from $85B/month to $75B/month (LSAP contractionary)
- "it likely will be appropriate to maintain the current target range for the federal funds rate well past the time that the unemployment rate declines below 6-1/2 percent" (forward guidance expansionary)

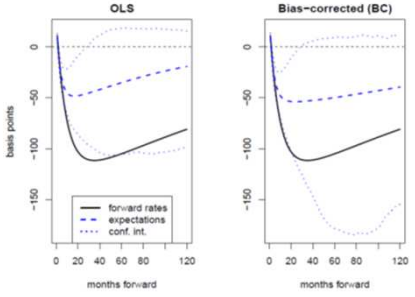
40

Forward guidance matters more for short yields, LSAP for long

	6-month	2-year	5-year	10-year	30-year
(A) estimated effects of federal funds rate and forward guidance, Jul. 1991–Dec. 2008					
change in federal funds rate	4.11***	3.70***	2.02***	0.82***	0.05
(std. err.)	(.397)	(.153)	(.213)	(.222)	(.175)
[t-stat.]	[10.36]	[24.22]	[9.47]	[3.70]	[0.30]
change in forward guidance	2.87***	4.81***	4.59***	3.44***	2.22***
(std. err.)	(.414)	(.191)	(.223)	(.169)	(.206)
[t-stat.]	[6.93]	[25.17]	[20.56]	[20.33]	[10.77]
Regression R^2	.80	.95	.87	.80	.53
# Observations	158	158	158	158	158
(B) estimated effects of forward guidance and LSAPs, Jan. 2009–Oct. 2015					
change in forward guidance	1.19***	5.14***	6.22***	3.06***	0.14
(std. err.)	(.322)	(.323)	(.363)	(.299)	(.886)
[t-stat.]	[3.69]	[15.91]	[17.13]	[10.24]	[0.16]
change in LSAPs	0.19**	0.20	−2.92***	−6.49***	−5.77***
(std. err.)	(.094)	(.118)	(.514)	(.343)	(.554)
[t-stat.]	[2.07]	[1.66]	[−5.69]	[−18.91]	[−10.42]
Regression R^2	.40	.93	.95	.98	.81
# Observations	55	55	55	55	55

41

Cumulative changes on announcement dates in forward rates (as function of months forward, in black) and portion attributable to expected future short rates (blue)



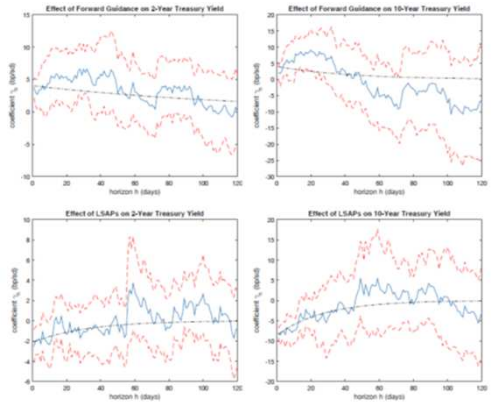
Source: Bauer and Rudebusch (2014)

42

How persistent are the effects?
Estimate with Jordà local projections for change over h days:

$$y_{t+h-1} - y_{t-1} = \gamma_h \tilde{F}_t + u_{ht}$$

43



44