Understanding and Influencing the Yield Curve at the Zero Lower Bound

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University of Pennsylvania

My comments do not necessarily represent the views of others in the Federal Reserve.

Understanding and influencing the yield curve at the ZLB

Understanding the yield curve

1. **What do financial economists do at the ZLB?**

Understanding and influencing the yield curve at the ZLB

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   Develop new term structure models

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1. What do financial economists do at the ZLB?

   Develop new term structure models

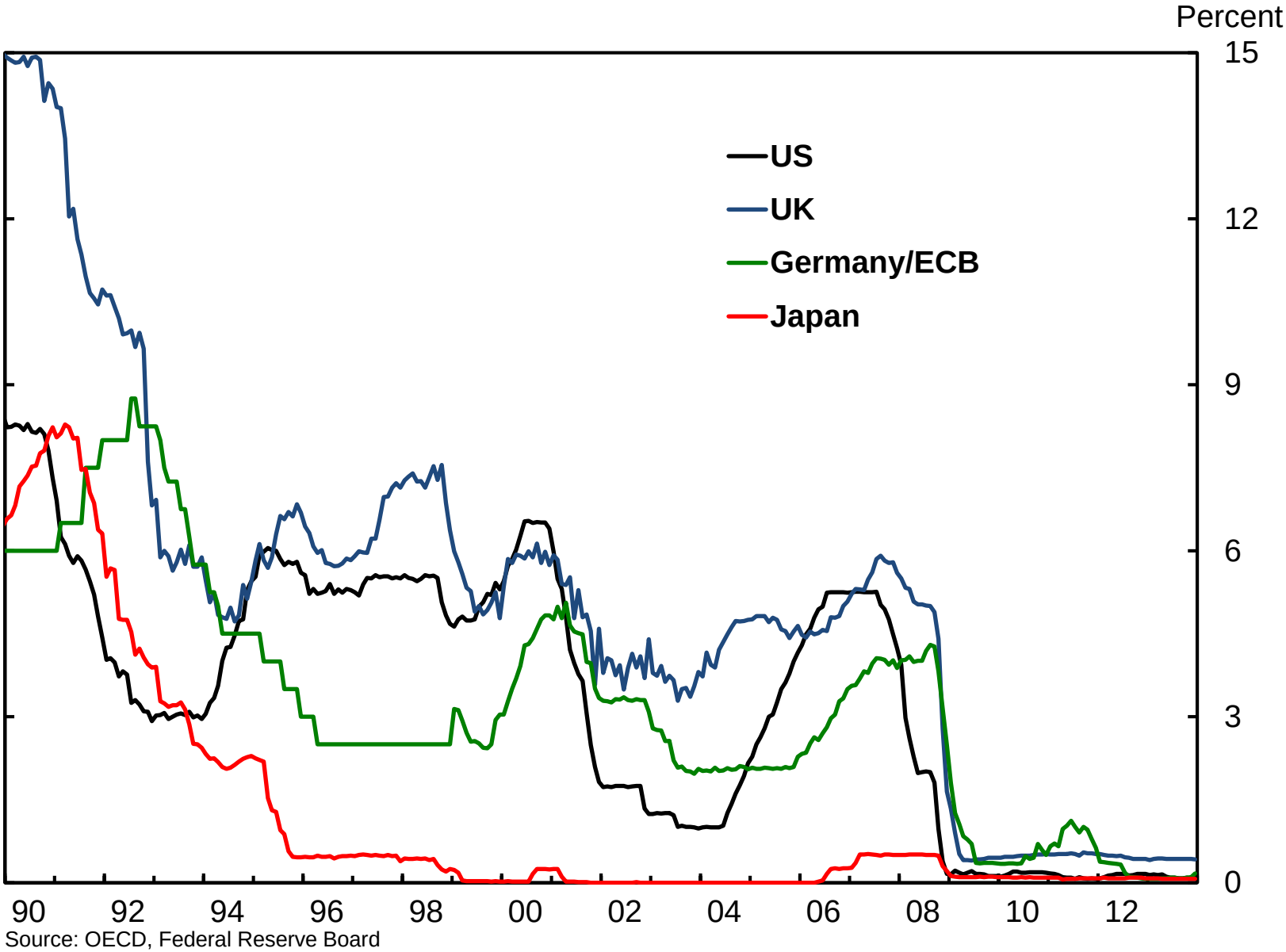
Influencing the yield curve

2. What do central bankers do at the ZLB?

   Worry!

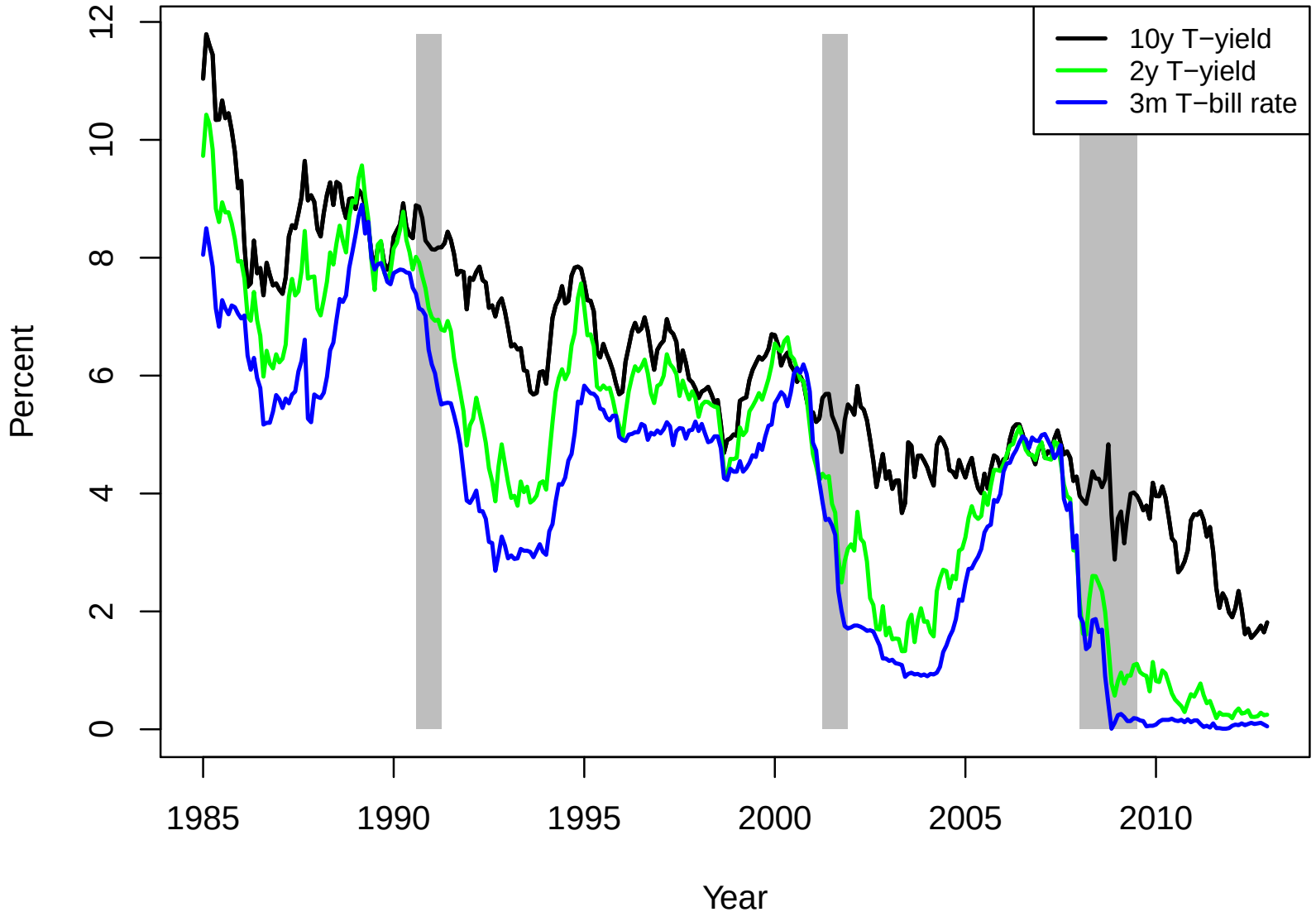
   Consider unconventional tools and strategies

Short-term rates at ZLB in many countries



Source: OECD, Federal Reserve Board

So far: Almost 6 years at ZLB in U.S.!



1. What do financial economists do at the ZLB?

Problem: Standard Gaussian term structure models do not restrict interest rates to be nonnegative.

Term structure models that do respect ZLB:

- Shadow-rate term structure models
- Stochastic-volatility models with square-root processes
- Gaussian quadratic models
- AR gamma zero process of Monfort, Pegoraro, Renne, Roussellet (2014)

Literature has focused on shadow-rate models:

- Issues include tractability, whether ZLB is reflecting or absorbing barrier, and familiarity away from ZLB.

Shadow-rate dynamic term structure models

Standard affine Gaussian DTSM

- Short rate: $r_t = \delta_0 + \delta_1' X_t$
- VAR for X_t under risk-neutral ($\mathbb{Q}$) and real-world ($\mathbb{P}$)
- Risk adjustment links cross section to time series

Shadow-rate DTSM based on Black (1995)

- Shadow rate: $s_t = \delta_0 + \delta_1' X_t$
- Short rate: $r_t = max(0, s_t)$ or $r_t = max(r_{min}, s_t)$

Bond prices and yields

- $y_t^m = m^{-1} \sum_{i=0}^{m-1} E_t^{\mathbb{P}} r_{t+i} + YTP_t^m$
- Affine model: yields and term premia are linear functions of X_t
- *Shadow-rate model is non-linear with no analytical solution*

Some related literature

Japan

- Gorovoi and Linetsky (2004). Ueono et al. (2006), Ichiue and Ueno (2007)
- Kim and Singleton (2012). Christensen and Rudebusch (2014), Monfront et al (2014)

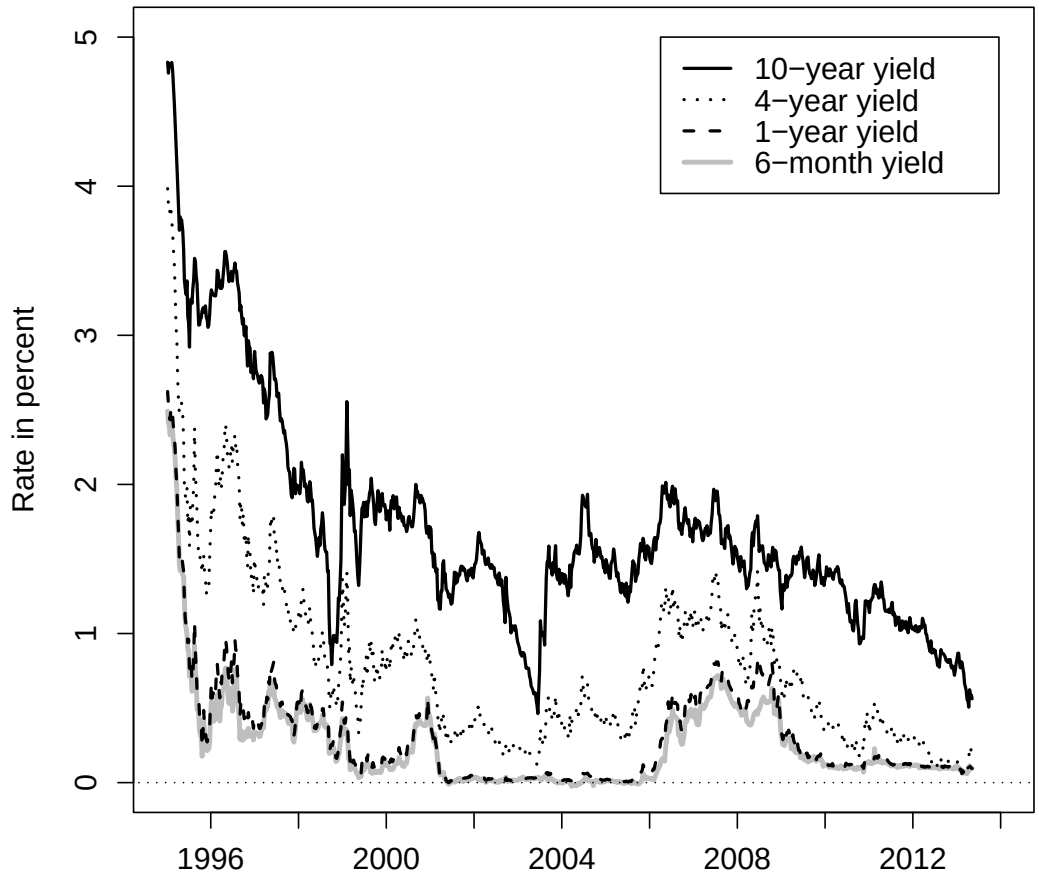
United States

- Bomfim (2003), Hamilton and Wu (2011)
- Krippner (2013), Xia and Wu (2013), Christensen and Rudebusch (2013), Andreasen and Meldrum (2013, Kim and Priebsch (2013), Christensen, Lopez, and Rudebusch (2014)

Euro Area

- Renne(2014)

Christensen and Rudebusch (JFinEc 2014): Estimate 1-, 2-, 3-factor shadow-rate models



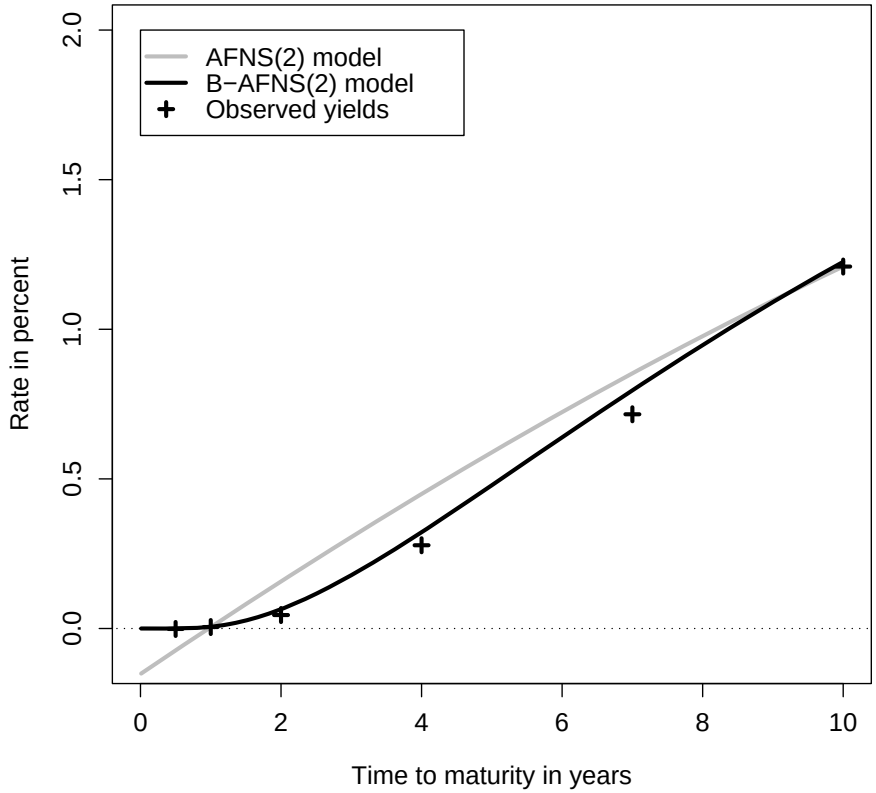
Japanese Government Bond Yields—weekly frequency

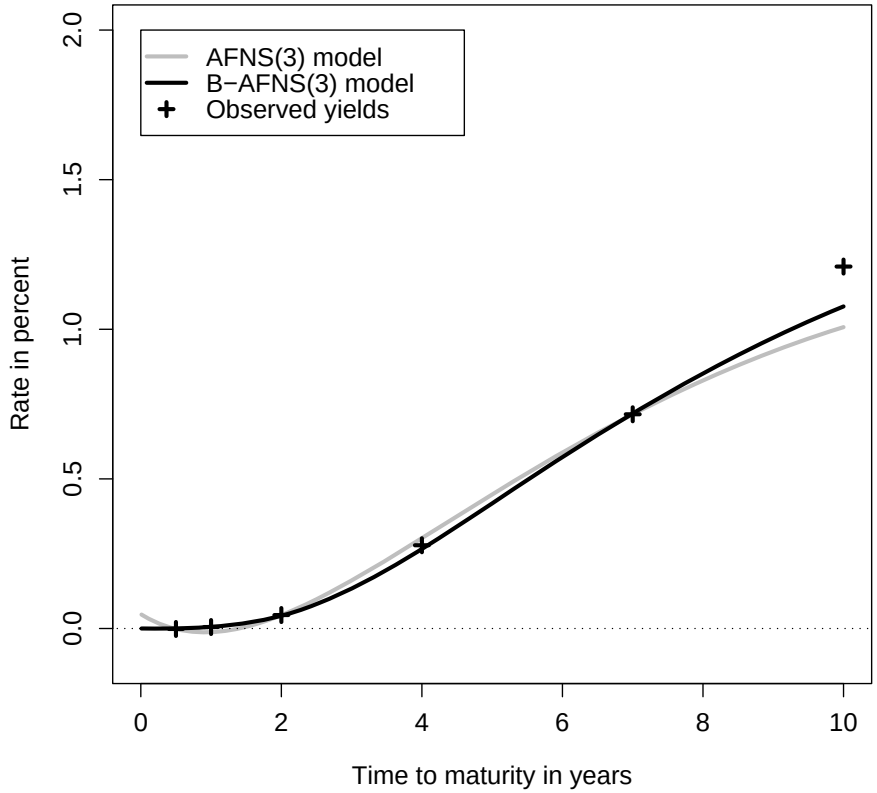
Fit of Standard and Shadow-Rate Models (RMSE)

		RMSE, all yields (in b.p.)
One-factor models		
affine:	V(1)	**34.4**
shadow:	B-V(1)	**32.7**
Two-factor models		
affine:	AFNS(2)	**12.2**
shadow:	B-AFNS(2)	**10.3**
Three-factor models		
affine:	AFNS(3)	**9.7**
shadow:	B-AFNS(3)	**7.0**

Shadow-rate models have somewhat closer fit.

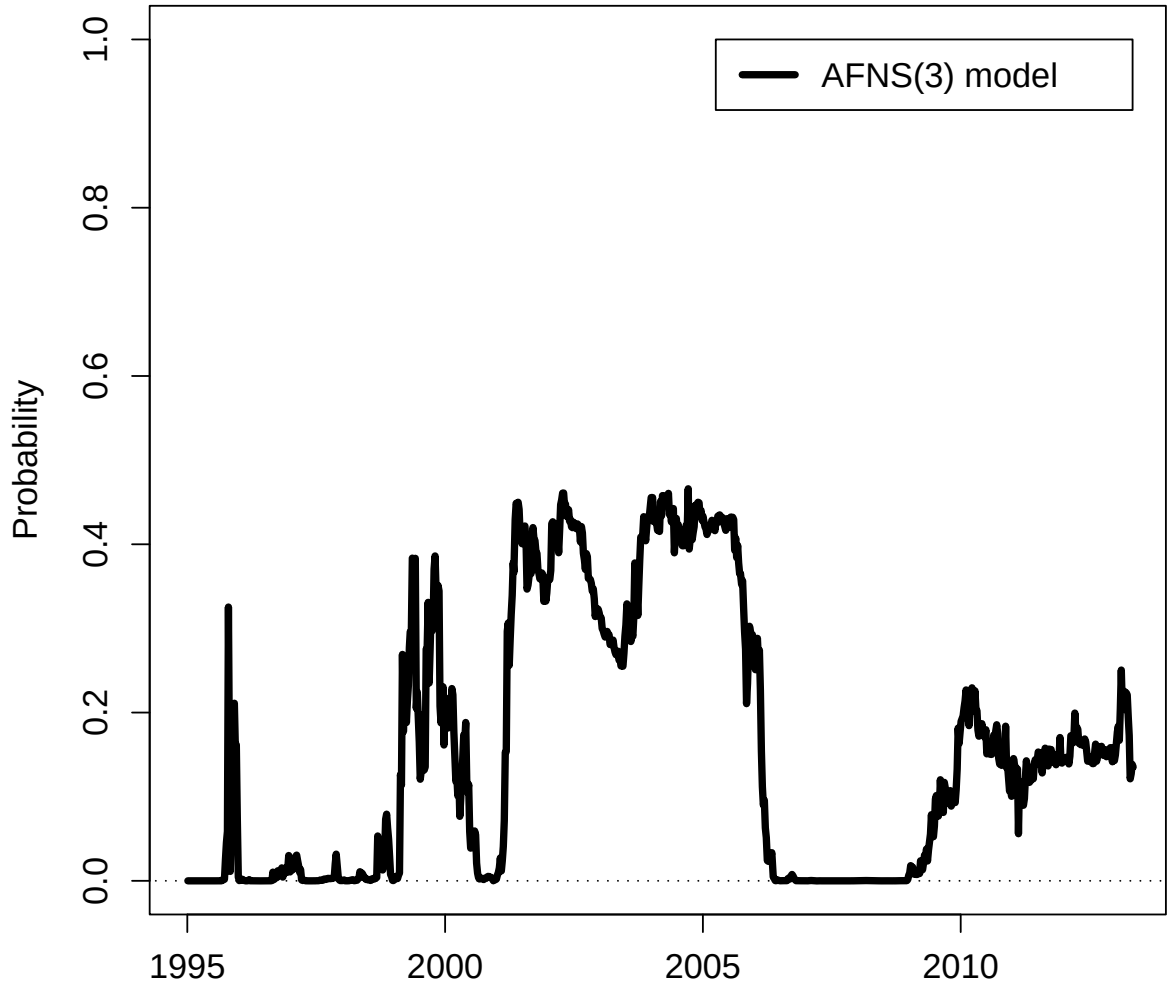
Fitted Yield Curves: Two- and Three-Factor Models





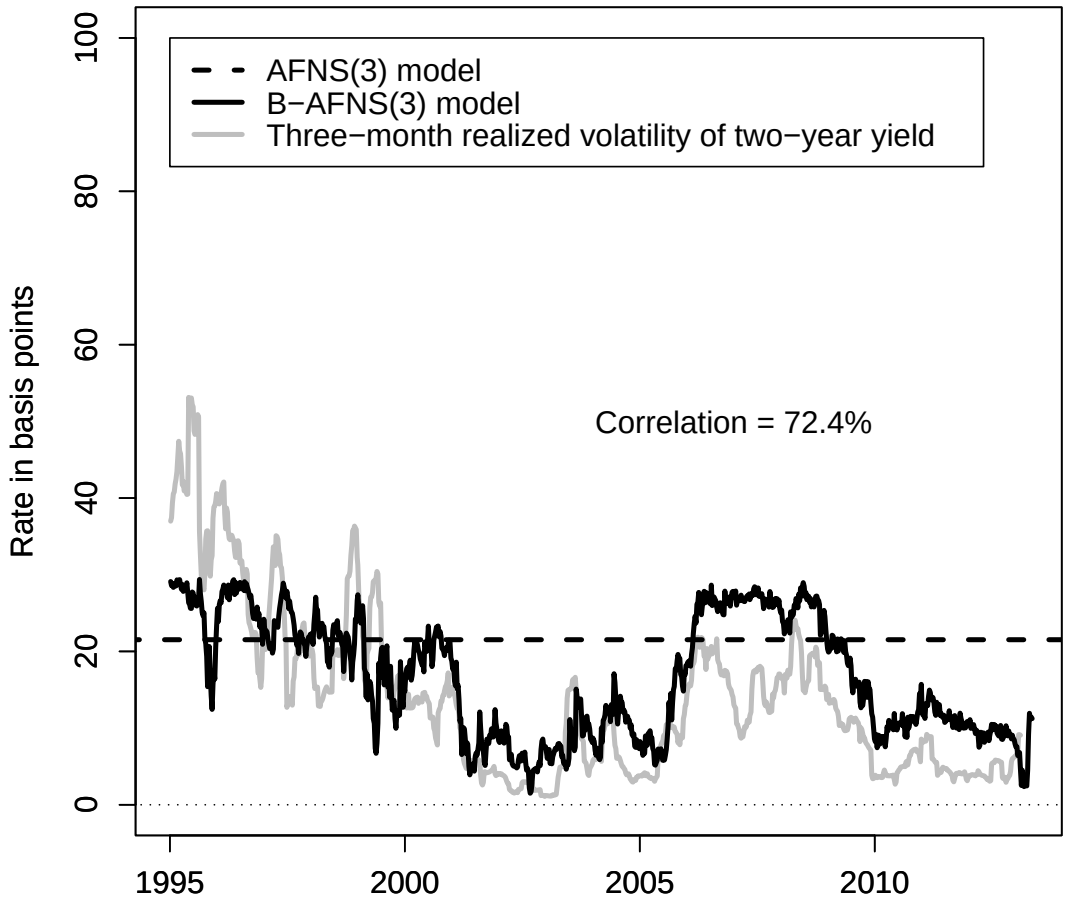
- On July 1, 2005, gain from shadow-rate implementation for the two-factor model, less for the three-factor model.

Why Use a Shadow-Rate Model?
Zero Probability of Negative Future Short Rates



Affine model produces significant probability that short rate will be negative three months ahead.

Why use a shadow-rate model?
Volatility compression for intermediate yields



Near ZLB, volatility of two-year yield is also near zero.
Shadow-rate model can replicate this correlation.

Bauer and Rudebusch (2014): Shadow-rate model with U.S. data

Advantages of shadow-rate models at ZLB:

Better cross-sectional fit

- Shadow-rate models fit the yield curve better

Avoid violations of ZLB by affine models

- Forward curves and short-rate expectations dip below zero
- Probability of negative future rates while mean positive

Greater forecast accuracy

- Shadow-rate models forecast better out of sample
- Macroeconomic information improves performance

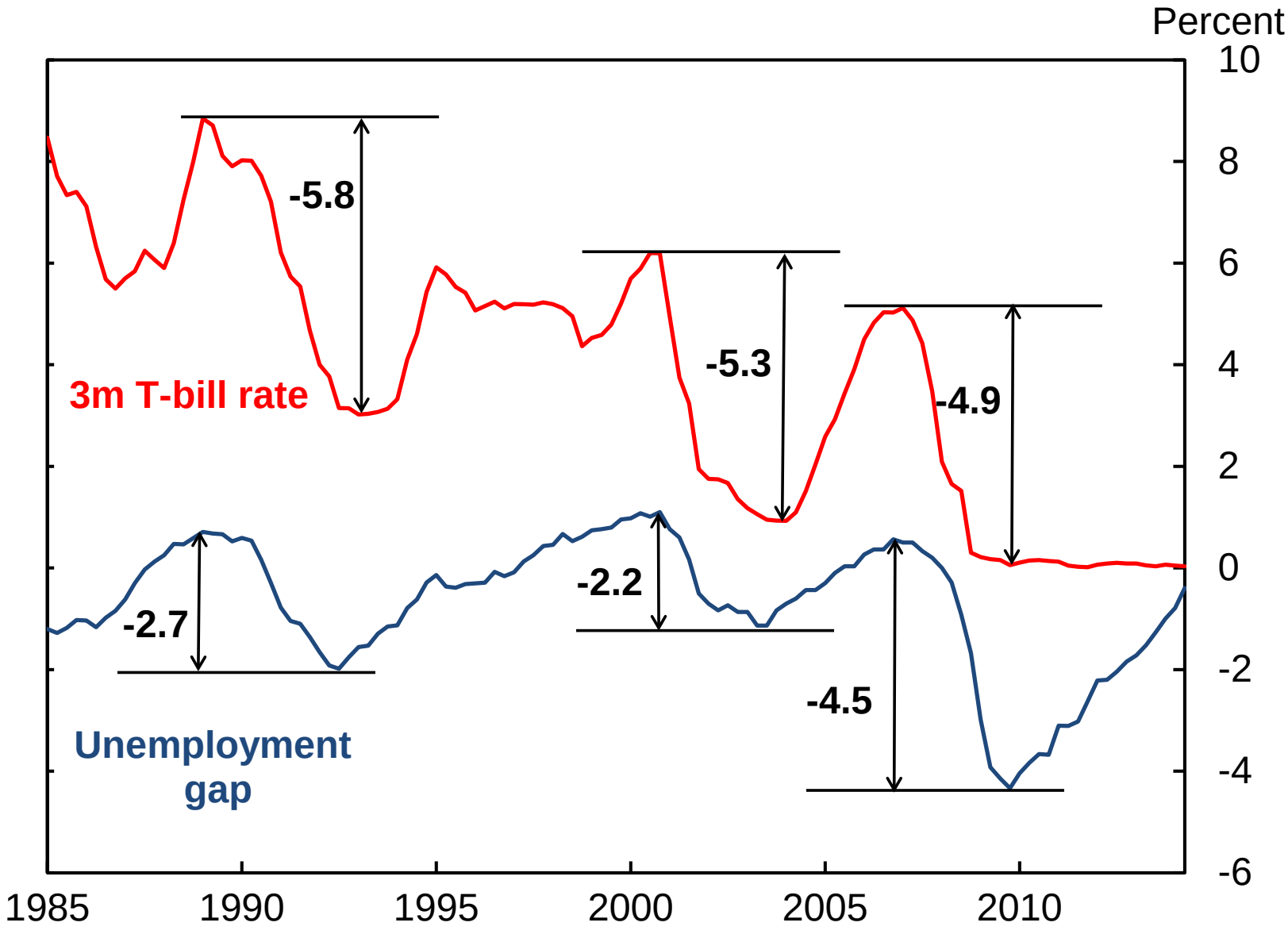
Shadow-rate model gives more accurate forecasts

Out-of sample RMSEs (in basis points). Forecasts of 3-month T-bill rate 12 months ahead, Dec. 2008 to June 2011

Model	RMSE
Yields-only	
affine (2,0)	32.3
shadow (2,0)	17.8
affine (3,0)	22.3
shadow (3,0)	14.3
Macro-finance	
affine (1,2)	103.5
shadow (1,2)	10.9
affine (2,2)	49.6
shadow (2,2)	10.4

Why are macro variables helpful at the ZLB?

Unemployment rate can help pin down shadow rate:



2. What do central bankers do at the ZLB?

Unconventional tools and strategies:

Mitigate effects of ZLB

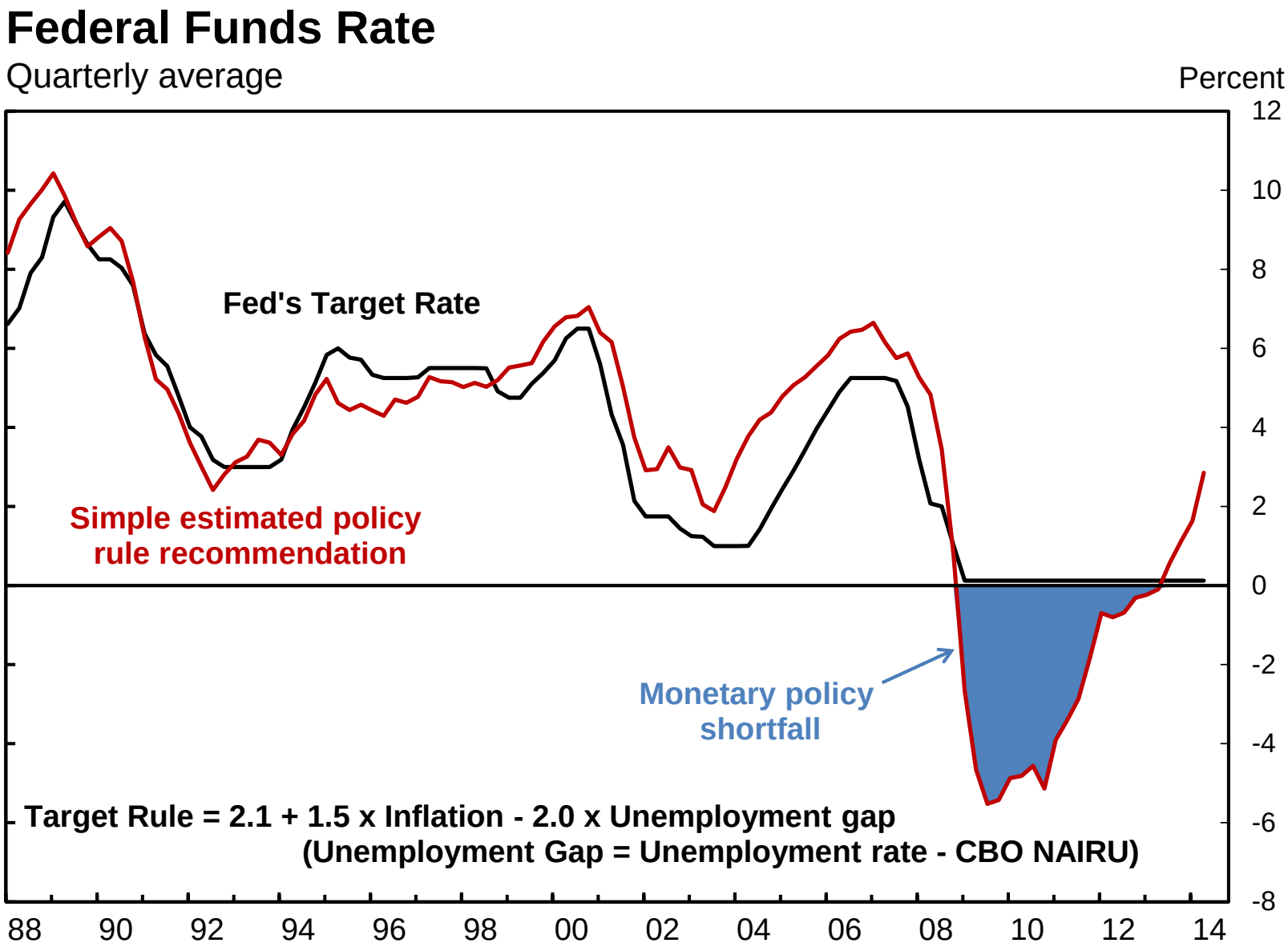
Try to ease financial conditions—e.g., lower long-term yields

- Conduct quantitative easing (QE)
- Provide forward guidance about future policy
- Conduct credit easing

Avoid future episodes at ZLB

- Reconsider the level of the inflation target
- Put greater emphasis on avoiding financial crises

ZLB was sizable constraint on U.S. monetary policy



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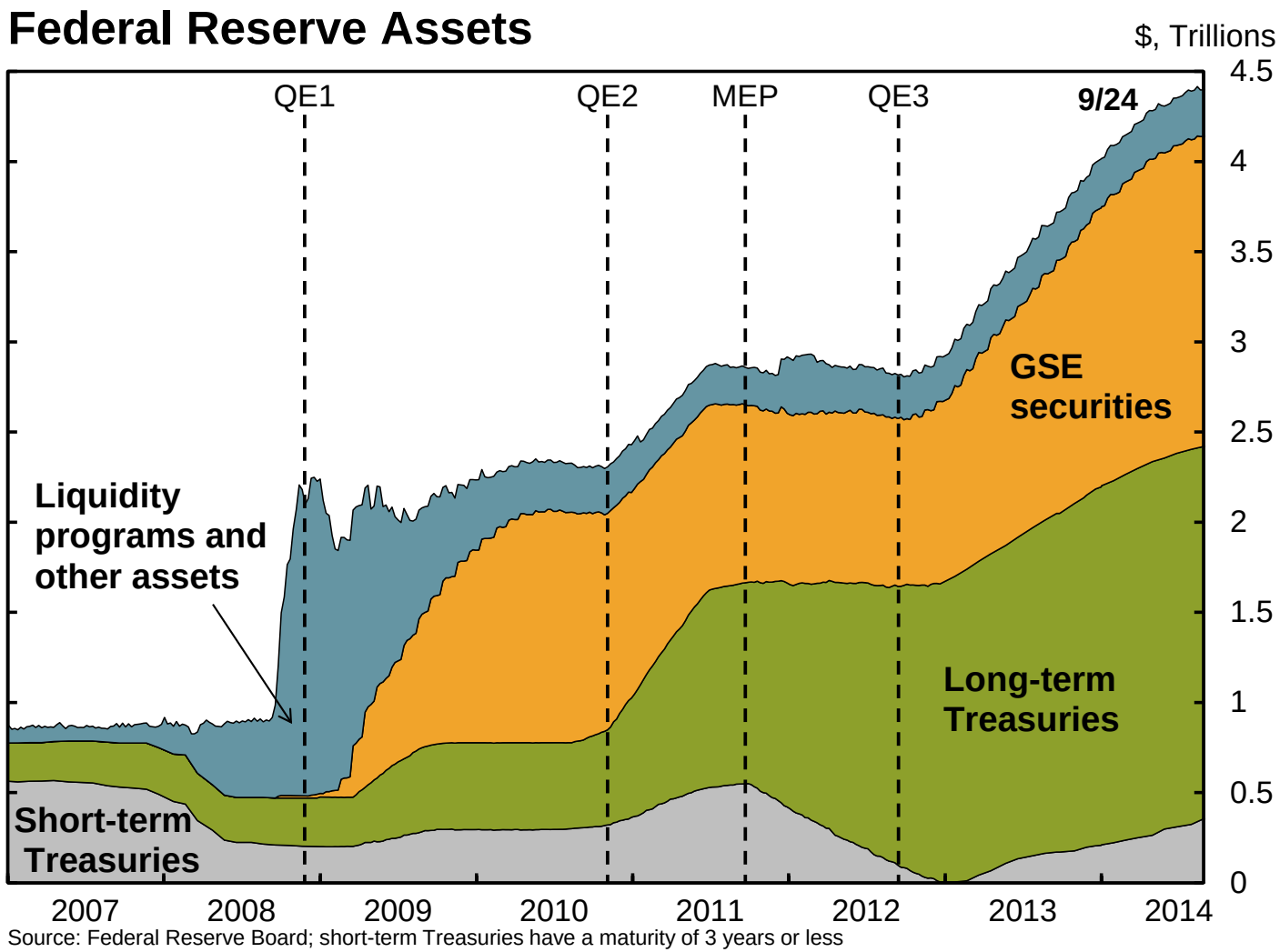
- Provide forward guidance about future policy **(B)**
- Conduct credit easing

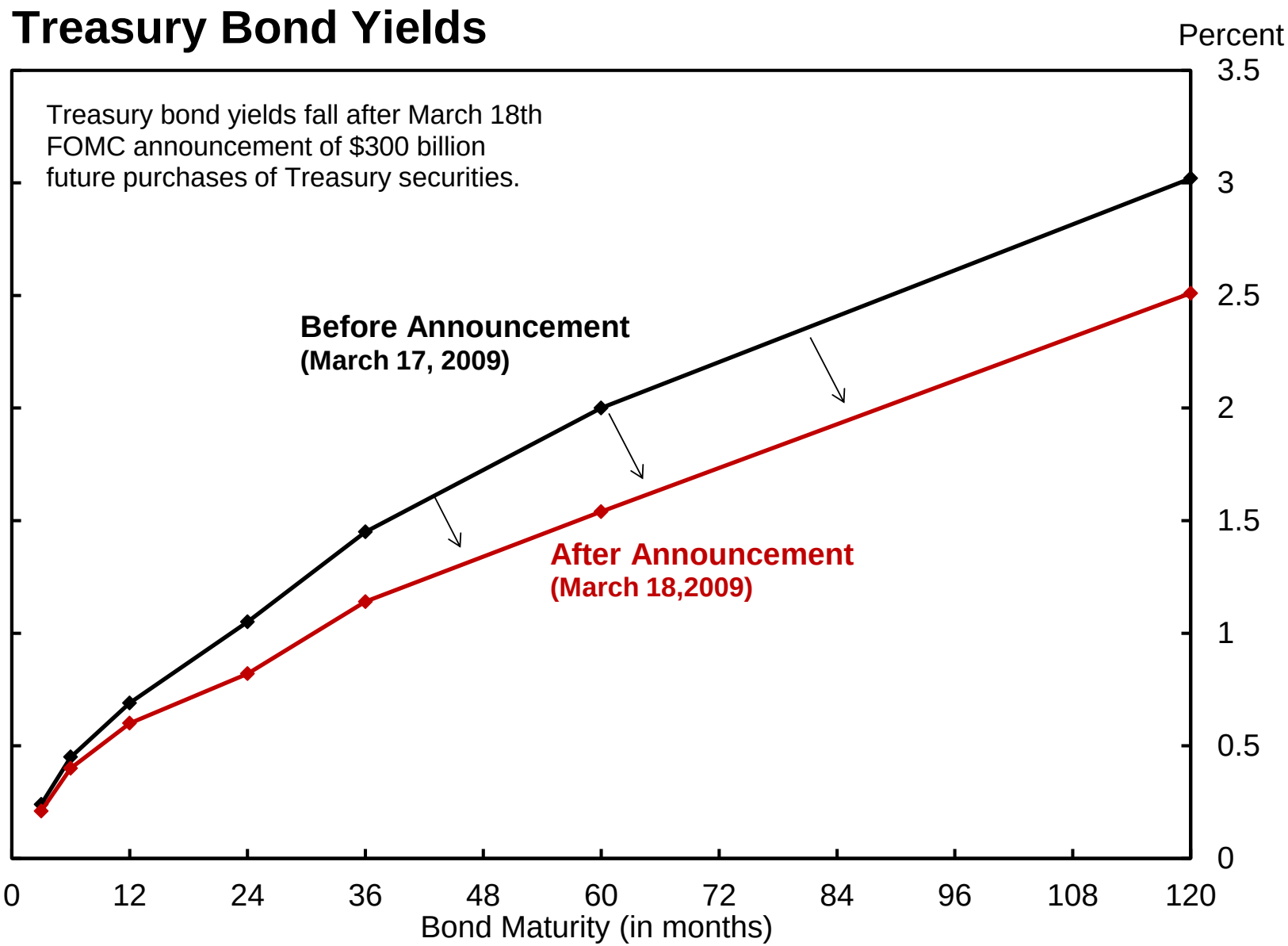
Avoid future episodes at ZLB

- Reconsider the level of the inflation target
- Put greater emphasis on avoiding financial crises **(C)**

A. Central banks purchase assets (QE)



Long-term bond yields fall on QE announcement



How did QE Work?

Chairman Bernanke (2010) saw portfolio balance channel:

> **"Purchases work primarily through the so-called portfolio balance channel [...] Different financial assets are not perfect substitutes in investors' portfolios, so that changes in the net supply of an asset available to investors affect its yield and those of broadly similar assets."**

But LSAPs also may have provided news about

- **a longer period of near-zero policy rate and slower liftoff**
- **lower risks around a little-changed policy path**
- **higher medium-term inflation and lower real rates**
- **improved prospects for real activity (esp. lower tail)**

Bauer-Rudebusch (IJCB, 2014)
Signaling vs. portfolio balance channels for QE

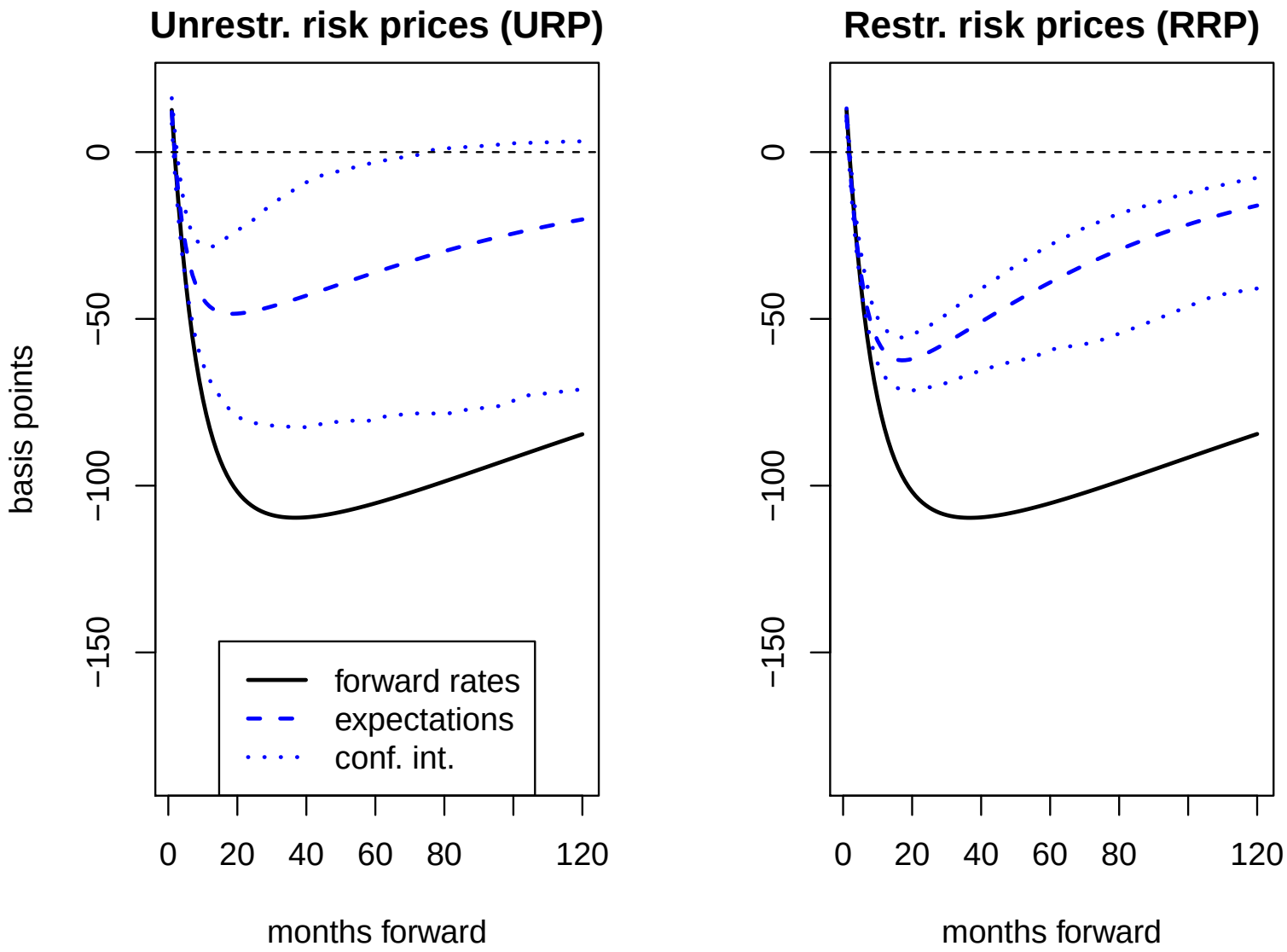
How did QE affect long-term Treasury yields?

- **Yield decomposition**:

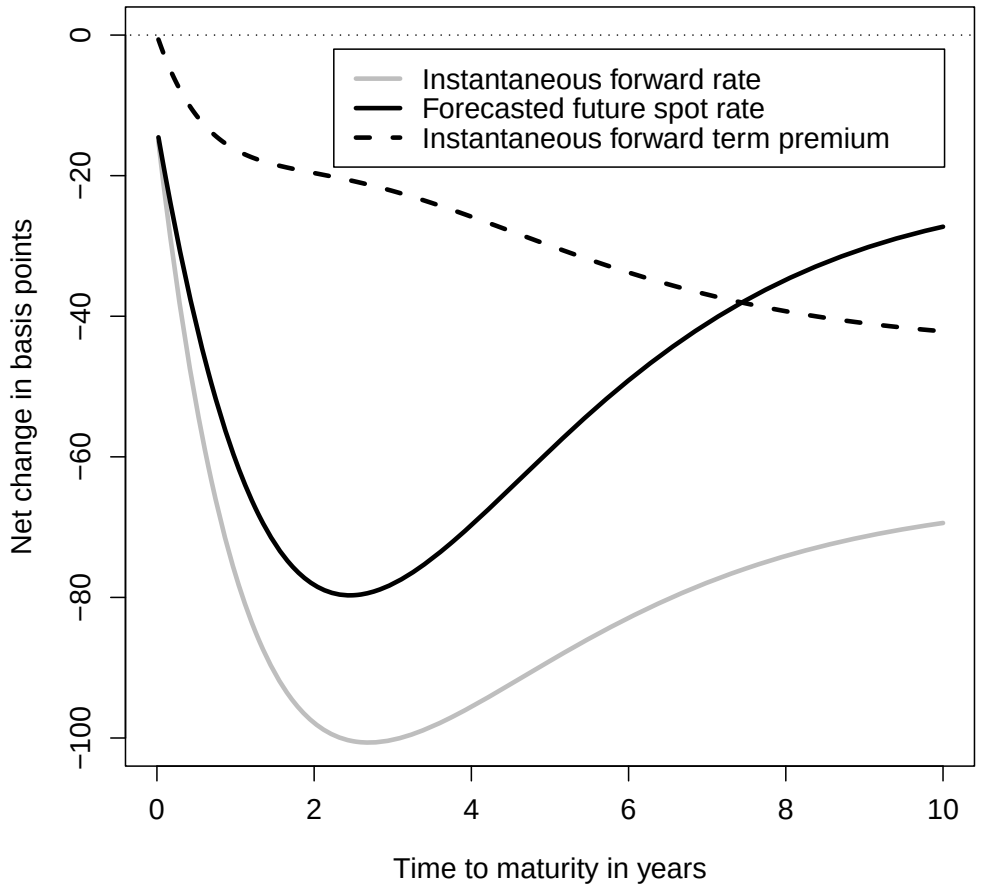
$$y_t^n = n^{-1} \sum_{i=0}^{n-1} E_t r_{t+i} + TP_t^n$$

- **Signaling Channel:** Announcements of asset purchases signal lower future policy rates to market participants, so QE reduces expectations component of Treasury yields.
- **Portfolio Balance Channel:** Changes in supply have price effects because of imperfect substitutability. Reduction in supply lowers term premium component of Treasury yields.

Changes in expected policy path during QE1

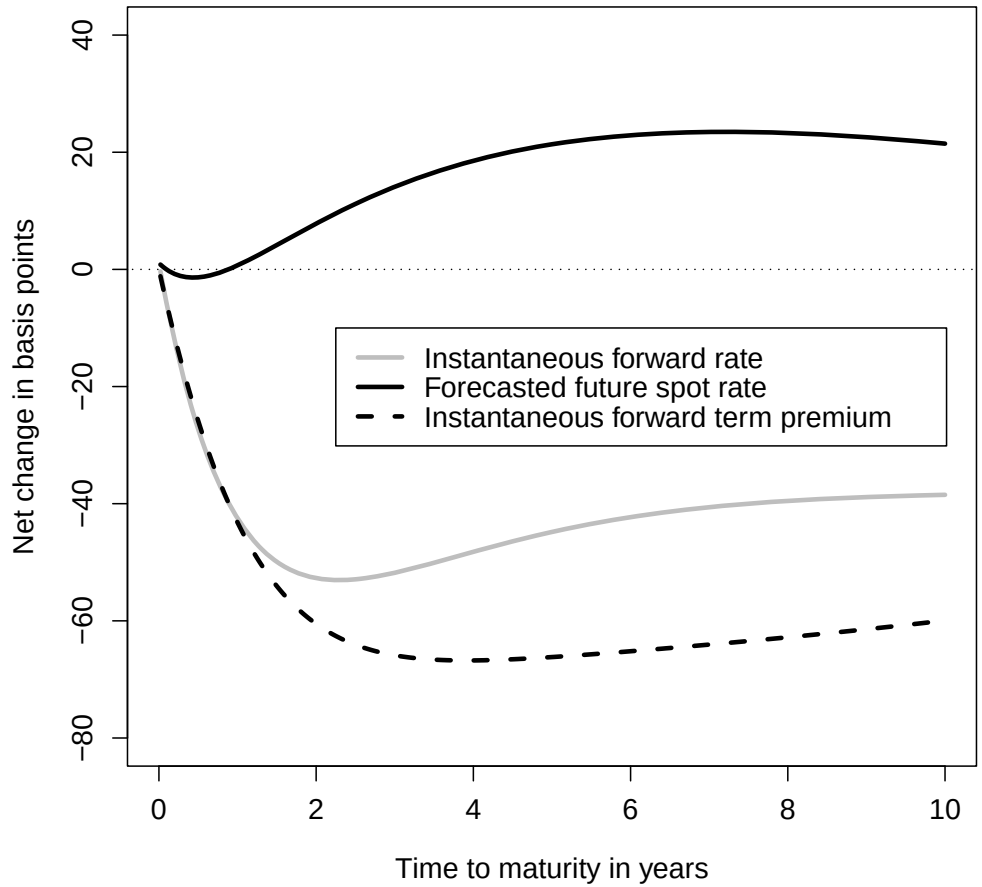


Christensen-Rudebusch (EJ, 2012) Support signaling channel in U.S.



- Policy expectations declined the most at the two- to three-year horizon as one would expect from a signaling effect.

Christensen-Rudebusch (EJ, 2012)
Support portfolio balance channel in U.K.



- Term premiums declined at all horizons, but the most in the three- to ten-year maturity range.

Will QE be part of the new normal?

Event studies suggest QE did effect yield curve

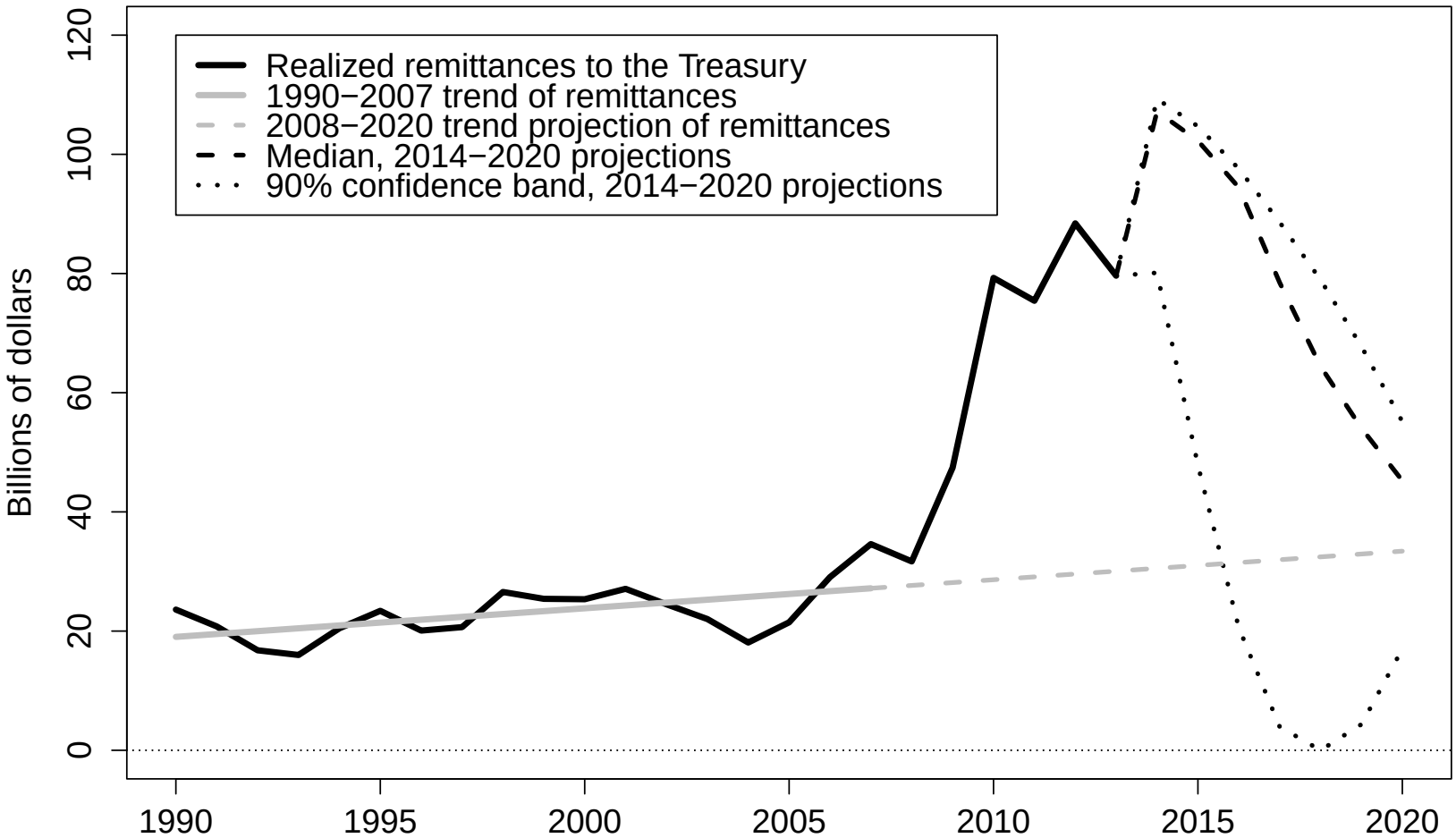
- But did effects persist?
- Did changes in yields pass through to private rates?
- Did changes in asset prices alter aggregate demand?

Potential costs:

- Loss of monetary/fiscal credibility (and pi*)
- Capital losses to central bank
- Financial instability
- Impaired securities market functioning
- Increased difficulty of managing monetary policy

Analysis needed to integrate QE into DTSM

Christensen-Lopez-Rudebusch (2014): Probability-Based Stress Test of Fed



B. Central bank guidance on future policy

Modern central banking stresses importance of guiding expectations about **future** monetary policy actions.

- Monetary policy is process of shaping or managing yield curve.

How can central banks best guide private expectations of future monetary policy actions?

- Old answer: Actions speak louder than words
- New answer: Talk, talk, talk, plus forecasts

Rudebusch, Glenn, and John C. Williams, 2008, "Revealing the Secrets of the Temple: The Value of Publishing Central Bank Interest Rate Projections." in Asset Prices and Monetary Policy.

Narrative forward guidance by Federal Reserve

Aug. 2003 - June 2006

accommodation can be "maintained for a considerable period," or "removed at a pace that is likely to be measured,"

March 2009

"economic conditions are likely to warrant exceptionally low levels of the federal funds rate for an extended period."

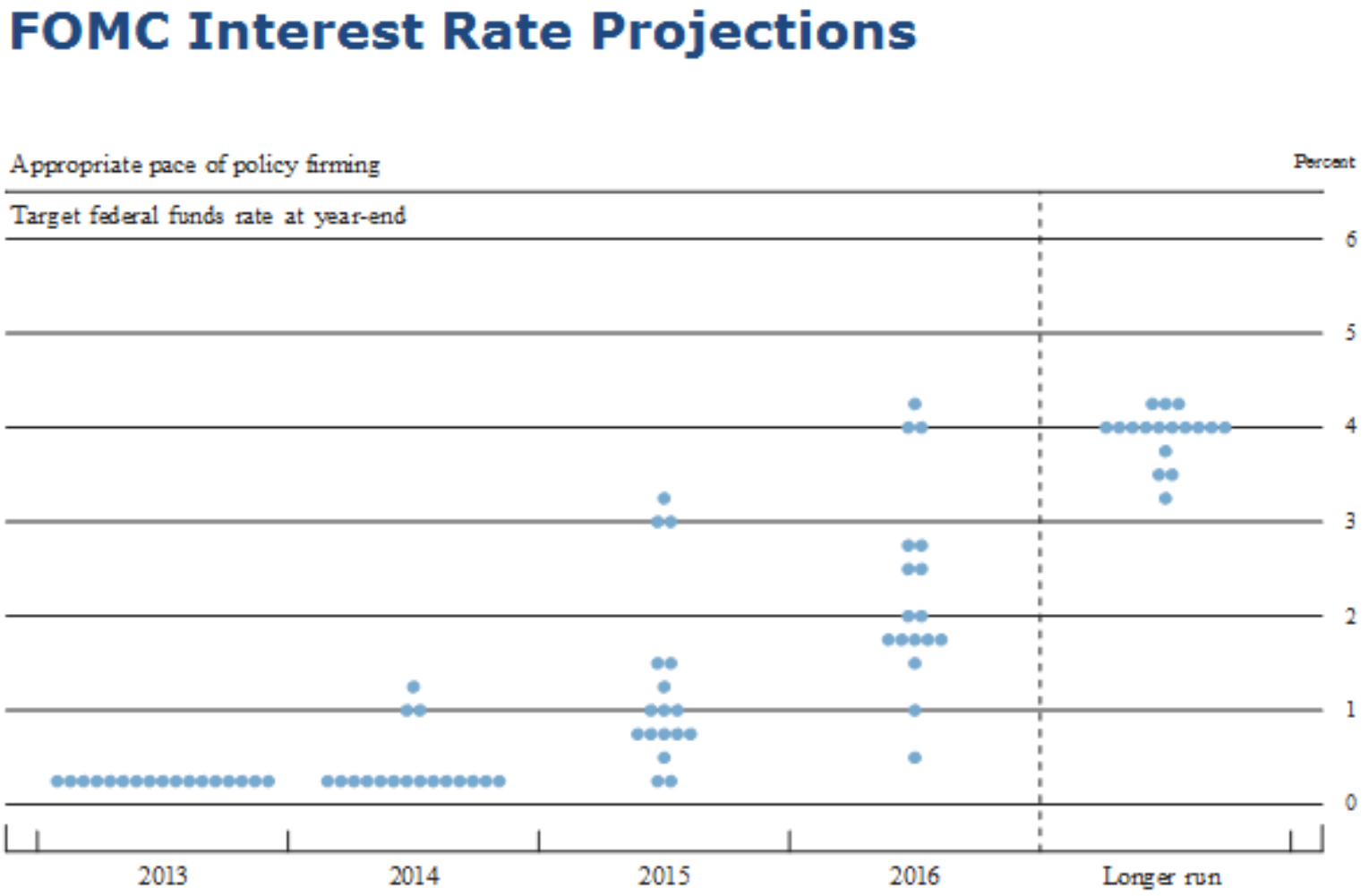
August 2011

"economic conditions...are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013."

December 2012

the "low range for the federal funds rate will be appropriate at least as long as the unemployment rate remains above 6.5%..."

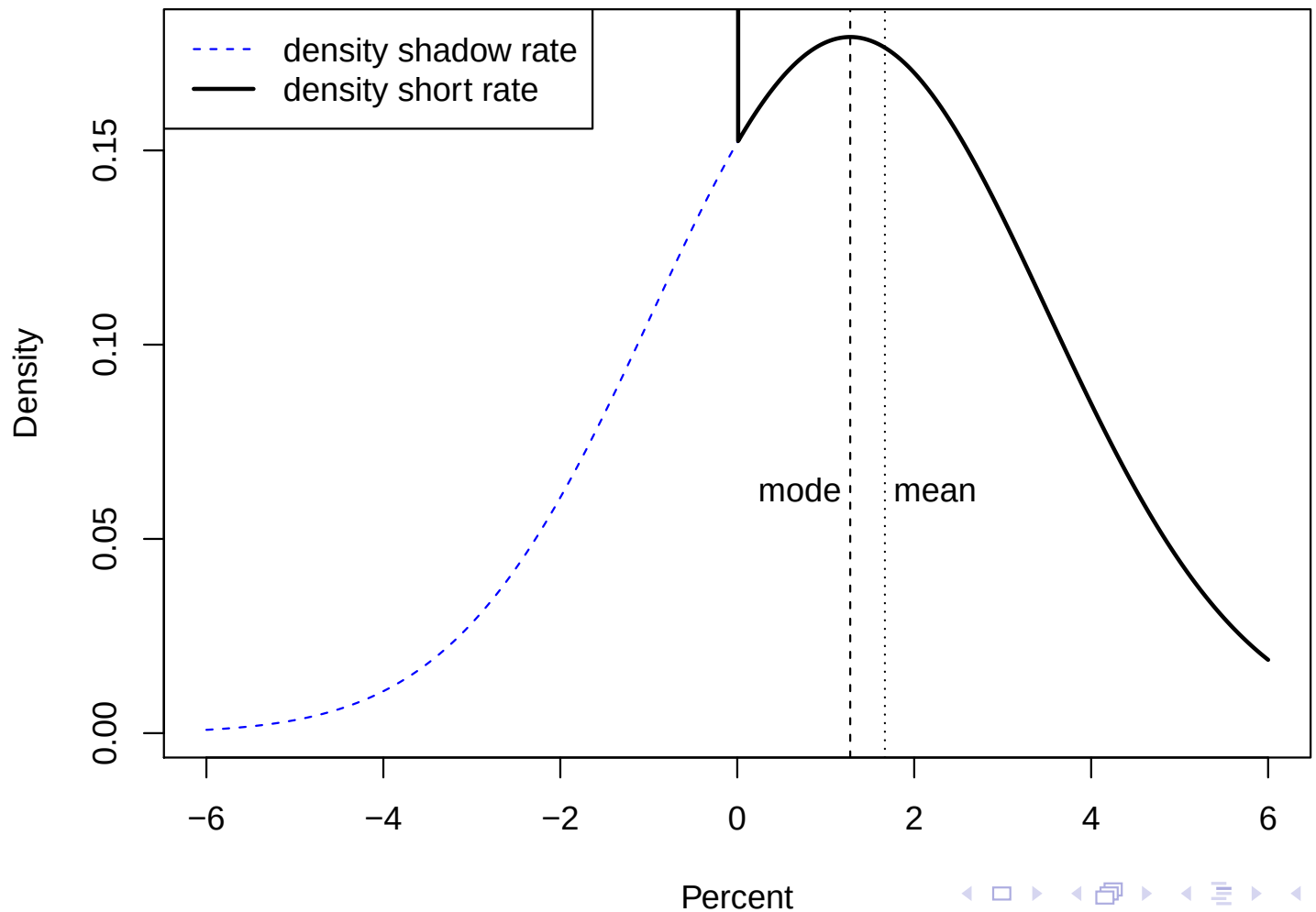
Quantitative forward guidance by Fed



Source: Federal Reserve Board of Governors (2013).

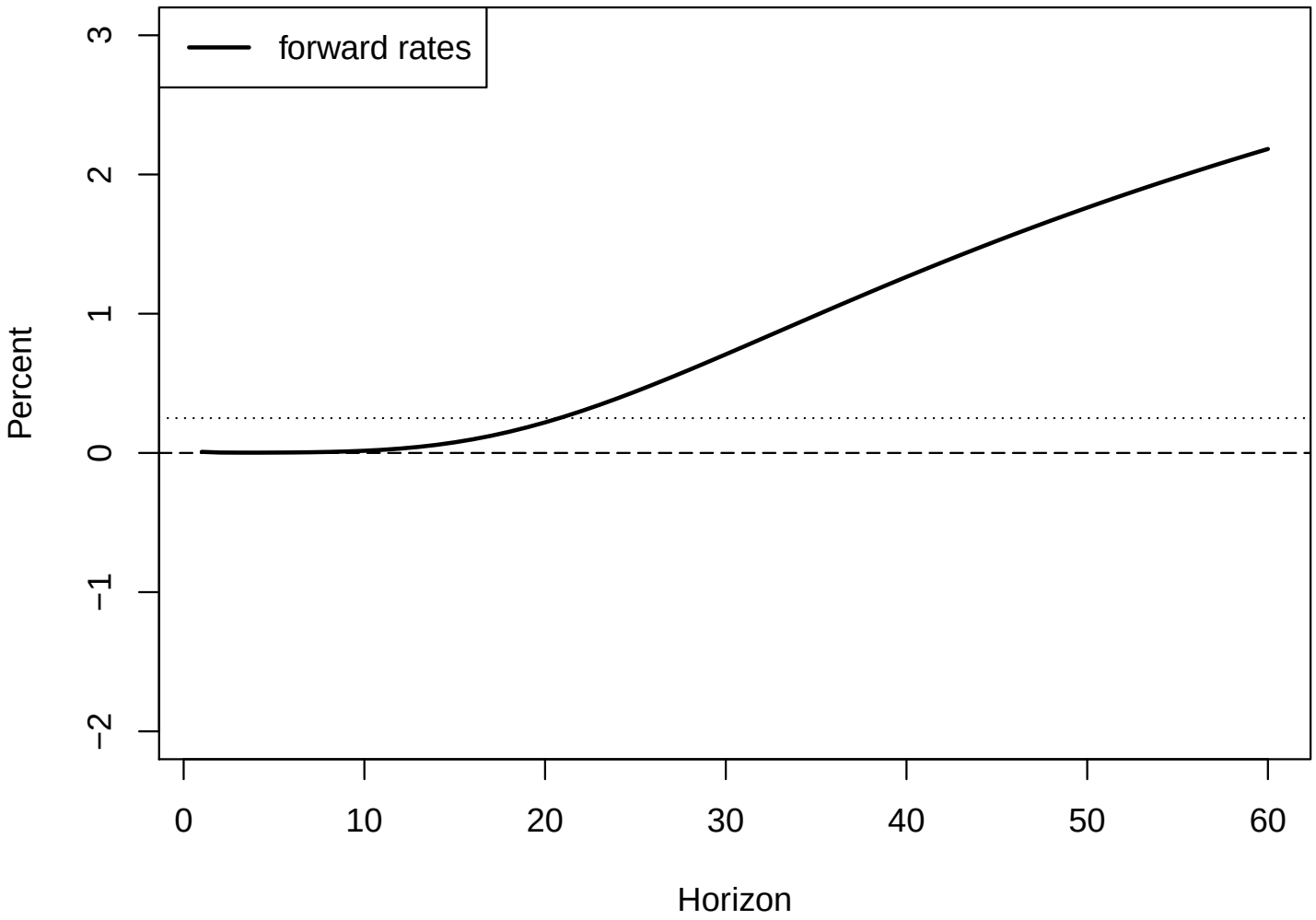
Probability density of future short rate

Distribution under $\mathbb{Q}$-measure, on December 31, 2012, four-year horizon, model MZ(2)



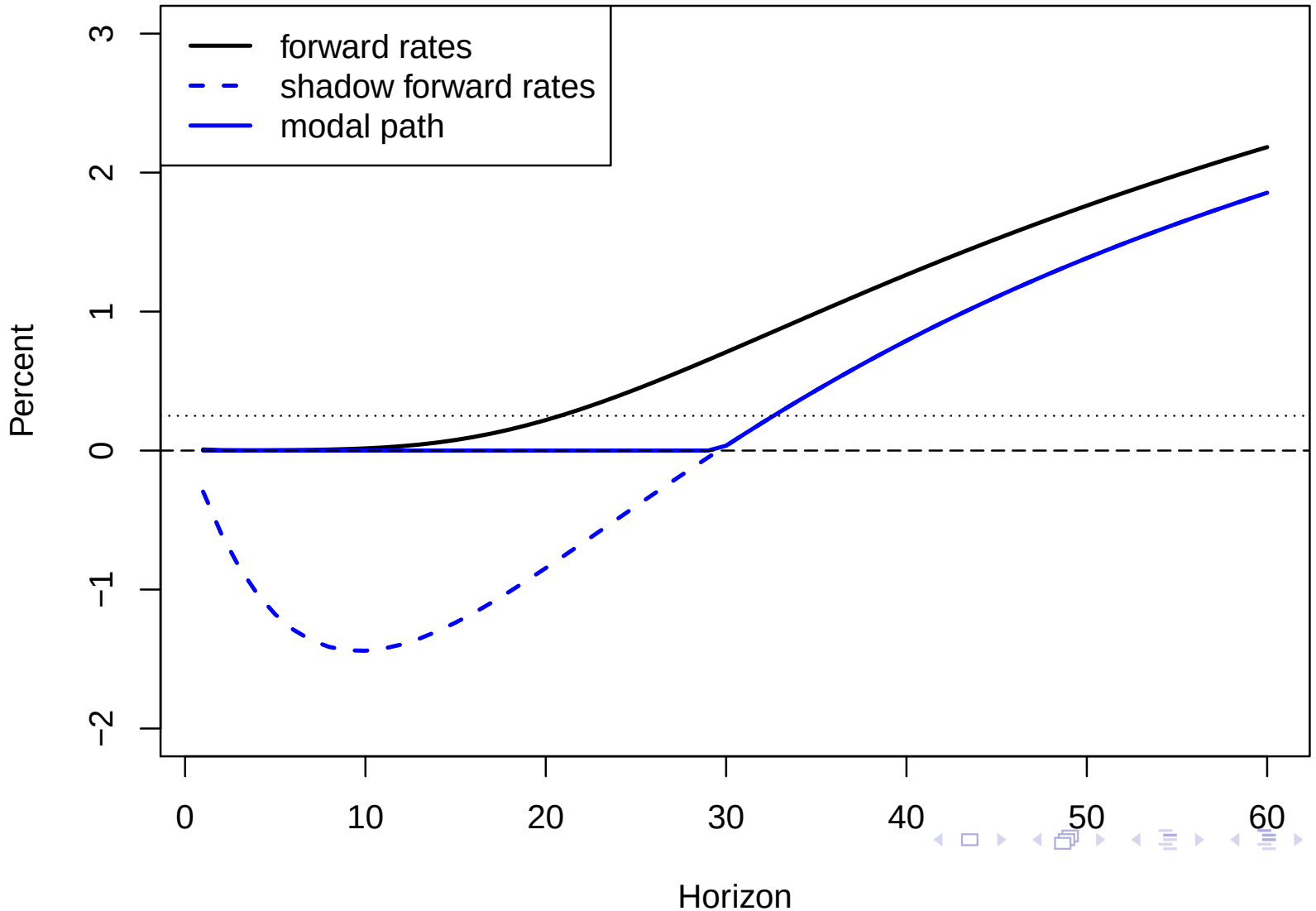
Liftoff estimate based on forward rates

Forward rates ($E_t^{\mathbb{Q}} r_{t+h}$) on December 31, 2012, for model MZ(2)

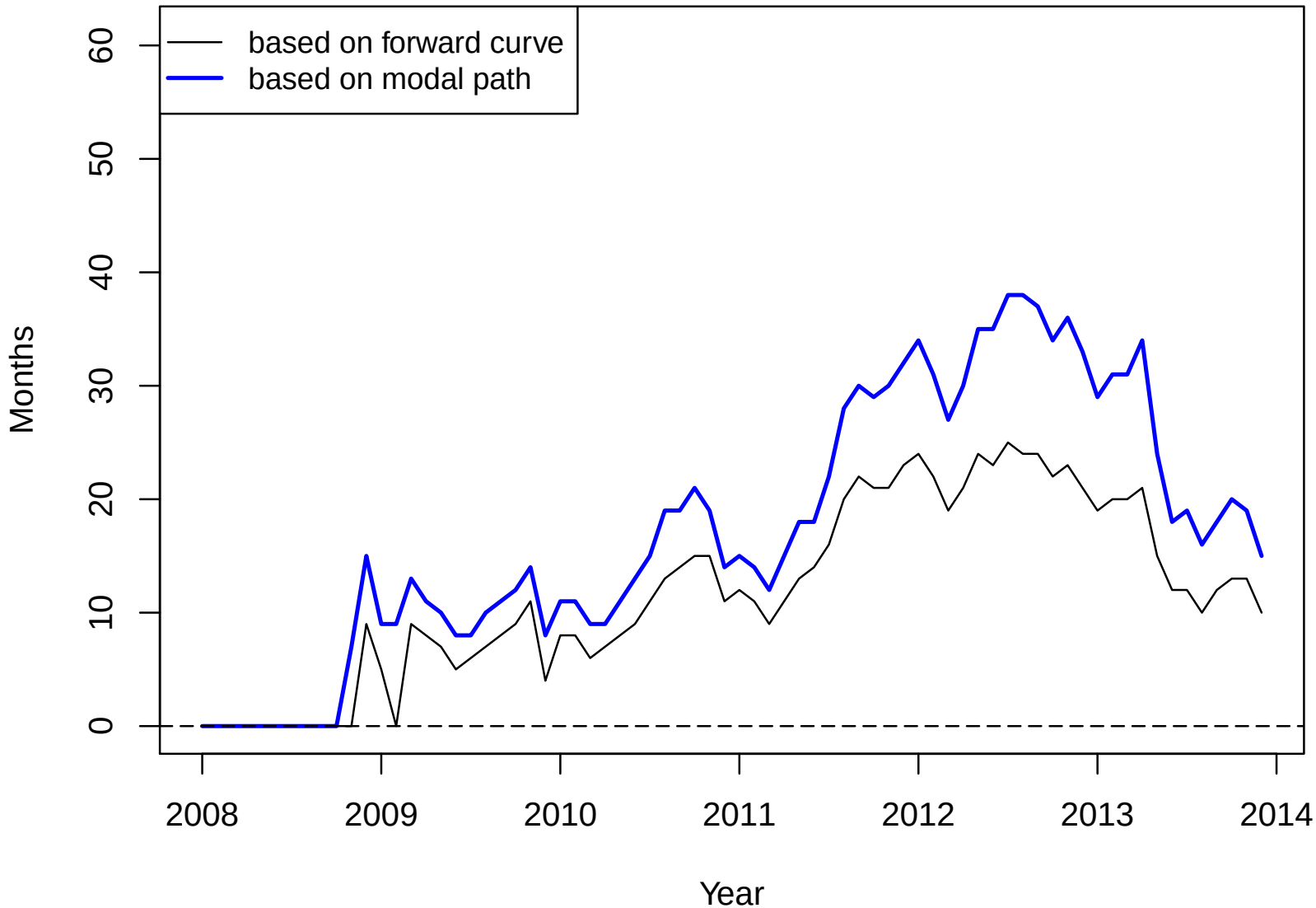


Liftoff estimate based on modal path

Bauer and Rudebusch (2013): Forward rates ($E_t^{\mathbb{Q}} r_{t+h}$), shadow forward rates ($E_t^{\mathbb{Q}} s_{t+h}$), and modal path, December 31, 2012



Estimated horizon (in months) until policy liftoff



Assessing effectiveness of forward guidance

Merits of clear forward policy guidance

- Greater policy effectiveness through greater transparency

Potential pitfalls of forward policy guidance

- Misinterpretation of conditionality of policy guidance
  "... tendency for the public to infer more of a commitment to following the implied path than would be appropriate for good policy." Kohn (2008)
- Incorrect inference about the meaning of the policy guidance (Rudebusch and Williams, 2008)
- Reduction in incentives for the collection of private-sector information. (Morris and Shin)

C. Policy actions to avoid financial crises

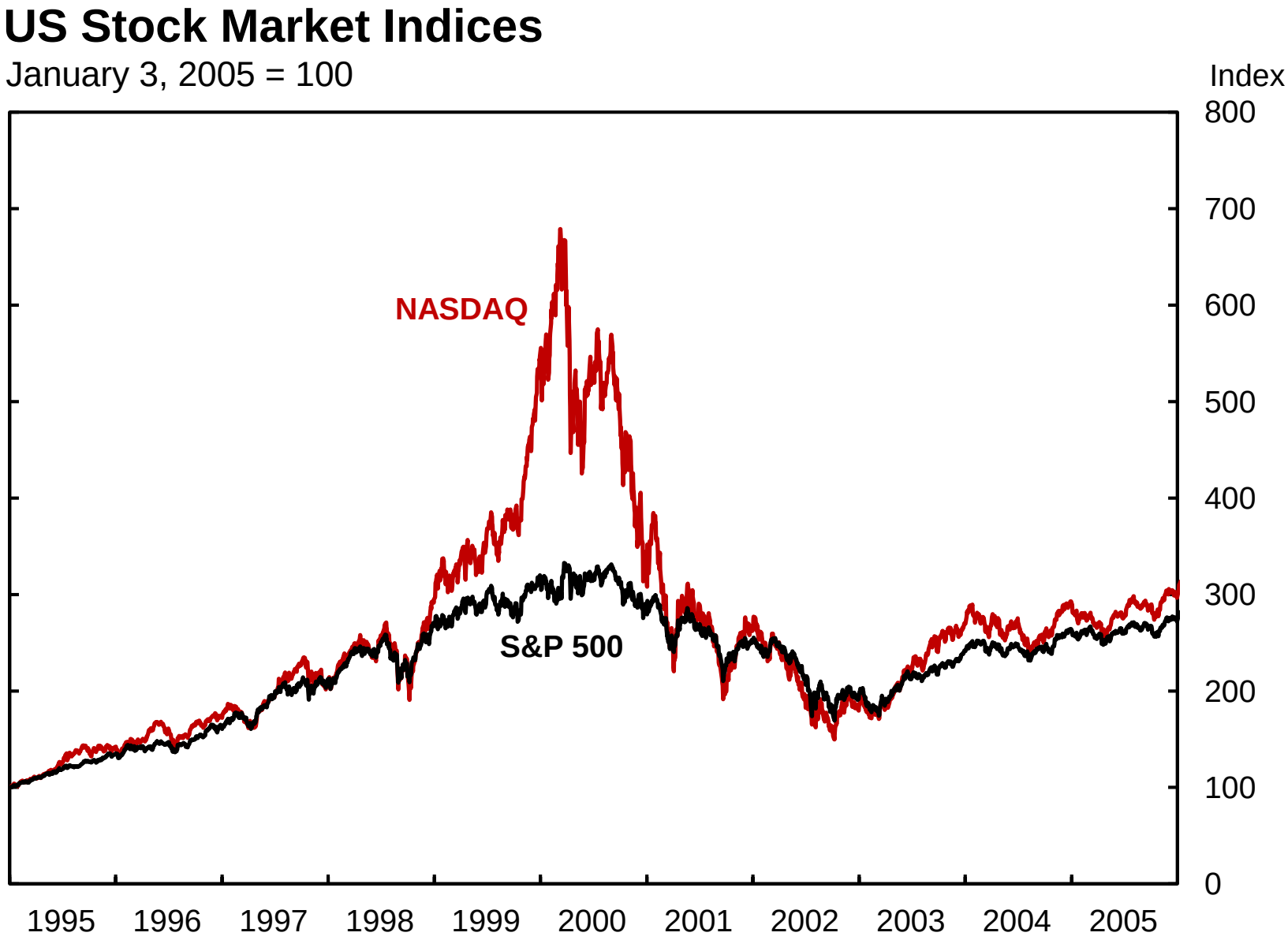
Should monetary policy take a more active role and try to offset financial imbalances (e.g. deflate an asset price bubble)?

To do so, three questions must be addressed:

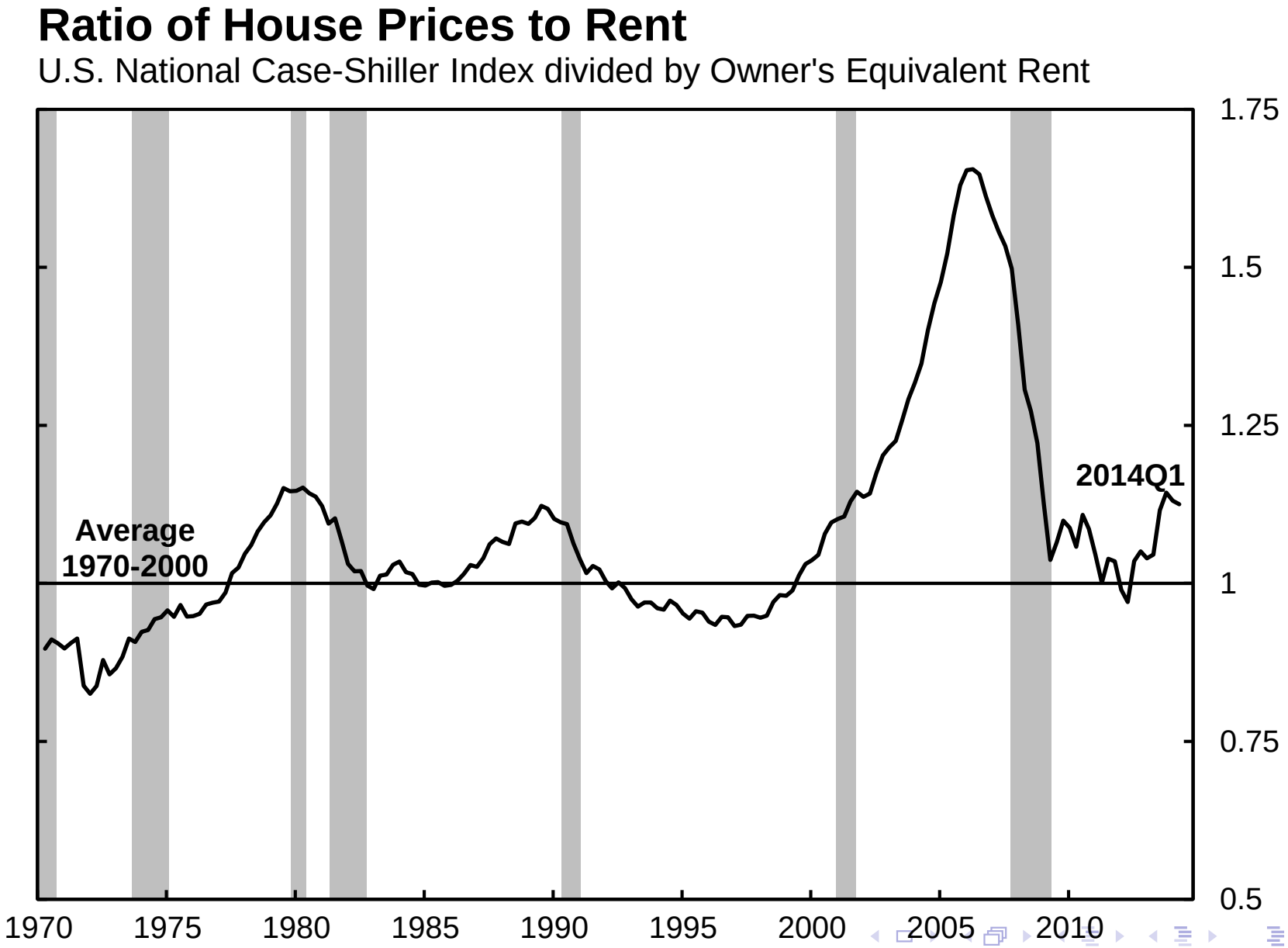
- Can an asset price bubble be identified?
- Will the bubble cause significant macro problems?
- Is monetary policy a good tool to deflate bubble? (Alternative would be macroprudential policy)

see Rudebusch, Glenn D., 2005, "Monetary Policy and Asset Price Bubbles," FRBSF Economic Letter.

Equity prices in 1999-2000

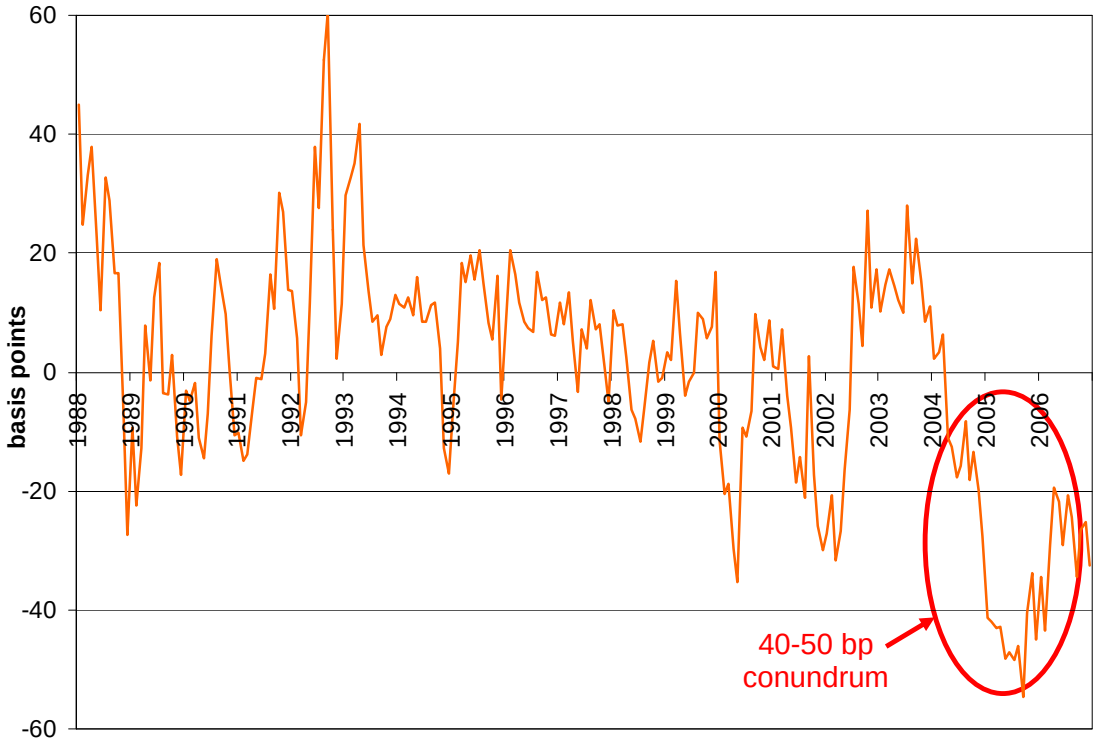


House price bubble?



Was there a 2004-06 bond yield "conundrum"?

RW Model Residuals for 10-Year Yield



Rudebusch, Glenn D., Eric Swanson, and Tao Wu, 2006, "The Bond Yield 'Conundrum' from a Macro-Finance Perspective," Monetary and Economic Studies 24, 83-128.

Lessons for everyone at the ZLB

Probability of ZLB seems higher than many judged

- This has implications for modeling the yield curve
- Possible implications for inflation target

Central Bank affects whole yield curve

- Recommends macro-finance term structure approach
- Should unconventional policies become conventional?
- Financial stability may be emphasized as goal for policy

Credit risk for sovereign debt.

- Government fiscal issues effect yield curve
- "flight to quality" adjustments as well