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Market-Based Inflation Expectations and Inflation Realities: A Comparison of the Treasury Breakeven Inflation (TBI) Rate Curve and the Consumer Price Index before, during, and after the Great Recession

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Market-Based Inflation Expectations and Inflation Realities: A Comparison of the Treasury Breakeven Inflation (TBI) Rate Curve and the Consumer Price Index before, during, and after the Great Recession

Abstract

This paper examines the extent to which market-based inflation expectations overshot or undershot actual inflation in the years before, during, and after the financial crisis of 2008-09. Specifically, it compares the U.S. Treasury Breakeven Inflation (TBI) Rate Curve, a unique measure of market-based inflation expectations that computes monthly breakeven inflation rates for short and long-term maturity horizons in 6-month increments, to the U.S. Bureau of Labor Statistics' Consumer Price Index for All Urban Consumers, U.S. City Average, All Items, in the 175 months from July 2003 to January 2018.

The analysis has three main findings. First, it finds that average deviations between TBI breakeven rates and respective annual CPI inflation rates per maturity horizon never exceeded 80 basis points, and for horizons of 2 years or more, never exceeded 55 basis points. Moreover, median deviations per maturity horizon never exceeded 70 basis points (except at the 1-year maturity horizon). In short, market-based inflation expectations, as measured by the U.S. Treasury Department TBI Curve, reasonably approximated realized inflation in the years before and after the financial crisis. Second, estimates tend to overshoot for short-term maturity horizons and undershoot for long-term maturity horizons, which likely reflects the effects of a liquidity premium on Treasury Inflation-Protected Securities (TIPS) in the early years of inflation-indexed debt issuance. Third, the dispersion of deviations, as measured by standard deviation and range, decreases as the maturity horizon increases. Thus, inflation expectations approximated inflation reality during the years before, during and after the crisis, with greater precision for long-term rates than short-term rates. At the height of the financial crisis, however, volatility, as measured by tracking risk (i.e. the standard deviation of the differences between breakeven rates and realized inflation rates), was high for the 6-month and 1-year maturity horizons.

Introduction

On January 29, 1997, the U.S. Department of Treasury issued a 10-year inflation-indexed Treasury note, and announced that 10-year Treasury Inflation-Protected Securities (TIPS)[1] would be regularly auctioned on the 15th of January, April, July, and October on an ongoing basis for the foreseeable future. In subsequent years, 5-year, 20-year, and 30-year notes were also introduced. Currently, the U.S. Treasury issues 5-year, 10-year, and 30-year notes, all of which are indexed to the Consumer Price Index for All Urban Consumers.[2]

Exactly one year before the Treasury Department held its first auction of 10-year notes, Campbell and Shiller (1996) provided a lengthy discussion of the primary issues motivating interest in inflation-indexed debt: (1) the effect of inflation-indexed debt issuance on government borrowing costs, (2) the relative risk-sharing efficiency of inflation-indexed debt as an inflation-hedging asset, and (3) the use of inflation-indexed debt to derive market-based inflation expectations.

This paper is concerned with (3), i.e. the use of inflation-indexed debt to derive market-based inflation expectations. The market-based measure of inflation expectations is called the breakeven rate of inflation. There are several methods to calculate the yield curve and thus capture the breakeven rate, and as explained in more detail below, this paper uses the Treasury Breakeven Inflation (TBI) rate curve based on the nominal and real yield curves calculated by the U.S. Treasury Department. Though viewed as a secondary benefit (TIPS were primarily seen as an inflation hedge and a potentially cheaper source of debt financing), the breakeven rate was nonetheless viewed as a source of information on inflation expectations derived from the market activities of investors.

The breakeven rate of inflation is derived from the Treasury yield curve. The yield curve is a fundamental concept in finance and refers to the spread between long- and short-term yields on Treasury securities, e.g. the spread between the 10-year Treasury note and the 2-year Treasury note. The yield curve ultimately reflects various expectations about long- and short-term risks to the economy and financial markets. Graphically, the yield curve slopes upward in an economy with a reasonably positive outlook, indicating a greater level of uncertainty associated with longer-term rates.

The yield curve does not have to slope upward. In fact, a downward-sloping Treasury yield curve has often signaled the onset of a recession. As stated in a historical survey of the yield curve by Zaloom (2009), "[a]n 'inverted' curve has preceded each recession since the mid-1960s (with one exception), a record that some use to orient their strategies, while others question its salience." A downward-sloping yield curve indicates that investors expect long-term rates to decline, which typically happens when the economy is expected to enter a recession and the demand for loans declines, liquidity dries up, and the Federal Reserve Board begins to push rates down to stimulate the economy.

Aside from predicting recessions, the yield curve can also be used to predict inflation; or rather, it provides a benchmark for what investors expect inflation to be in the future. This relationship is based on an equation proposed by economist Irving Fisher that sets the real interest rate equal to the nominal interest rate minus inflation. This equation derives its intuition from the observation that the nominal return on a dollar of investment must be discounted by the rate of inflation to arrive at the real return on a dollar of investment. Inflation is a measure of the change in purchasing power on a dollar of nominal return. Thus the breakeven inflation rate is derived as a discount rate that equates the nominal return on a dollar of investment to the real return (not as an arithmetic difference between the nominal rate and the real rate).

For example, one can obtain the nominal and real yields on 1-year, 2-year, and 10-year Treasury securities from either the nominal or real yield curves, respectively. From these yields, one can derive the 1-year, 2-year, and 10-year nominal and real spot rates. Forward rates can be further derived from spot rates and reflect rates that would prevail at a point in the future for a specified horizon beyond that future point.[3]

Once yields, spot rates, or forward rates are obtained, breakeven inflation rates can be derived as annualized rates from the nominal and real rates of return (yields or spot rates) on Treasury securities. It is in keeping with market convention that nominal and real rates of return on fixed income securities are calculated on a semi-annual basis, while inflation rates are calculated on an annualized basis. Thus, the TBI curve converts semi-annually compounded nominal and real rates to annual rates, allowing for a direct comparison to annual inflation. Thus, the TBI breakeven rate is the expected annualized rate of inflation and is obtained by the following formula:

$$[[\frac{(1 + nominal\ spot\ rate/2)}{(1 + real\ spot\ rate/2)}]\hat{}2\ - 1] * 100,$$

where the nominal and real spot rates are the monthly average nominal and real spot rates published on the Treasury site.[4]

As discussed below, breakeven rates may have an upward bias given a term premium embedded in the nominal yield that reflects uncertainty about future inflation. Alternatively, the breakeven rate may have a downward bias given a term premium embedded in the TIPS yield that reflects the relative illiquidity of TIPS securities. Moreover, in practice, nominal and real yields tend to be lower than their respective spot rates, which generates a downward bias in breakeven rates when yields are used instead of spot rates. [5] Finally, market volatility implies that one cannot count on expectations to match reality exactly. The upward slope of the yield curve results from a premium on the rates associated with Treasuries with longer maturity. In other words, there is more volatility associated with a 10-year rate than there is with a 5-year rate. One of the most pertinent risks in fixed income markets is interest rate risk, i.e. the risk that market yields will diverge from coupon yields with increasing likelihood as maturity increases. This risk affects the prices of securities, as rates and prices move inversely, but also the risk that yields will diverge from expectations.

Nonetheless, investors look to Treasury breakeven rates as a barometer of inflation rates that may materialize in the future.

Literature review

A vast literature studies the dynamics of inflation. Since the emergence of inflation-indexed sovereign debt in the U.S., a segment of this literature has been devoted to an examination of an observed discrepancy between the breakeven rate of inflation and survey-based measures of inflation expectations, as well as between the breakeven rate of inflation and the realized rate of inflation. Not long after the initial issuance of inflation-indexed debt by the U.S. Treasury Department, economists began to observe that TIPS breakeven rates consistently underestimated both survey-based forecasts of inflation and realized rates of consumer price inflation.

The literature has come to focus primarily on the crucial role played by the tradeoff between two risk premiums embedded in Treasury securities: (1) the inflation risk premium embedded in the nominal yield on ordinary Treasury securities, and (2) the liquidity premium embedded in the real yield on TIPS securities.

Grishchenko and Huang (2013) note the lack of consensus on the size of the inflation risk premium and whether, in fact, it is positive or negative, which often depends on the economic circumstances. However, Bekaert and Wang (2010), in a study of inflation hedging strategies using various asset classes, present historical evidence that the inflation risk premium usually tends to be positive, reflecting compensation to investors for the risk associated with inflation volatility.

A positive inflation risk premium increases the nominal yield on ordinary Treasury securities, or alternatively, decreases the real yield on TIPS securities because investors effectively pay "insurance" to avoid inflation risk. All else equal, a lower TIPS yield (or alternatively, a higher nominal yield on ordinary Treasuries) leads the breakeven rate of inflation to overshoot realized inflation.

The liquidity risk premium also tends to be positive, reflecting compensation to investors for the risk associated with a lower level of liquidity for TIPS securities relative to ordinary Treasury securities. The lower relative liquidity comes from holding securities that (1) lack the market depth of ordinary Treasury securities, (2) are typically held by buy-and-hold investors seeking an inflation hedge, and (3) in the early years of their issuance, bore the uncertainty of whether the Treasury Department would continue to issue inflation-indexed debts. A positive liquidity risk premium increases the real yield on TIPS securities, which, all else equal, leads the breakeven rate of inflation to undershoot realized inflation.

If the inflation risk premium and liquidity premium are equal, they cancel each other out and the breakeven rate of inflation approximates realized inflation (assuming other market factors driving the supply and demand of government debt do not have a nontrivial effect on yields). But since breakeven rates have been found to consistently underestimate survey-based expectations and actual inflation, the literature on TIPS securities often focuses on estimation of the liquidity premium. Among the papers that attempt to estimate the liquidity premium are Carlstrom and Fuerst (2004); Shen (2006); Pflueger and Viceira (2011); Christensen and Gillan (2011); Abrahams, Adrian, Crump, and Moench (2012); Pflueger and Viceira (2012); D'Amico, Kim, and Wei (2014); Gospodinov and Wei (2015); Andreasen and Christensen (2016); and Coroneo (2018). A bibliography at the end of this paper provides a more comprehensive list of papers relevant to this discussion.

Since this paper is concerned with inflation expectations, it should be noted that breakeven rates are only one way to generate inflation forecasts. Ang, Bekaert, and Wei (2006) provide an overview of four alternative methods used in forecasting inflation: time-series ARIMA models; regressions using real activity measures motivated from the Phillips curve; term structure models that include linear, non-linear, and arbitrage-free specifications; and survey-based measures. In general, they conclude that surveys generate the best forecasts, especially in comparison to term structure models. Combining forecasts from different approaches does not improve results.

The Treasury Breakeven Inflation (TBI) rate curve

While the economic literature is concerned with several theoretical and empirical aspects of inflation-indexed debt, and employs a variety of modelling techniques to forecast inflation, this paper is concerned with the efficacy of TIPS breakeven rates, specifically calculated by the Treasury Breakeven Inflation (TBI) Rate Curve, as a measure of market-based inflation expectations. It employs monthly breakeven rates calculated for short and long-term maturity horizons by the U.S. Treasury Department to provide a unique empirical investigation of how well market-based inflation expectations matched realized inflation in the months and years before, during, and after the 2008-09 financial crisis. To my knowledge, it is the first use of the TBI curve to examine the efficacy of breakeven inflation rates on a monthly basis using a database of incremental 6-month maturities for nominal and TIPS securities from January 2003 to January 2018.

While there are many sources of breakeven rates, the TBI Rate Curve is derived from nominal and real rates of return on off-the-run coupon-issue Treasury notes and bonds, or more specifically, the Treasury Nominal Coupon-Issue Yield Curve (TNC) and Treasury Real Coupon-Issue Yield Curve (TRC).[6] The TNC is derived using a methodology that adjusts for a hump in yields observed at the twenty-year maturity horizon, and for the price difference between on-the-run and off-the-run securities. TRC yield curve is derived from returns on Treasury Inflation-Protected Securities, or TIPS, using a methodology similar to one used for deriving the TNC. It adjusts for the hump in yield at the twenty-year maturity horizon, but in contrast to the TNC, does not distinguish between on-the-run and off-the-run securities.[7] The TBI Rate Curve estimates monthly breakeven inflation rates derived from the TNC and TRC for incremental 6-month maturity horizons.

Breakeven rates can be obtained directly from the Treasury yield curves, or from spot rates derived from the Treasury yield curves, or from forward rates derived from spot rates.[8] There is some difference of opinion about which to use, although in principle, spot rates are the best measure to use for a "prediction" of inflation in the future. Spot rates equate a one-time payment in the future (e.g. a principal repayment) to its present value (i.e. it is the rate of return on a zero-coupon bond). Spot rates thus avoid the complexities associated with yields, or more specifically, a yield-to-maturity (YTM), which is an internal rate of return that equalizes the cash outflow made to purchase a Treasury security (or any fixed income security) with the cash inflow generated by coupon payments (assumed to be reinvested at a fixed rate) and repayment of principal at the end of term. It is important to note, however, that forward rates can also be used as a "prediction" of inflation in the future.

In practice, investors and the financial press often rely on breakeven inflation rates derived from both yields and spot rates. Either way, TBI rates, derived from the TNC and TRC curves which use spot rates, are increasingly used as a barometer of inflation expectations. The U.S. Defense Department's Uniformed Services Blended Retirement System, for example, uses the Treasury Department's breakeven inflation rates when computing a lump-sum retirement payout.[9]

Matching TBI breakeven inflation rates to their respective annualized CPI rates

For actual inflation, the analysis relies on annualized rates of change in the non-seasonally-adjusted Consumer Price Index for All Urban Consumers, U.S. City Average, All Items, 1982-84=100 (the "CPI"). The CPI is a measure of the average change over time in the prices paid by urban consumers for a constant-quality market basket of goods and services—that is, a sample of goods and services that consumers purchase. Produced monthly, the CPI weights the price of each item in the market basket based on the amount of spending reported by a sample of families and individuals and reflects additional adjustments like imputation to account for missing quotes, and hedonics to account for changes in quality, among other adjustments.

The CPI is used because the real yields on Treasuries are derived from TIPS, which adjust principal and coupon interest by the rate of change in the non-seasonally-adjusted CPI. Thus, the real yield is equal to the inflation-adjusted coupon divided by the market price of Treasury securities.

Breakeven inflation rates are mapped to the respective annualized CPI inflation rate to which they correspond. For example, the 6-month breakeven inflation rate in January 2003 (0.39 percent) is matched with the annualized CPI inflation rate (2.44 percent) from January 2003 to July 2003 (i.e. the 6-month rate of change in the CPI between January 2003 and July 2003 is squared). Because the TBI data begin in January 2003, July 2003 is the first month in which a Treasury breakeven inflation rate, derived from 6-month spot rates on Treasury securities in January 2003, is available for matching; August 2003 is the second month in which a Treasury breakeven inflation rate, derived from 6-month spot rates on Treasury securities in February 2003, is available for matching; similarly, for all months until December 2003. In January 2004, two breakeven inflation rates are available for matching---the breakeven inflation rate derived from 6-month spot rates on Treasury securities in July 2003, and the breakeven inflation rate derived from 1-year spot rates on Treasury securities in January 2003; and so on until June 2004. In July 2004, three breakeven inflation rates become available for matching to their respective annualized CPI inflation rates.

Given that the data begin in January 2003, CPI data published in July to December 2003 can only be compared to breakeven inflation rates derived from TBI spot rates on Treasuries with 6-month maturity in the months January to June 2003. Breakeven inflation rates derived from spot rates on Treasuries with a 1-year maturity in the months July to December 2002 are unavailable. Similarly, breakeven inflation rates derived from spot rates on Treasuries with 1.5-year maturity in the months January to June 2002 are unavailable; and so on.

One significant result of the unavailability of TBI data before January 2003 is that more breakeven inflation rates are available for mapping to annualized CPI inflation rates in later years than in earlier years. For example, there are 10 years of Treasury breakeven inflation rates available in the TBI data for matching to their respective annualized CPI rates of inflation in January 2013, which equates to 20 breakeven inflation rates available for matching given that the Treasury breakeven inflation rates are available in 6-month increments. There is a breakeven inflation rate corresponding to the annualized CPI inflation rate in January 2013 based on the 6-month spot rates on Treasuries in July 2012; there is a breakeven inflation rate based on 1-year spot rates on Treasuries in January 2012; and so on, back to January 2003. In total, there are 20 breakeven inflation rates available for matching to their respective annualized CPI inflation rates in January 2013.

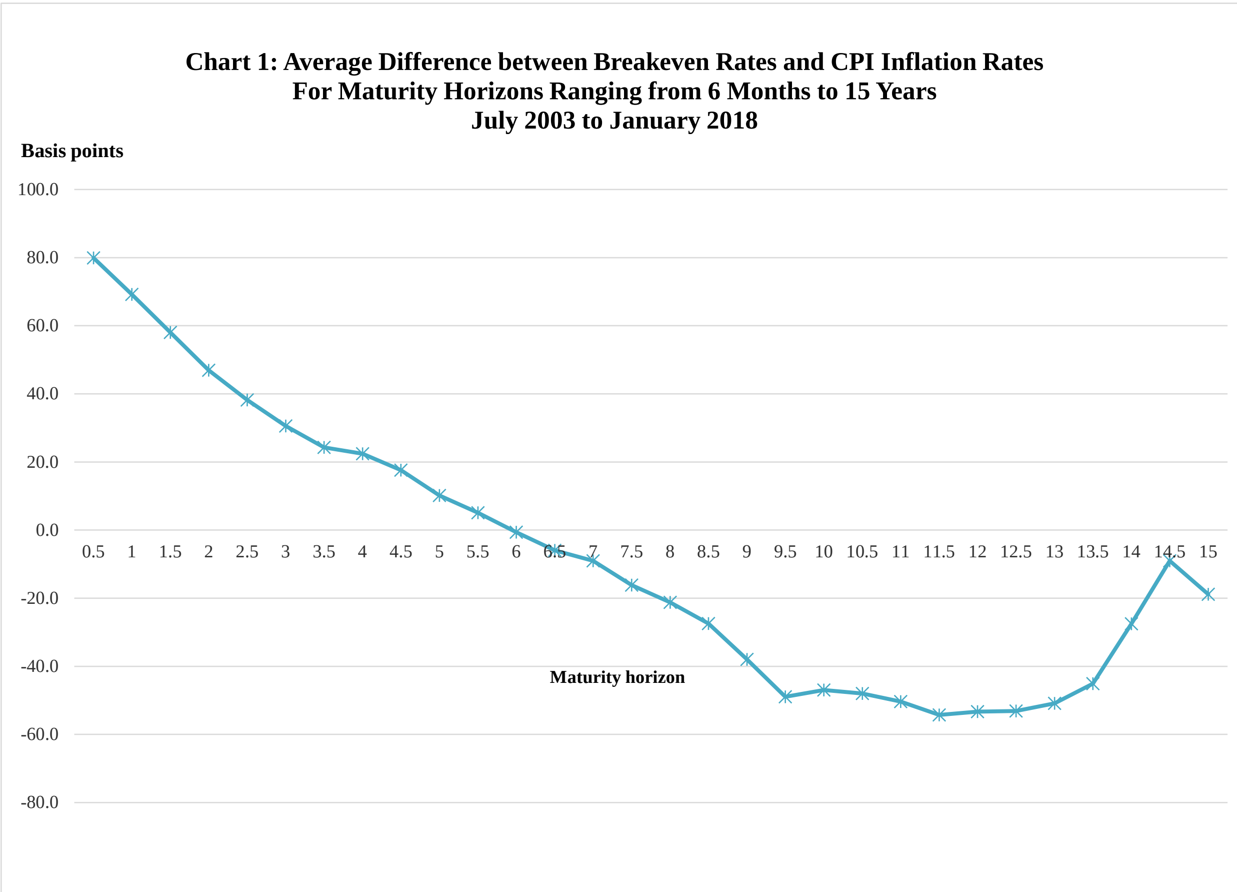
Given that breakeven inflation rates for longer horizons in the dataset are available only for their respective annualized CPI rates in later months (because an additional breakeven rate becomes available with each 6-month increment), there are more observations of breakeven rates based on spot rates on 6-month Treasuries (175) than there are observations of breakeven rates based on spot rates on 1-year Treasuries; there are more observations of breakeven rates based on spot rates on 1-year Treasuries (169) than there are observations of breakeven rates based on 1.5-year Treasuries; there are more observations of breakeven rates based on spot rates on 1.5-year Treasuries (163) than there are observations of breakeven rates based on 2-year Treasuries; and so on. See table 1.

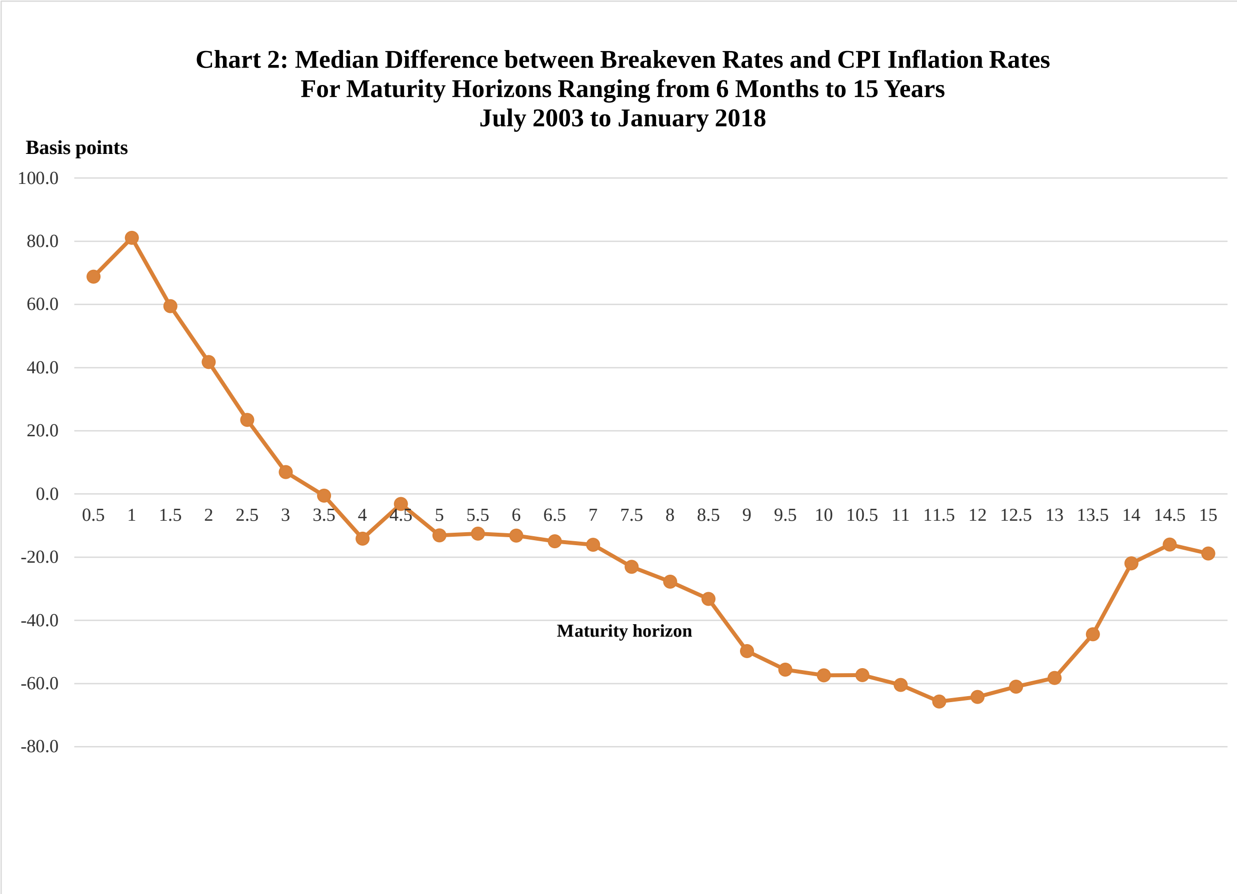
How well did TBI inflation expectations estimate CPI inflation before, during, and after the Great Recession?

This paper examines the discrepancy between expected inflation and actual inflation by calculating the difference between the breakeven inflation rate for a specific maturity horizon and its respective annualized CPI rate of change. Given the incremental nature of the data, this difference is calculated for every month spanning the months July 2003 to January 2018 for the 6-month maturity horizon because 6-month breakeven inflation rates are available for matching to respective annualized CPI inflation rates for all months from July 2003 to January 2018; the difference is calculated for every month spanning the months January 2004 to January 2018 for the 1-year maturity horizon because 1-year breakeven inflation rates are available for matching to respective annualized CPI inflation rates for all months from January 2004 to January 2018; and so on. Though the number of observations decreases with each maturity horizon, there are still 30 or more observations available for maturity horizons of 12 or fewer years. Given this framework, three main results follow.

Result 1: Average and median deviations never exceeded 80 basis points

The analysis finds that the average deviation between breakeven inflation rates and annualized CPI inflation never exceeds 80 basis points for any 6-month increment (1 basis point is equal to one-hundredth of a percent, so 100 basis points is equal to 1 percent), and never exceeds 55 basis points for any 6-month increment beyond a 2-year horizon. The median deviation never exceeds 70 basis points (except at the 1-year horizon). (See table 1, and charts 1 and 2.) If we take an average or median of the average deviations per horizon, the breakeven rate is virtually equivalent to the annualized inflation rate (i.e. the average of averages per horizon is -0.07; the median of averages per horizon is -0.13); similarly, for an average or median of the median deviations per horizon (the average of medians is -0.17; the median of medians is -0.19).



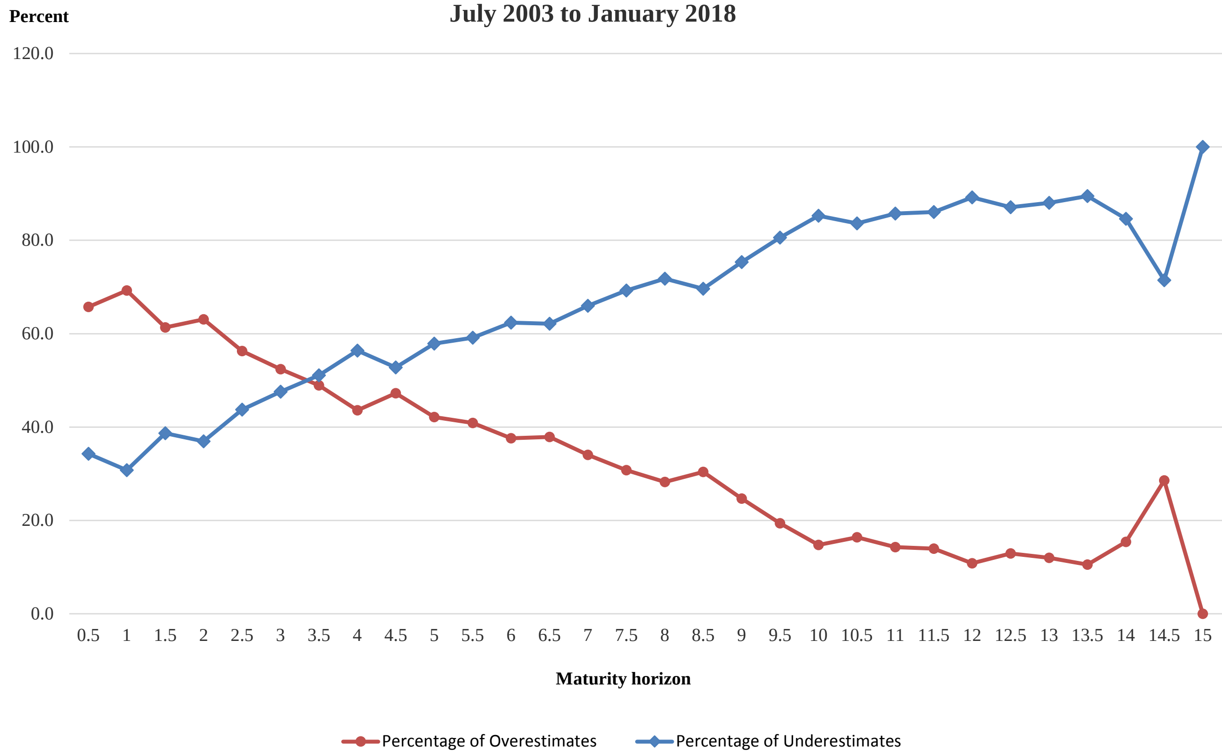


Result 2: TBI expectations overshoot realized inflation for short maturity horizons, and undershoot for long maturity horizons

The percentage of breakeven inflation rates that exceed actual annualized inflation for a specific maturity horizon decreases as the maturity horizon increases. Of the 175 observations available at the 6-month maturity horizon, 66 percent of the breakeven rates overshoot the matching CPI inflation rate. At the 2-year maturity horizon, 63 percent of the breakeven rates overshoot the matching CPI inflation rate. Concentrating on maturity horizons with 30 or more observations, this percentage steadily decreases until the 13-year maturity horizon, when 12 percent of breakeven inflation rates (out of a total of 25 observations) overshoot the matching annualized CPI inflation rate. On the flip side, the percentage of breakeven rates that undershoot inflation steadily increases as the maturity horizon expands. In both cases, however, the degree to which breakeven rates overestimate or underestimate annualized inflation is small, as evidenced by the average and median deviations cited above. Given that expectations tend to overshoot in the short-term and undershoot in the long-term, it is likely that a liquidity premium was embedded in the TIPS yield in the early years of issuance. Longer-horizon breakeven rates are only available for matching to respective longer-horizon annualized CPI rates in the early years of the dataset.

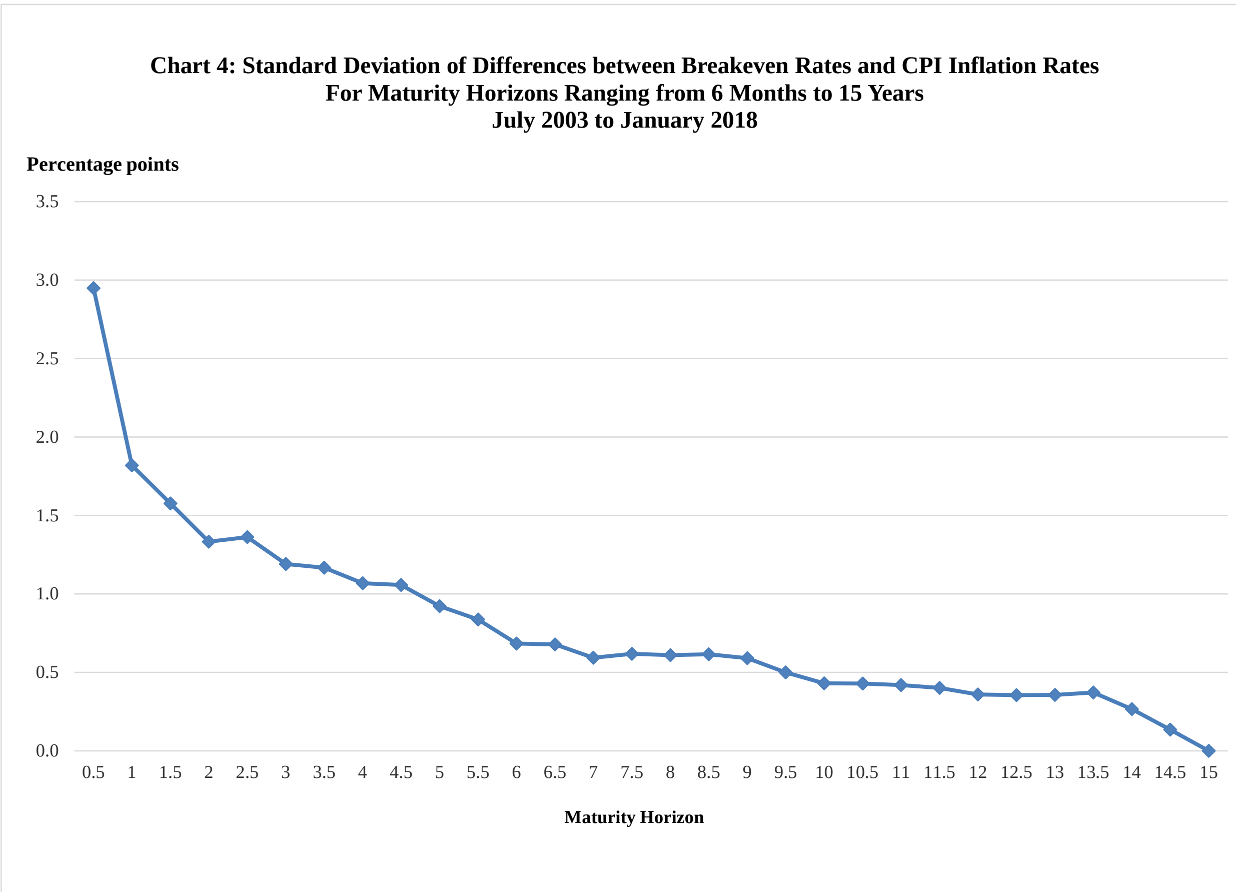
Note, however, that the data begin January 2003, six years after the first issuance of inflation-indexed debt. Given that the TIPS market was more developed, and thus presumably more liquid than TIPS securities were after initial issuance, the liquidity premium exerts a smaller influence. Indeed, for maturities of between 3.5 (the first horizon when more than 50 percent of the observed breakeven rates undershoot actual inflation) and 12.5 years (after which the number of observations per maturity horizon falls below 30), the average deviation never exceeds 54 basis points, while the median deviation never exceeds 66 basis points (moreover, the average of averages over this span is -21 basis points, while the average of medians over this span is -34 basis points). Observations at the 12.5-year maturity horizon begin in July 2015 and end in January 2018, and thus would be based on breakeven rates calculated for January 2003 through July 2004. (See chart 3.)

Chart 3: Percentage of Breakeven Rates That Overestimate and Underestimate CPI Inflation For Maturity Horizons Ranging from 6 Months to 15 Years July 2003 to January 2018



Result 3: The dispersion of differences between expectations and reality decreased as the maturity horizon increased

While the size of the average and median differences between breakeven rates and actual annualized inflation is small, the dispersion of differences between breakeven rates and actual inflation decreases as the maturity horizon increases. This result holds when measuring dispersion by standard deviation, range, and the maximum and minimum differences. The standard deviation of differences decreases from a peak of 2.95 at the 0.5-year horizon (175 observations) to 0.13 at the 14.5-year horizon (7 observations; with only 1 observation at the 15-year horizon, the standard deviation is not defined). The range of differences decreases from a peak of 23.61 at the 0.5-year horizon (175 observations) to 0.34 at the 14.5-year horizon (7 observations, with only 1 observation at the 15-year horizon, the maximum and minimum are the same). The largest maximum difference between expectation and reality is observed at the 0.5-year horizon (13.17, based on 175 observations), which decreases to a maximum difference of 0.09 observed at the 14.5-year horizon (7 observations). The largest minimum difference between expectation and reality is observed at the 0.5-year horizon (-10.44), based on 175 observations), which decreases to a minimum difference of -0.25 observed at the 14.5-year horizon (7 observations). (See charts 4-7.)



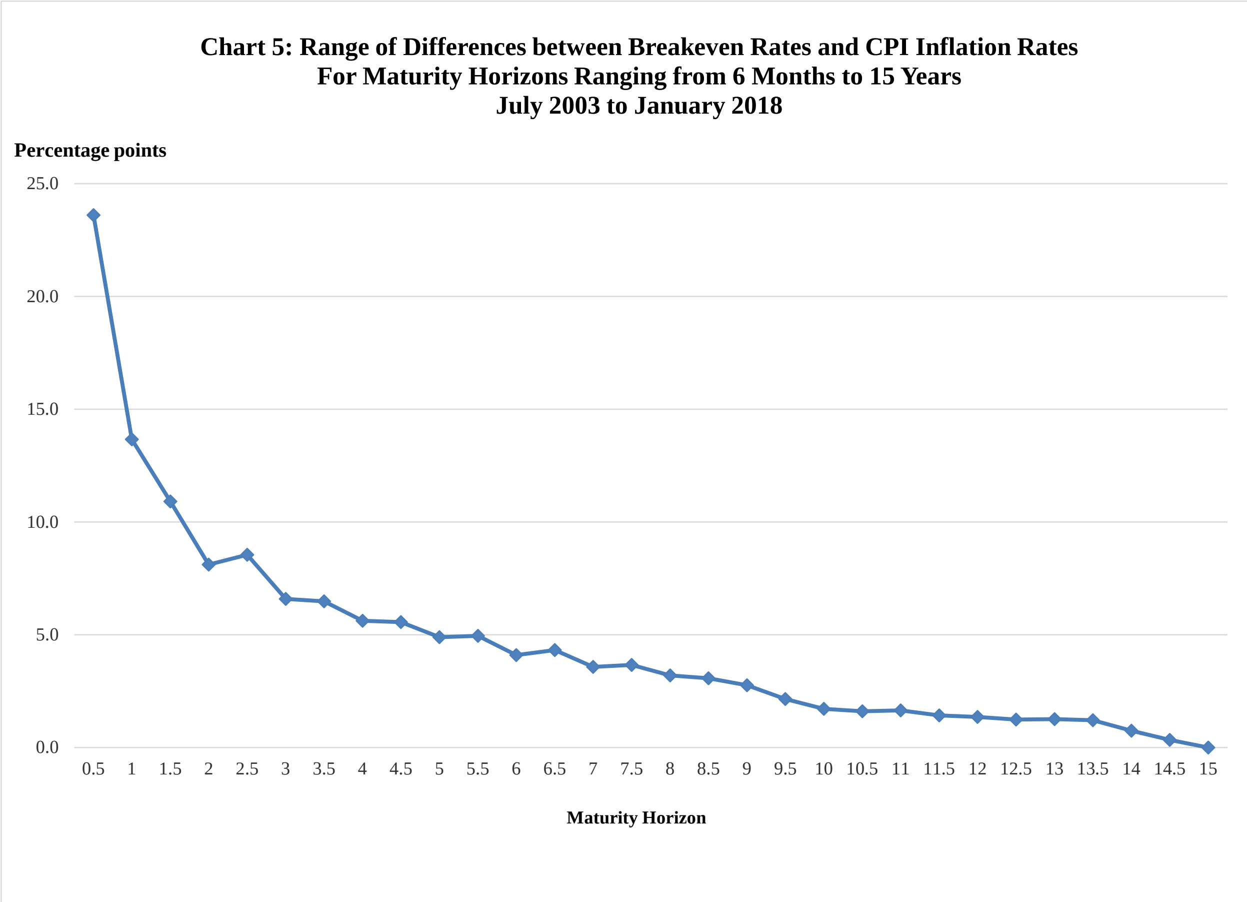


Chart 5: Range of Differences between Breakeven Rates and CPI Inflation Rates
For Maturity Horizons Ranging from 6 Months to 15 Years
July 2003 to January 2018
Percentage points
25.0
20.0
15.0
10.0
5.0
0.0
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 8.5 9 9.5 10 10.5 11 11.5 12 12.5 13 13.5 14 14.5 15
Maturity Horizon

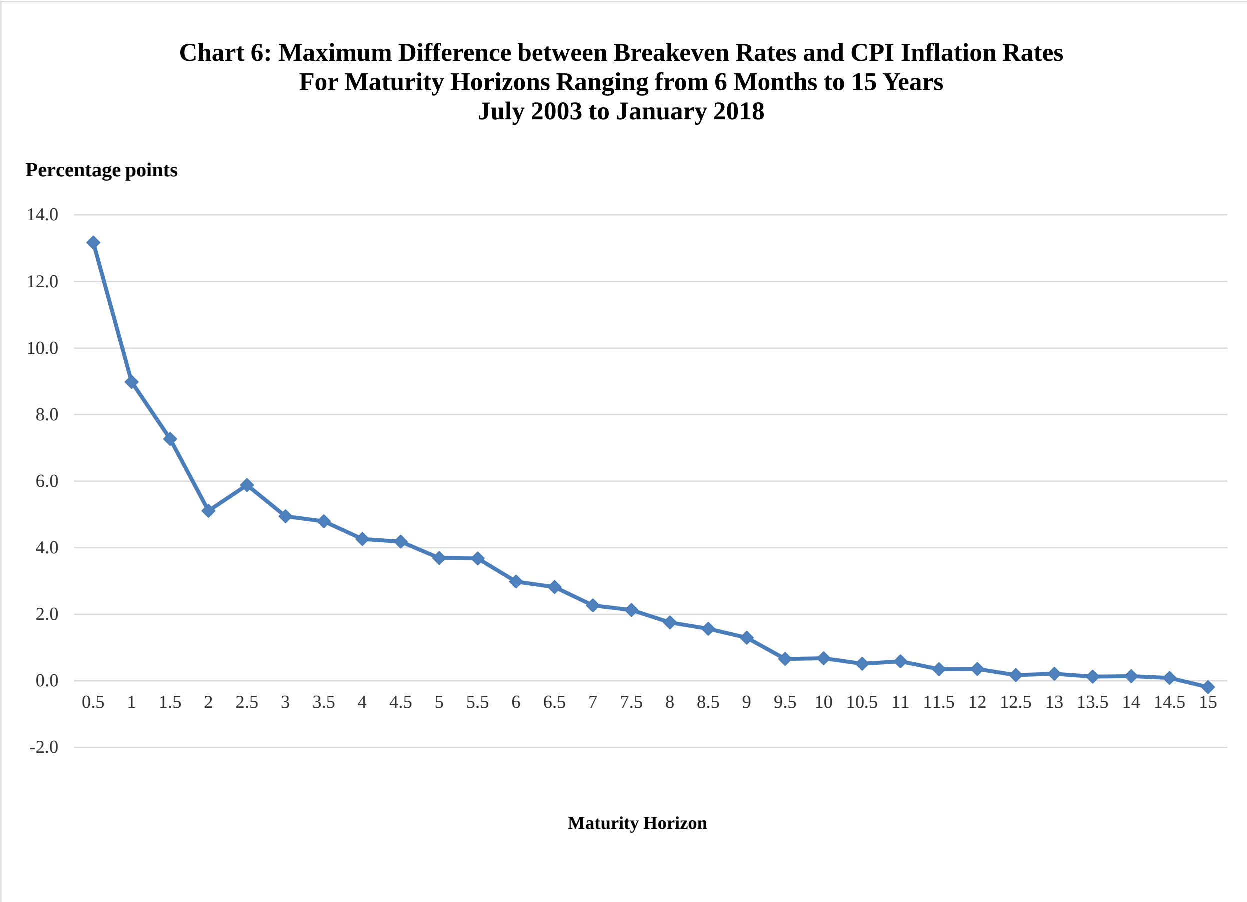


Chart 6: Maximum Difference between Breakeven Rates and CPI Inflation Rates
For Maturity Horizons Ranging from 6 Months to 15 Years
July 2003 to January 2018
Percentage points
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
-2.0
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 8.5 9 9.5 10 10.5 11 11.5 12 12.5 13 13.5 14 14.5 15
Maturity Horizon

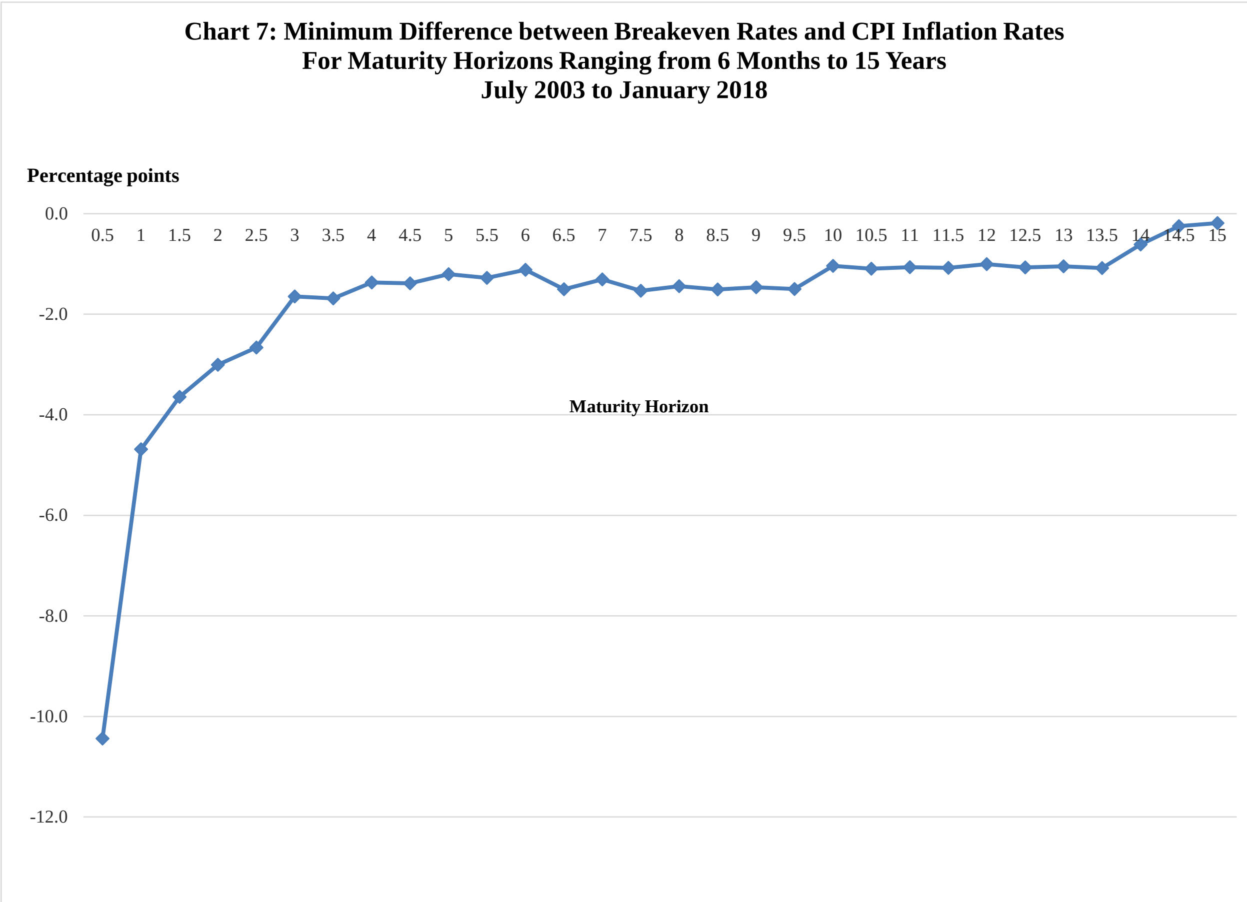
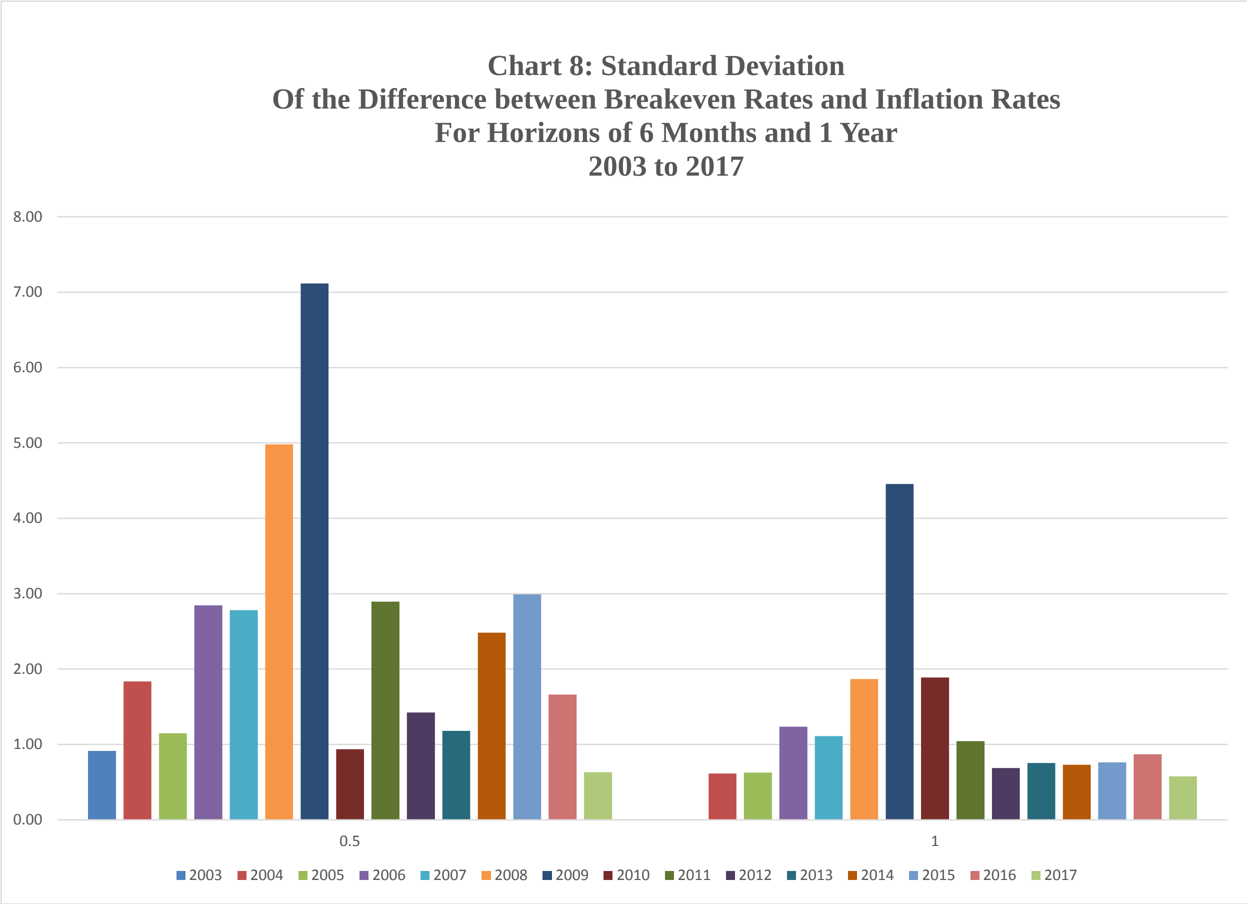


Chart 7: Minimum Difference between Breakeven Rates and CPI Inflation Rates
For Maturity Horizons Ranging from 6 Months to 15 Years
July 2003 to January 2018
Percentage points
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 8.5 9 9.5 10 10.5 11 11.5 12 12.5 13 13.5 14 14.5 15
Maturity Horizon

Table 1: Difference between Expected Inflation and Actual Inflation
As Measured by the Treasury Breakeven Inflation Rate
Per Six-Month Horizon
July 2003 to January 2018

		Deviations		Std				Over		Under		
Horizon	**Obs**	**Average**	**Median**	**Dev**	**Max**	**Min**	**Range**	**Number**	**Percent**	**Number**	**Percent**	
0.5	175	0.80	0.69	2.95	13.17	-10.44	23.61	115	65.71	60	34.29	%
1	169	0.69	0.81	1.82	8.98	-4.69	13.67	117	69.23	52	30.77	
1.5	163	0.58	0.59	1.58	7.27	-3.65	10.91	100	61.35	63	38.65	
2	157	0.47	0.42	1.33	5.11	-3.00	8.11	99	63.06	58	36.94	
2.5	151	0.38	0.23	1.36	5.89	-2.66	8.55	85	56.29	66	43.71	
3	145	0.31	0.07	1.19	4.94	-1.65	6.59	76	52.41	69	47.59	
3.5	139	0.24	-0.01	1.17	4.79	-1.68	6.48	68	48.92	71	51.08	
4	133	0.22	-0.14	1.07	4.26	-1.37	5.63	58	43.61	75	56.39	
4.5	127	0.18	-0.03	1.06	4.18	-1.39	5.57	60	47.24	67	52.76	
5	121	0.10	-0.13	0.92	3.69	-1.20	4.90	51	42.15	70	57.85	
5.5	115	0.05	-0.13	0.84	3.68	-1.28	4.96	47	40.87	68	59.13	
6	109	-0.01	-0.13	0.68	2.98	-1.12	4.10	41	37.61	68	62.39	
6.5	103	-0.06	-0.15	0.68	2.82	-1.50	4.32	39	37.86	64	62.14	
7	97	-0.09	-0.16	0.59	2.27	-1.31	3.58	33	34.02	64	65.98	
7.5	91	-0.16	-0.23	0.62	2.13	-1.54	3.66	28	30.77	63	69.23	
8	85	-0.21	-0.28	0.61	1.75	-1.44	3.20	24	28.24	61	71.76	
8.5	79	-0.27	-0.33	0.62	1.56	-1.51	3.07	24	30.38	55	69.62	
9	73	-0.38	-0.50	0.59	1.30	-1.46	2.76	18	24.66	55	75.34	
9.5	67	-0.49	-0.56	0.50	0.66	-1.50	2.15	13	19.40	54	80.60	
10	61	-0.47	-0.57	0.43	0.68	-1.04	1.71	9	14.75	52	85.25	
10.5	55	-0.48	-0.57	0.43	0.51	-1.09	1.61	9	16.36	46	83.64	
11	49	-0.50	-0.60	0.42	0.59	-1.06	1.65	7	14.29	42	85.71	
11.5	43	-0.54	-0.66	0.40	0.35	-1.08	1.43	6	13.95	37	86.05	
12	37	-0.53	-0.64	0.36	0.35	-1.01	1.36	4	10.81	33	89.19	
12.5	31	-0.53	-0.61	0.36	0.17	-1.07	1.24	4	12.90	27	87.10	
13	25	-0.51	-0.58	0.36	0.21	-1.05	1.26	3	12.00	22	88.00	
13.5	19	-0.45	-0.44	0.37	0.12	-1.08	1.21	2	10.53	17	89.47	
14	13	-0.28	-0.22	0.27	0.14	-0.61	0.75	2	15.38	11	84.62	
14.5	7	-0.09	-0.16	0.13	0.09	-0.25	0.34	2	28.57	5	71.43	
15	1	-0.19	-0.19	na	-0.19	-0.19	0.00	0	0.00	1	100.00	

One final observation is that the standard deviation of the difference between breakeven rates and inflation rates (i.e. tracking risk) was relatively high in all years for the 6-month maturity range, but especially high in 2008 and 2009. It was also high in 2009 for the 1-year maturity range. An increase in volatility is not unexpected for short-term horizons in the midst of the greatest financial crisis since the Great Depression. (See chart 8.)



Conclusion

The analysis finds that TBI breakeven rates reasonably approximated inflation reality before and after the financial crisis of 2008-09. More specifically, average and median deviations between TBI breakeven rates and respective annualized CPI inflation rates never exceed 81 basis points, though a liquidity premium embedded in the TIPS yield probably explains the undershoot of expectations for longer maturity horizons. Moreover, the dispersion of deviations, as measured by standard deviation and range, decreases as maturity horizon increases. Thus, inflation expectations, as measured by TBI rates, reasonably approximated inflation reality during the years before and after the crisis, with greater precision for long-term rates than short-term rates. This was true even at the height of the financial crisis in the early months of 2009, though tracking risk was high for the 6-month and 1-year horizons.

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[1] Treasury Inflation-Protected Securities, or TIPS, would subsequently be renamed Treasury Inflation-Indexed Securities. But TIPS remains in the market lexicon.

[2] For a timeline of Treasury Inflation-Protected Securities (TIPS), see: https://www.treasurydirect.gov/indiv/research/history/histtime/histtime_tips.htm. See also: https://www.treasurydirect.gov/indiv/research/indepth/tips/res_tips.htm.

[3] It is a straightforward matter of deriving forward rates, as described by Treasury Acting Director for the Office of Macroeconomic Analysis James Girola: Let L be a longer term period into the future and S be a shorter term period, and we want to compute the (L-S)-year forward breakeven rate S years hence. For example, if L = 10 and S = 7, we would be computing the 3-year forward breakeven rate 7 years hence. Let b_L be the spot breakeven rate for L years, b_S be the spot breakeven rate for S years, and f be the forward breakeven rate. To get the forward rate f, back out f from the following equation: $(1+b_L/100)^L = (1+b_S/100)^S * (1+f/100)^{(L-S)}$.

[4] For more information on the derivation of the Treasury Breakeven Inflation (TBI) rate curve, see James A. Girola, "The Treasury Real Yield Curve and Breakeven Inflation," July 21, 2015 (https://www.treasury.gov/resource-center/economic-policy/corp-bond-yield/Documents/tii_may2015.pdf). TNC, TRC, and TBI data are maintained on the website of the U.S. Department of Treasury: https://www.treasury.gov/resource-center/economic-policy/corp-bond-yield/Pages/TNC-YC.aspx.

[5] See slides 33 and 34 in James A. Girola, "The Treasury Real Yield Curve and Breakeven Inflation," July 21, 2015 (https://www.treasury.gov/resource-center/economic-policy/corp-bond-yield/Documents/tii_may2015.pdf).

[6] For more information on these curves, see James A. Girola, "The Yield Curve for Treasury Nominal Coupon Issues," May 16, 2014 (https://www.treasury.gov/resource-center/economic-policy/corp-bond-yield/Documents/trp_apr2014.pdf), and James A. Girola, "The Treasury Real Yield Curve and Breakeven Inflation," July 21, 2015 (https://www.treasury.gov/resource-center/economic-policy/corp-bond-yield/Documents/tii_may2015.pdf).

[7] As explained on the Treasury website (https://www.treasury.gov/resource-center/economic-policy/corp-bond-yield/Documents/tii_may2015.pdf): "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."

[8] TNC, TRC, and TBI data are maintained on the website of the U.S. Department of Treasury: https://www.treasury.gov/resource-center/economic-policy/corp-bond-yield/Pages/TNC-YC.aspx.

[9] See Attachment 2 of the Uniformed Services Blended Retirement Systems Policy at: http://militarypay.defense.gov/Portals/3/Documents/BlendedRetirementDocuments/Combined%20BRS%20Policy%20Document.pdf?ver=2018-01-02-105828-370. "In computing the amount of the lump sum described in 7.a.(3)(c) of Attachment 1, the discounted present value will be determined in accordance with the rate that is an inflation-adjusted 7-year average of the Department of Treasury High-Quality Market (HQM) Corporate Bond Spot Rate Yield Curve at a 23-year maturity plus an adjustment factor of 4.28 percentage points. The inflation adjustment applied is the Department of Treasury 'Breakeven Inflation Spot Rate Yield Curve.'"