THE TREASURY REAL YIELD CURVE AND BREAKEVEN INFLATION

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Introduction

- This presentation introduces the Treasury Real Coupon-Issue (TRC) Yield Curve. The TRC yield curve is derived from Treasury Inflation-Protected Securities, which are called TIPS.
- The TRC yield curve is a companion to the Treasury Nominal Coupon-Issue (TNC) Yield Curve, and uses the same methodology with a few variations. This methodology is also used for the High Quality Market (HQM) Corporate Bond Yield Curve. The TNC and TRC curves are combined to derive breakeven inflation rates.
- This presentation assumes basic familiarity with the TNC yield curve; see the last slide for references for the TNC and HQM curves.

TRC Yield Curve Summary

- The TRC yield curve provides information including yields about Treasury real coupon issues. Real coupon issues are called Treasury Inflation-Protected Securities, or TIPS, and are made up of both real notes and real bonds.
- TIPS are analogous to Treasury nominal coupon issues in that they pay semiannual fixed coupons and the principal at maturity. The difference is that the coupon and principal payments from TIPS are in real terms.
- Payments in real terms are converted to dollars by adjusting the payments up or down by changes in the (not seasonally adjusted) Consumer Price Index for All Urban Consumers (CPI-U). (Except that when the CPI-U falls, the principal is not adjusted downward.)

TRC Yield Curve Summary, continued

- The nominal TNC yield curve estimates separately the yields of on-the-run issues (securities most recently issued of each maturity) and older off-the-run issues. In contrast, TIPS appear to have minimal on-the-run effects, so no distinction is made in the real TRC yield curve between on-the-run and off-the-run.
- Similar to the TNC yield curve, the TRC yield curve projects real yields beyond 30 years maturity out through 100 years maturity. The methodology ensures that the projections are consistent with real yields before 30 years maturity and with long-term investment returns available in the market.

The Real Par Yield Curve

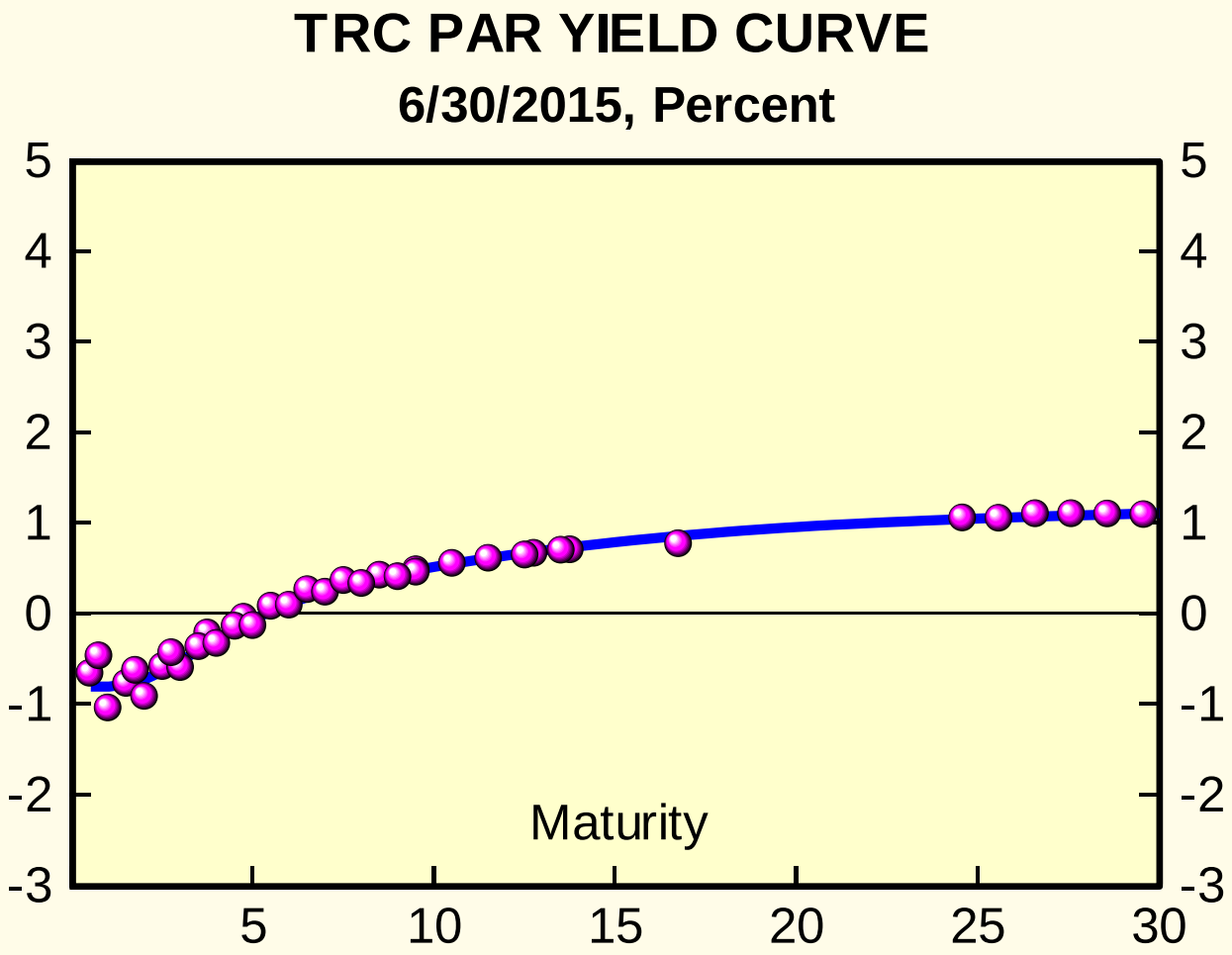
- Analogous to the TNC yield curve, the real TRC yield curve provides the Treasury par yield curve and spot yield curve in real terms.
- The real par yield curve shows for each maturity the real yield on a TIPS of that maturity that is selling at par (price excluding accrued interest equals 100).
- Analogous to the TNC curve, the TRC curve generates real par yields for each maturity at half-year intervals for maturities of ½ year up through 100 years, for a total of 200 yields. Following market convention, yields are semiannually compounded.

The Real Spot Yield Curve

- The TRC yield curve also provides the Treasury real spot yield curve, which shows for each maturity the yield on a Treasury security with a single real payment at that maturity. Such a security can be called a real zero coupon Treasury bond.
- The real spot rates are inferred from the TRC par yield curve.
- TRC real spot rates can be interpreted as risk-free real social rates of time preference. This is analogous to the interpretation of off-the-run TNC spot rates as nominal social rates of time preference with no default risk but with uncertain inflation.

Yield Curves for End of June

- The next two charts show the TRC par and spot yield curves for June 30, 2015, the last business day in June. There are 38 TIPS in the dataset for this day, compared with 280 Treasury nominal securities in the TNC curve.
- The par yield curve in slide 8 includes a scatter diagram of individual TIPS yields, and shows that the yields are close to the curve on this day. The par curve reaches 1.12 percent near 30 years maturity and has no hump.
- The yields are negative at low maturities. This occurs when the price of the TIPS is greater than the sum of real coupon and principal payments. Of course, the nominal return on the TIPS can still be positive once real payments are converted to dollars.

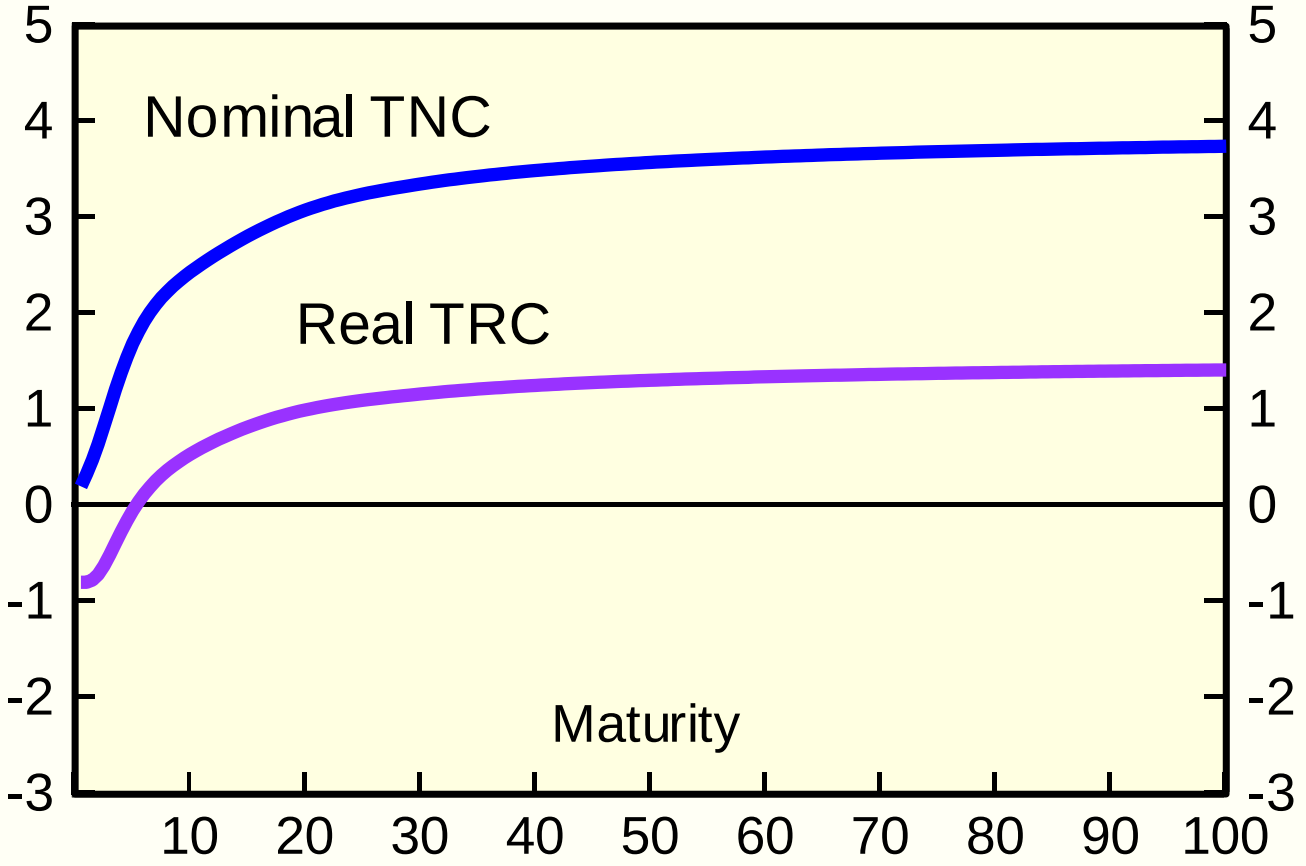

TRC PAR YIELD CURVE
6/30/2015, Percent
5
4
3
2
1
0
-1
-2
-3
Maturity
5
10
15
20
25
30

Yield Curves for End of June, continued

- The real spot yield curve in slide 10 is derived from the real par curve and is projected out to 100 years maturity. The slide also contains the nominal TNC spot yield curve, which is above the real curve. Both curves are very smooth on this day.
- The real spot rate rises to 1.17 percent at 30 years maturity, and continues to rise throughout the projection range beyond 30 years maturity, reaching 1.42 percent at 100 years maturity.

TNC AND TRC SPOT YIELD CURVES

6/30/2015, Percent



Breakeven Inflation

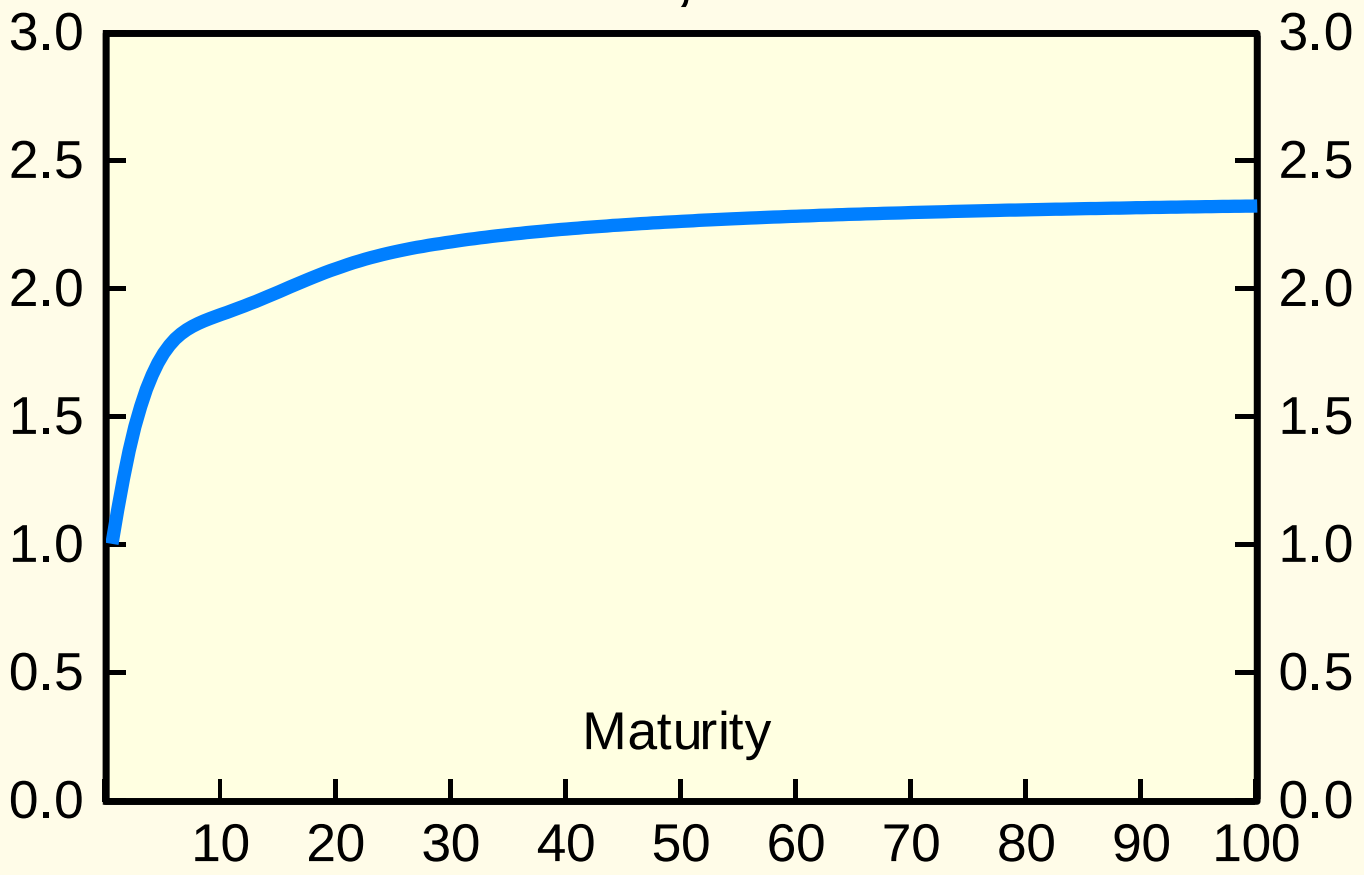
- The nominal TNC and real TRC spot yield curves can be combined to derive the Treasury Breakeven Inflation (TBI) Curve, which provides breakeven inflation rates.
- The breakeven inflation rate (sometimes called inflation compensation) for any maturity is the inflation rate that equates nominal and real Treasury spot rates at that maturity in dollar terms.
- Therefore, the breakeven inflation curve shows possible future inflation rates that, if realized, would equate the nominal and real spot yield curves in dollars.
- As opposed to yields, breakeven inflation rates are calculated as annual rates, which is the usual convention for inflation data.

Breakeven Inflation, continued

- Breakeven inflation rates are often used as measures of inflationary expectations.
- However, breakeven rates may be biased as expectations indicators. The most important possible bias stems from the fact that nominal yields embody a risk factor stemming from the uncertainty of future inflation that real yields do not have. This factor acts as a term premium, pushing up breakeven rates above expected inflation.
- The chart in slide 13 shows the breakeven inflation curve calculated from the spot curves in the previous chart, projected out through 100 years. The breakeven inflation rate at 30 years maturity is 2.19 percent.

BREAKEVEN INFLATION RATE CURVE

6/30/2015, Percent



TRC Yield Curve Methodology

- The methodology for the TRC yield curve is the same as the methodology for the TNC yield curve with some variations.
- The following slides summarize this methodology, and point out differences from the TNC curve.
- Further information on the TNC methodology is in the references at the back.

TRC Methodology: Regression Variable

- As in the TNC curve, the TRC yield curve contains the regression variable to measure the hump in yields that is sometimes seen around 20 years maturity.
- However, in contrast to the TNC curve, the TRC yield curve makes no distinctions between on-the-run and off-the-run securities. This is because no noticeable on-the-run effects appear in the TIPS market. Moreover, the number of TIPS is so small that it would not be possible to sort out statistically any on-the-run effects.
- Therefore, the TNC regression variables for on-the-run and first off-the-run are omitted from the TRC yield curve.

TRC Methodology: Projections

- The TRC methodology projects real par and spot yields beyond 30 years maturity out through100 years maturity.
- The projection methodology is the same as the TNC methodology cast in real terms, and ensures that the projections are consistent with real yields before 30 years maturity and with long-term real returns for maturities over 30 years.

TRC Methodology: Established Market Views

- The TRC yield curve methodology is derived from the same basic hypotheses about bond markets that underlie the TNC yield curve, translated into real terms.
- As summarized in the next slides, these hypotheses imply forward rate functions over selected maturity ranges that provide the functional form for estimating the TRC curve.

The Real Forward Rate

- Analogous to the TNC yield curve, the concept of the real forward rate is used for setting up the functional form for estimating the TRC yield curve.
- The definition of the real forward rate is the same as the nominal forward rate in real terms: for each maturity, consider entering into a contract to invest some money at the time of that maturity for a small amount of time beyond that maturity. The real forward rate at that maturity is the real interest rate on this investment.

Maturity Ranges

- Furthermore, similar to nominal securities, trading in TIPS tends to divide into maturity ranges, such that the trading activity in each range on average reflects similar purposes, similar views of risk, and similar expectations about securities in that range.
- Because market views can be considered similar for TIPS in the same range, the real forward rates in each maturity range can be assumed to be related to each other.
- Therefore, the TRC methodology models the real forward rates in each maturity range as a cubic equation, and joins the equations together smoothly across ranges as a cubic spline.

Maturity Ranges, continued

- The current TRC methodology uses the same five maturity ranges as the TNC yield curve, delineated by the maturity points 0, 1.5, 3, 7, 15, and 30 years maturity.
- However, earlier in the sample period there were insufficient numbers of TIPS at low maturities, requiring that the earlier ranges be combined. All five ranges were used since mid 2008.
- The choice of fixed maturity ranges ensures the stability of the TRC yield curve estimates over time, even with small samples of TIPS.

The Long-Term Real Forward Rate

- Analogous to the TNC yield curve, the long-term real forward rate beyond 30 years maturity through 100 years maturity is set to a constant, which is taken to be the average real forward rate in the 15- to 30-year maturity range.
- This approach enables real yields and breakeven inflation rates to be projected beyond 30 years maturity even when there are few long-term TIPS in the market. The long-term inflation projections provide a sense of market expectations for future inflation.

Estimation

- The real forward rates in the maturity ranges are estimated by least squares, and the real par and spot yields are derived from the estimated forward rate curve. The regression term is simultaneously estimated with the forward rates.
- Before estimation, the TIPS data are weighted by the (square root of the) inverse of duration.
- However, in contrast to the TNC yield curve, the TRC estimates of the real forward rates are allowed to be negative, thereby giving negative yields.
- As in the TNC curve, the TRC methodology is statistically straightforward and is well-conditioned and stable.

Data

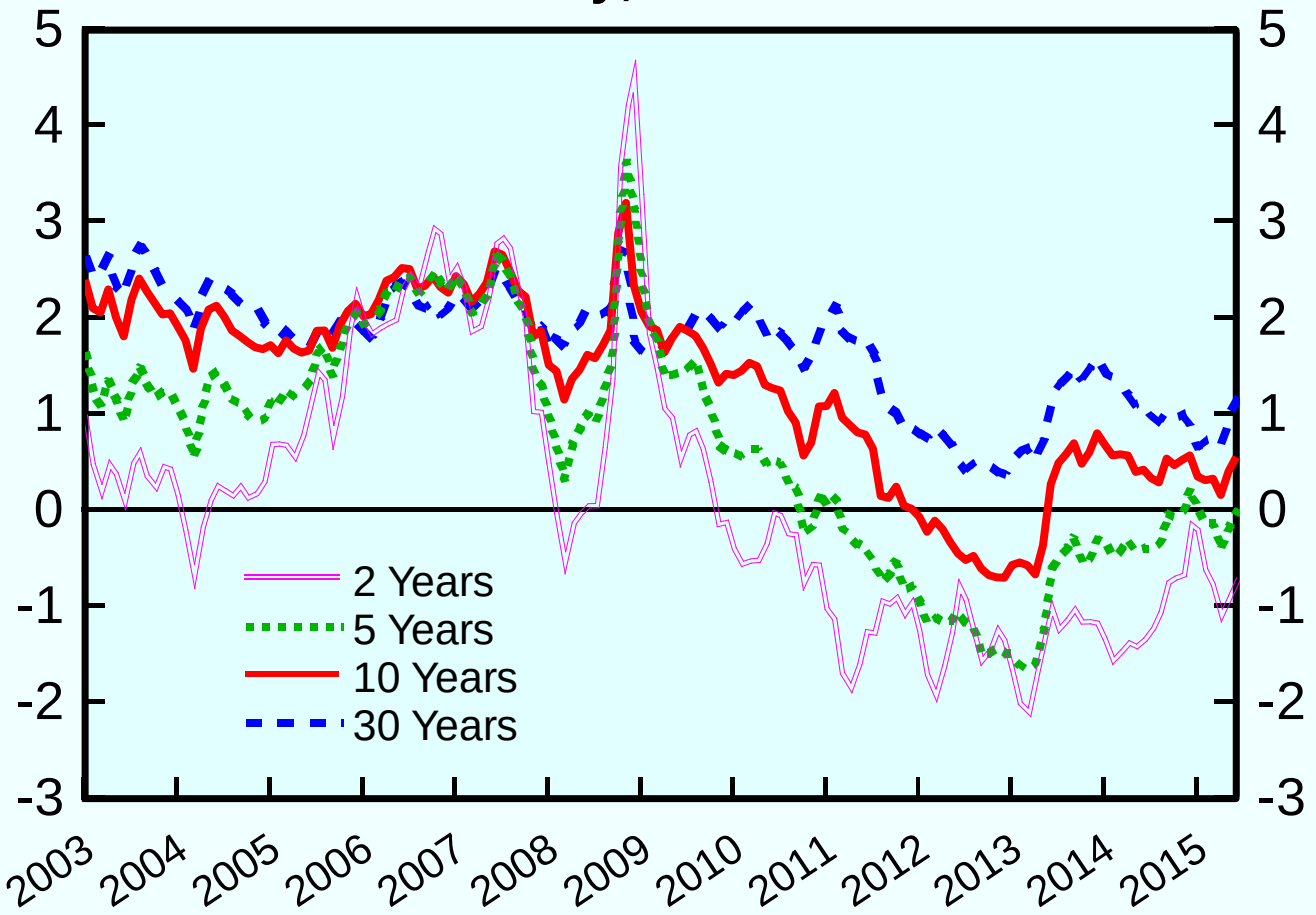
- The TRC yield curve represents all extant TIPS on each business day.
- Therefore, each day's dataset includes all TIPS existing on that day, with the exception that TIPS with fewer than two coupon payments remaining are excluded.
- The daily TIPS pricing data are bid prices.
- Because TIPS do not have call features, no provision must be made for call options.
- The sample period in this presentation covers the period January 2003 through June 2015, for a total of 3,121 business days and 150 months. The TNC yield curve also starts in 2003.

Real Par Yields over Time

- The chart in slide 25 shows TRC real par yields from 2003 forward at 2 years, 5 years, 10 years, and 30 years maturities.
- Real yields generally fell over this period, and recently yields were frequently negative at lower maturities.
- Yields spiked in the financial crisis at the end of 2008, reflecting to some extent lower liquidity of TIPS relative to nominal Treasuries. Also, at that time there may have been the expectation of short-term deflation, which would have made short-term nominal Treasuries more desirable.

TRC PAR YIELDS AT SELECTED MATURITIES

Monthly, Percent



Breakeven Inflation over Time

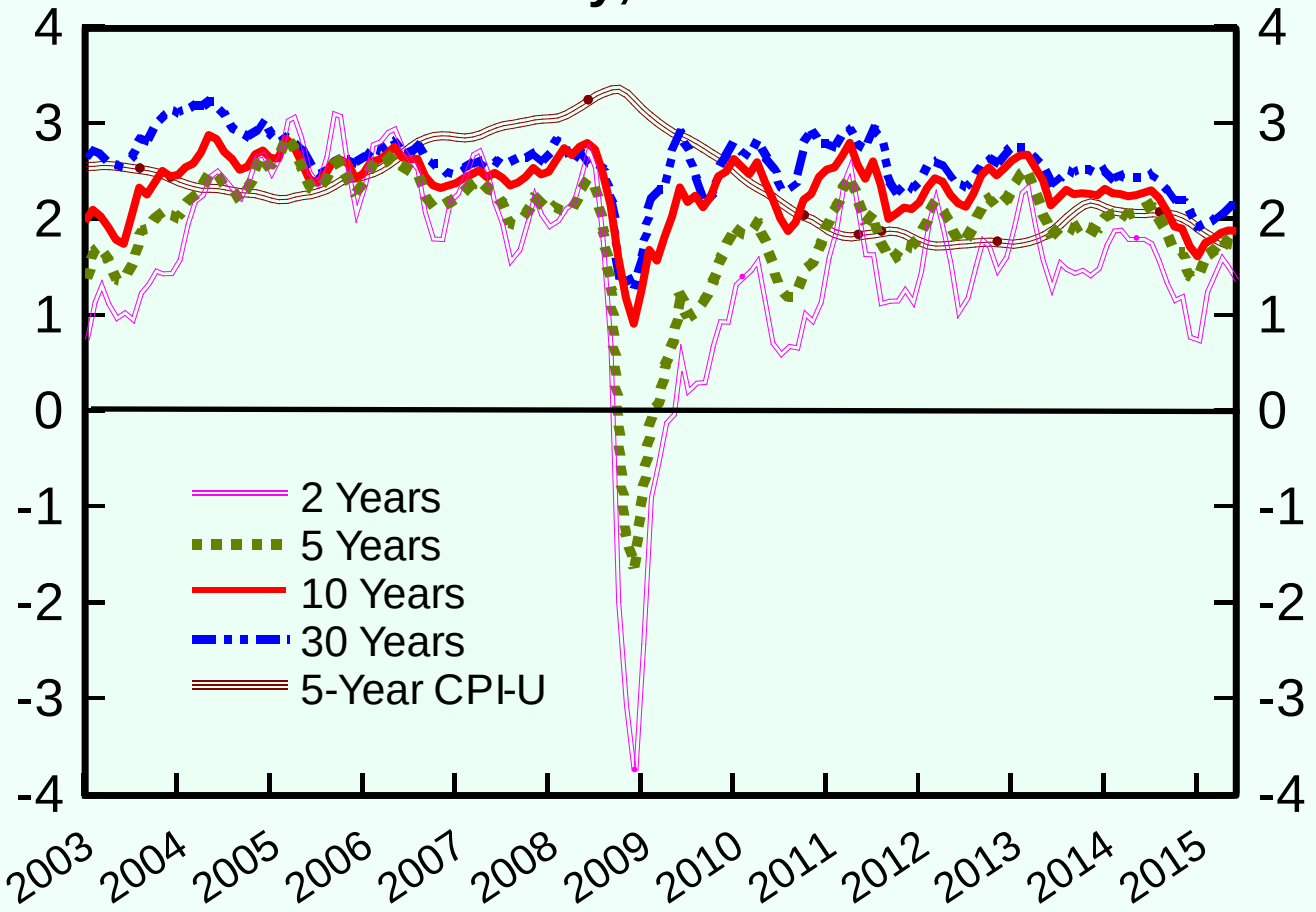
- The following chart in slide 28 shows TBI breakeven inflation at selected maturities. The chart includes the 5-year CPI-U inflation rate for comparison, smoothed by logarithmic trend line least squares.
- The chart shows that 5-year inflation started around 2-1/2 percent or above early in the period and has decelerated to around 2 percent recently.
- The lagged breakeven rates as forecasts are reasonably close to actual inflation, even picking up the recent deceleration. This suggests that the breakeven rates were not significantly biased upward and did not contain much of a term premium.

Breakeven Inflation over Time, continued

- However, the term premium may be larger in a period when inflation is not so stable and harder to forecast.
- Also, the breakeven rates in the chart are somewhat higher at higher maturities: in the recovery since mid 2009, the average difference between the 10-year and 5-year rates is 41 basis points, and the average difference between the 30-year and 10-year rates is 23 basis points. This may indicate that inflation expectations rose with maturity, but these differences may also reflect some term premium.
- The chart in slide 28 shows sharp declines in breakeven inflation in the crisis at the end of 2008, corresponding to the spikes in real yields seen in the previous chart.

BREAKEVEN INFLATION RATES AT SELECTED MATURITIES

Monthly, Percent

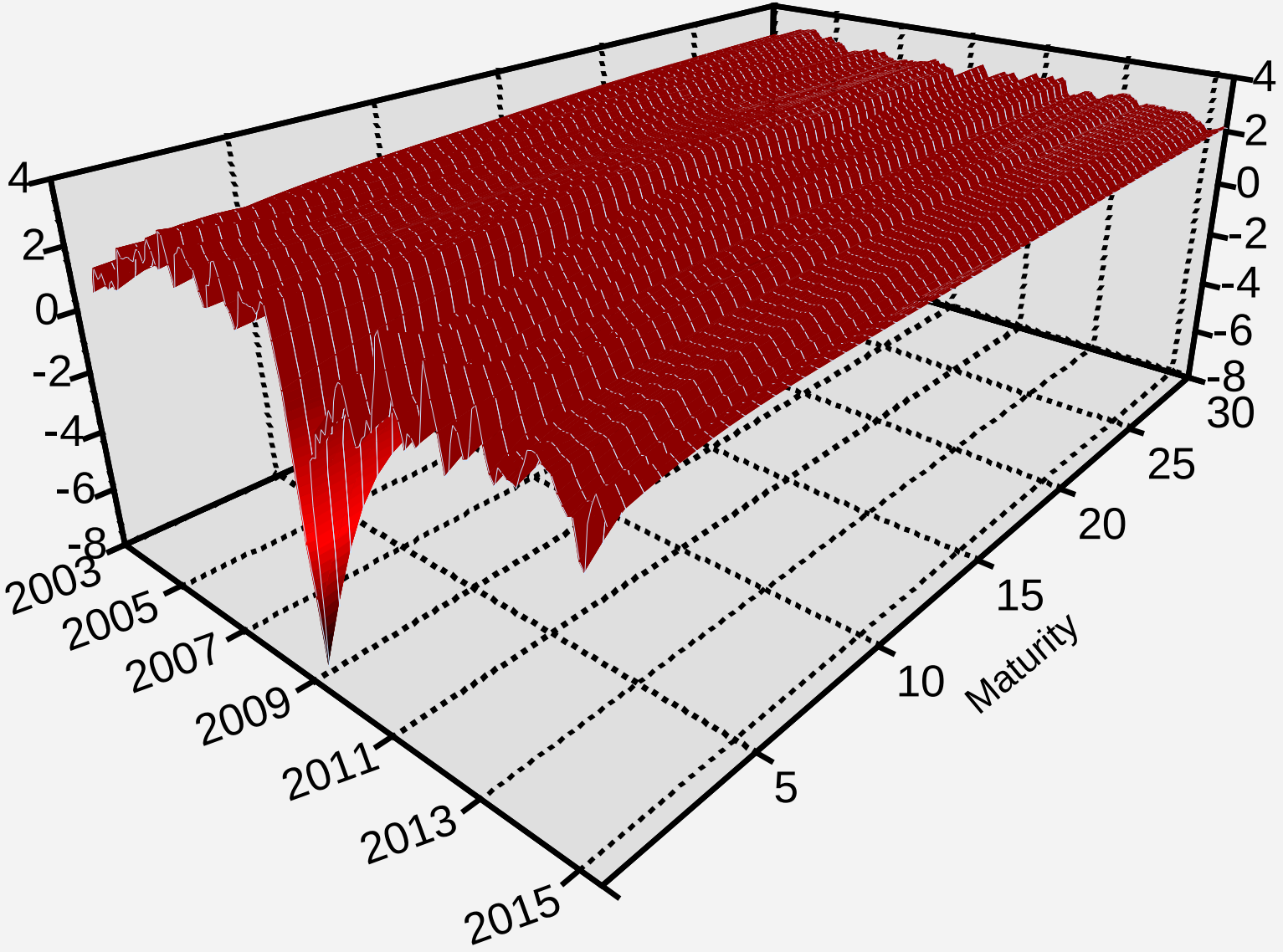


Breakeven Inflation over Time, continued

- The chart in slide 30 shows the monthly TBI breakeven inflation over the entire period.
- The chart indicates that breakeven inflation was relatively flat and stable over this period and across all maturities.
- The chart depicts the sharp declines in breakeven inflation in the crisis at the end of 2008.

BREAKEVEN INFLATION RATES

Monthly, Percent

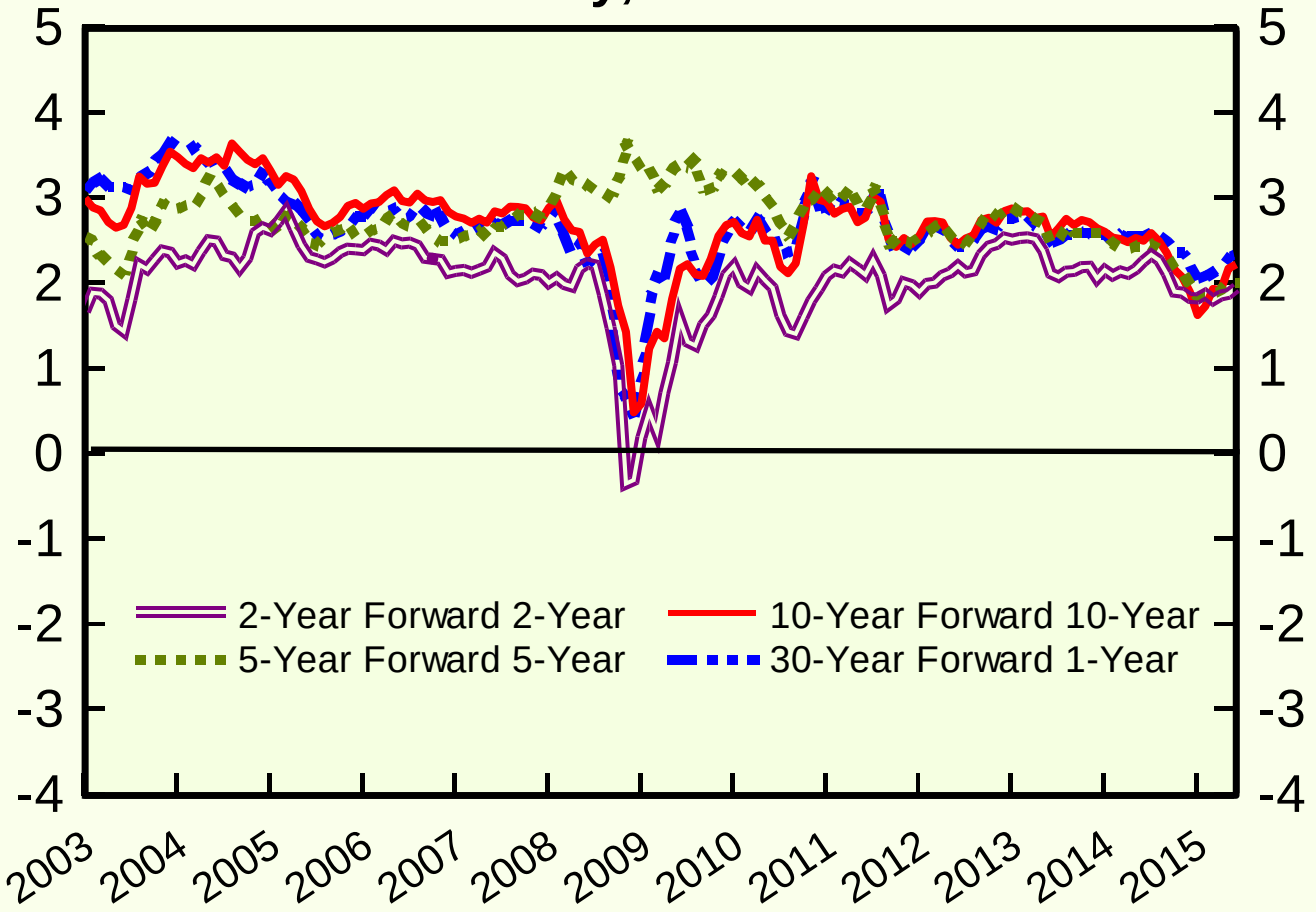


Forward Breakeven Inflation

- The chart in slide 32 shows selected forward breakeven inflation rates.
- Forward breakeven inflation is the inflation rate over a given horizon at a future time.
- The series included in the chart are common measures of future inflation expectations.
- All the breakeven rates converge around 2 percent at the end, similar to the breakeven rates on slide 28. This may suggest that inflation is expected to remain near 2 percent for some time.

SELECTED FORWARD BREAKEVEN INFLATION RATES

Monthly, Percent

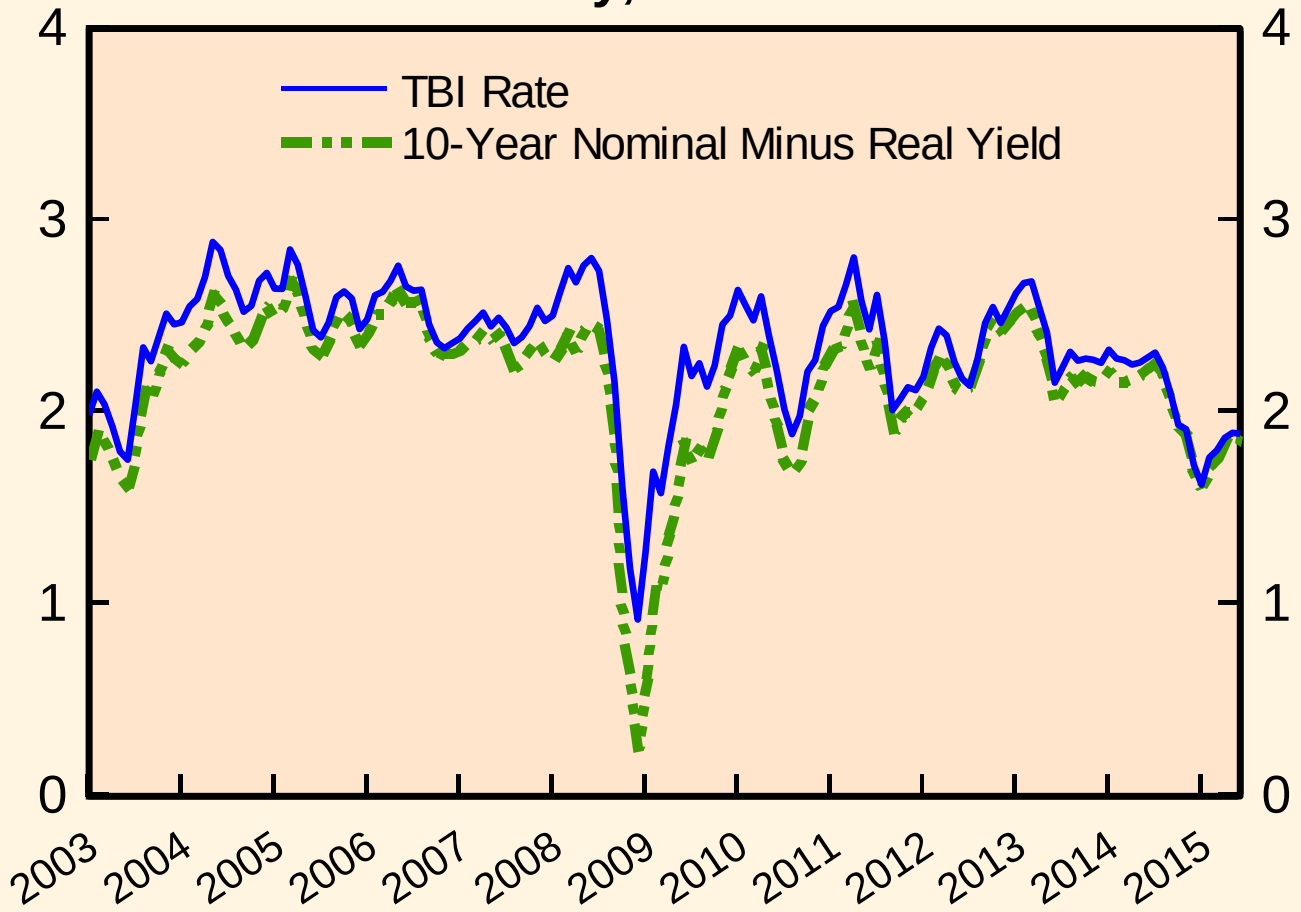


10-Year Breakeven Inflation

- The chart in slide 34 plots two measures of breakeven inflation at 10 years maturity.
- The first measure is the TBI rate already shown. The second measure is the 10-year Treasury constant maturity nominal yield minus real yield. The second measure is often used for the 10-year breakeven rate.
- The second measure is less than the TBI rate in each month. The average difference between the two is 18 basis points throughout the period and 14 basis points since mid 2009.

10-YEAR BREAKEVEN INFLATION

Monthly, Percent

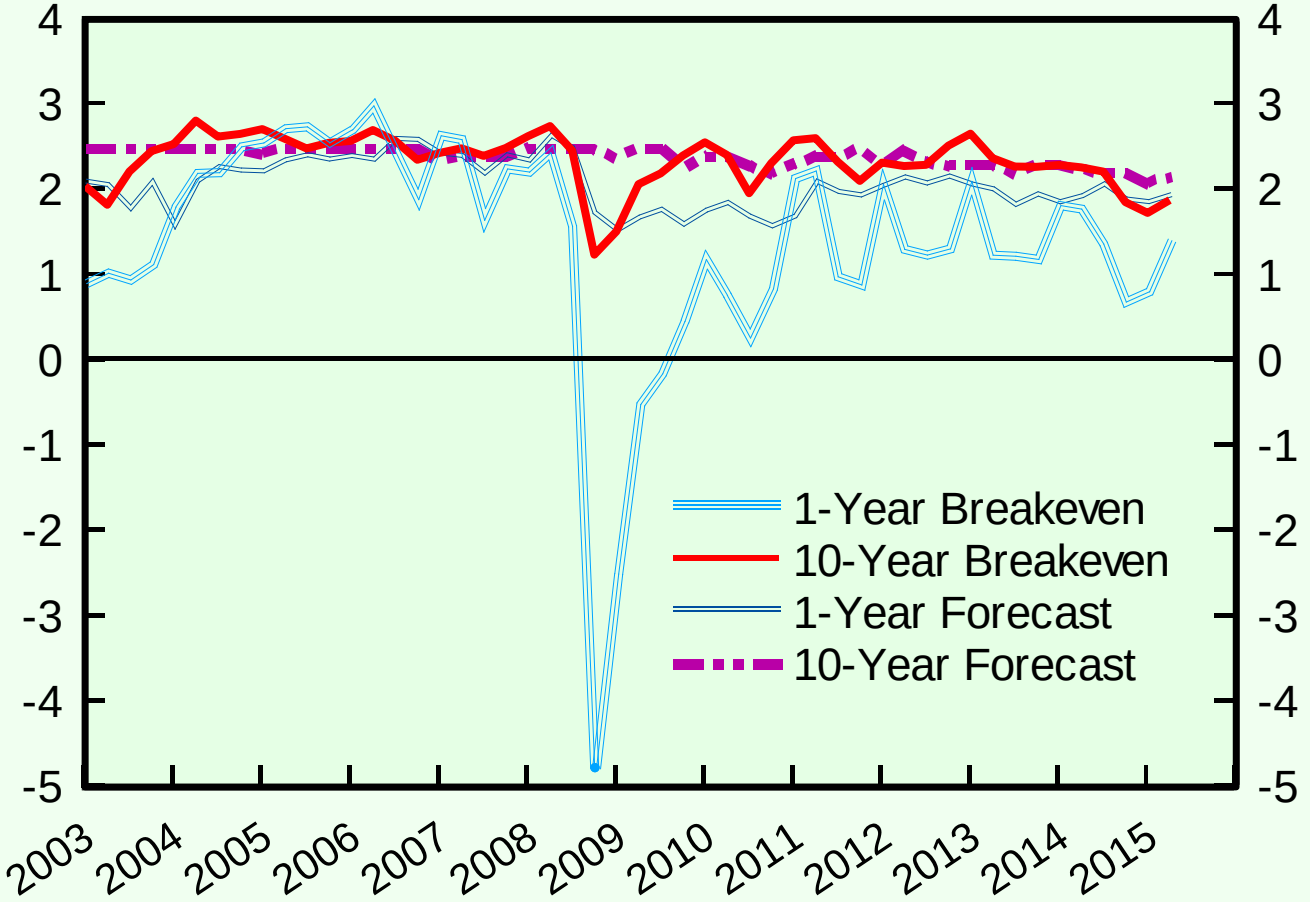


Breakeven Inflation and Forecasts

- The chart in slide 36 compares breakeven inflation with CPI forecasts from the Survey of Professional Forecasters at the Federal Reserve Bank of Philadelphia.
- The breakeven rates are close to the forecasts, and there seems to be little evidence of a term premium.
- The 10-year breakeven and forecast inflation are particularly close: the average difference between 10-year breakeven and forecast rates is -6 basis points over the entire period and -3 basis points since mid 2009.

BREAKEVEN AND FORECAST INFLATION RATES

Quarterly, Percent



Forecasts from Survey of Professional Forecasters

Breakeven Inflation and Forecasts, continued

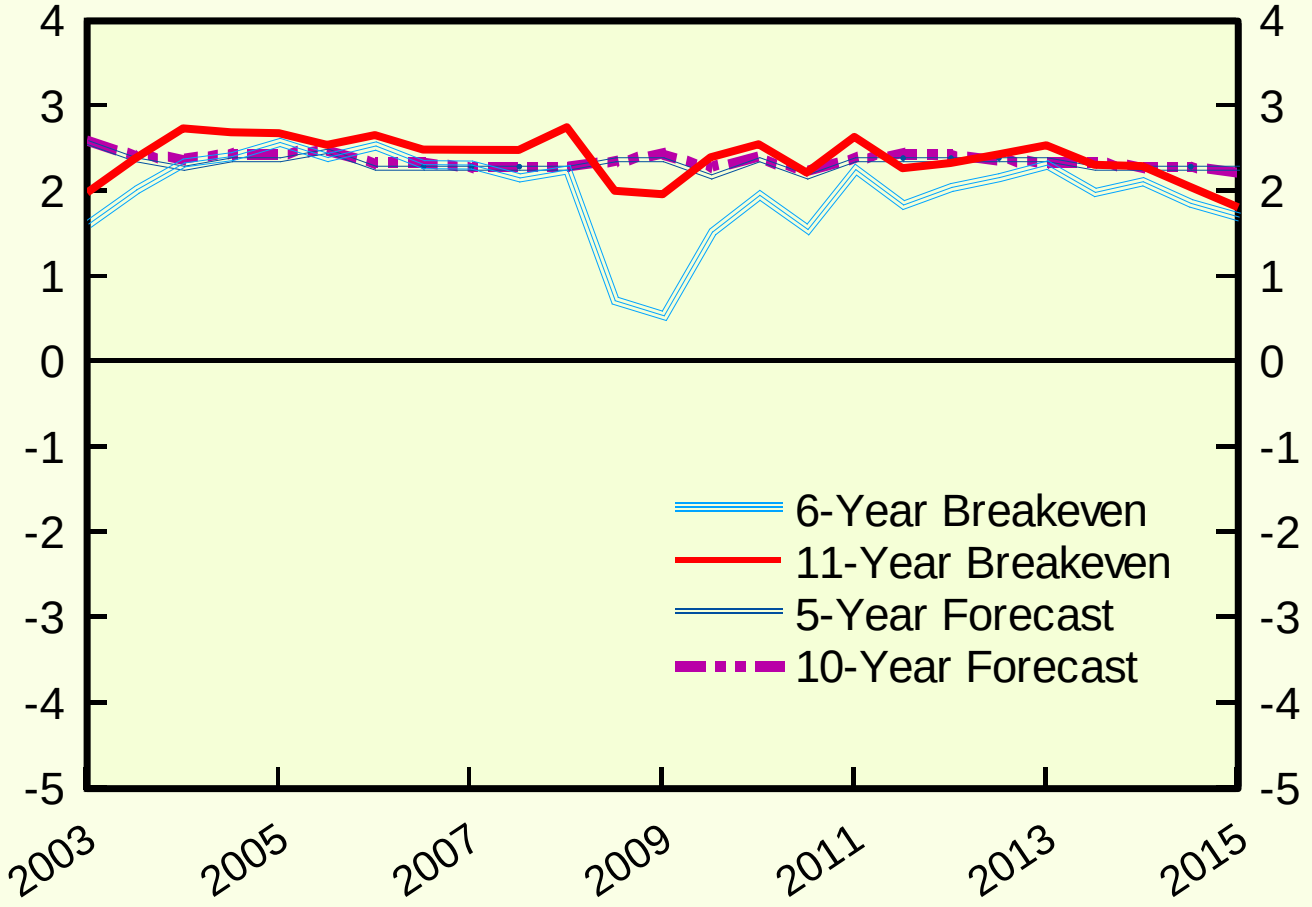
- The chart in slide 39 compares breakeven inflation with CPI forecasts from the long-range consensus in Blue Chip Economic Indicators.
- The chart plots the Blue Chip 5-year and 10-year forecasts, with the latter derived from the first and second 5-year average forecasts.
- Because these forecasts begin a year ahead, the breakeven rates for comparison are extended a year to 6 years and 11 years.

Breakeven Inflation and Forecasts, continued

- The breakeven rates are generally close to the forecasts. As in the previous chart, there does not seem to be much evidence of a term premium.
- For the 5-year, the breakeven rates fall below the forecast rates toward the end of the period. The 10-year breakeven rates are a bit above the forecast earlier in the period.
- The 10-year breakeven and forecast inflation are again especially close: the average difference between 10-year breakeven and forecast rates is 1 basis point over the entire period and -3 basis points since mid 2009.

BREAKEVEN AND FORECAST INFLATION RATES

Semiannual, Percent



Forecasts from Blue Chip Long-Range

More Information and References

- The High Quality Market (HQM) Corporate Bond Yield Curve for the Pension Protection Act (PPA) is published by the IRS each month. Data are also available on the Economic Policy website.
- Data for the Treasury Nominal Coupon-Issue (TNC) Yield Curve are published monthly on the Economic Policy website.
- For more details on the methodology for the TNC and HQM yield curves and for the data, visit the Office of Economic Policy website. Go to www.treasury.gov, under "Resource Center" choose "Economic Policy," then choose "Treasury Yield Curve" and "Corporate Bond Yield Curve Papers."
- Previous applications of this methodology to TIPS yield curves can be found in papers 0601 and 0501 in the Economic Policy Research Paper Series on the Office of Economic Policy website.