

# Inflation Risk Premia and Survey Evidence on Macroeconomic Uncertainty\*

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The difference between nominal and real interest rates (break-even inflation) is often used to gauge the market’s inflation expectations—and has become an important tool in monetary policy analysis. However, break-even inflation can move in response to shifts in inflation risk premia and liquidity premia as well as to changes in expected inflation. This paper sheds light on this issue by analyzing the evolution of U.S. break-even inflation from 1997 to mid-2008. Regression results show that survey data on inflation uncertainty and proxies for liquidity premia are important factors.

JEL Codes: E27, E47.

## 1. Introduction

Break-even inflation (the difference between nominal and real interest rates) is often used as an indicator of inflation expectations. It has several advantages over surveys and other methods: It is available on a daily basis, it focuses on the beliefs of financial markets, and it is based on decisions that matter (“put your money where your mouth is”). On the other hand, survey data is often considered to give a cleaner measure of inflation expectations. It is therefore important to study how the break-even inflation rates differ from survey data on inflation expectations—and to find proxies that can account for the difference. In addition, understanding the pricing of Treasury bonds is important for both analysts and investors.

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The idea of this paper is very simple. Data on the U.S. nominal and real interest rates is combined with survey data on inflation expectations to construct a time series of “break-even deviations”—that is, the deviation of break-even inflation from inflation expectations—for the sample 1997:M1–2008:M6. This deviation is likely to be driven mainly by inflation risk premia (on the nominal bonds) and liquidity premia (on the real bonds). It is therefore regressed on measures of inflation uncertainty from survey data on probability distributions and proxies for real liquidity premia. The results indicate that the regressors are significant and explain a considerable fraction of the movements of the break-even deviation. This leads to significant adjustments of the usual break-even inflation.

Several studies have looked at similar issues, but very few have combined real interest rates, survey data on inflation expectations and inflation uncertainty, and proxies for real liquidity premia to estimate a Fisher equation. (However, recent work by García and Werner 2010 uses a similar approach on European Central Bank [ECB] data.)

Reschreiter (2004), Chen, Liu, and Cheng (2005), and Grishchenko and Huang (2008) use nominal and real interest rates to estimate no-arbitrage yield-curve models with latent factors. D’Amico, Kim, and Wei (2008) and Joyce, Lildholdt, and Sorensen (2009) go one step further by including also inflation expectations. The current paper does not estimate a fully fledged yield-curve model (mostly because inflation expectations are only available for a few horizons), but it uses observable factors to capture the inflation risk and real liquidity premia. This might facilitate the interpretation of the results.

Lahiri, Teigland, and Zaporowski (1988), García and Manzanares (2007), and Wright (2008) also use survey data to estimate inflation uncertainty. The first paper does not find any effect of uncertainty on nominal interest rates (on the sample 1969–86), but the second paper finds that it is important for understanding the inflation scares during the Volcker period in the early 1980s. The current paper differs from these earlier contributions in many details—in particular, on how to estimate uncertainty from survey data, but more importantly by focusing on the period when real (inflation-indexed) interest rates are available (since 1997). This allows for controlling for an important driving force of nominal rates.

Carlstrom and Fuerst (2004) and Shen (2006) compare the break-even inflation rate with survey measures of inflation expectations. They argue that the break-even inflation rates are too low—due to a considerable liquidity premium in the observed real rates. The current paper incorporates those results—and goes on to study if other factors (inflation uncertainty/disagreement) add explanatory value by capturing the inflation risk premium. Kajuth and Watzka (2008) is similar, but does not use a survey-based direct measure of inflation uncertainty (instead, they study inflation disagreement).

The current paper draws on all these strands of research in order to estimate a modern Fisher equation where we use information on real interest rates and inflation expectations but also control for the liquidity premium on real bonds and the inflation risk premium on nominal bonds. The liquidity premium is modeled in terms of observed liquidity premia for off-the-run Treasury bonds (and some other proxies) and the inflation risk premium by unique information about inflation risk reported by the participants of the Survey of Professional Forecasters (and some other proxies). The results indicate that these variables are important—and lead to significant adjustments of break-even inflation.

The outline of the paper is as follows. Section 2 discusses the Fisher equation and the data, section 3 presents the empirical results, section 4 shows break-even inflation rates and inflation uncertainty for other economies (the United Kingdom and the euro area), and section 5 concludes.

## 2. Data and Relation to the Fisher Equation

This section summarizes the Fisher equation, and describes the data and how to construct proxies for inflation uncertainty and liquidity premia.

### 2.1 *The Fisher Equation*

A modern Fisher equation says that the nominal interest rate ( $i$ ) equals the sum of expected inflation ( $E\pi$ ), the real interest rate ( $\tilde{r}$ ), and an inflation risk premium ( $IRP$ ):

$$i = E\pi + \tilde{r} + IRP. \quad (1)$$

(For notational simplicity, subscripts for time and maturity are suppressed.)

However, the real (inflation-indexed) bonds traded in the United States have occasionally been somewhat illiquid, and it is often argued that they carry a liquidity premium (see Shen 2006 and also Roush 2008 for a detailed discussion of the TIPS market). Therefore, let  $r$  indicate the real interest rate observed in data and let  $LPr$  indicate the liquidity premium on real bonds. The observed real interest rate needs to be adjusted down ( $\tilde{r} = r - LPr$ ) to correct for this liquidity premium. The Fisher equation for observable data can then be written

$$i - r - E\pi = IRP - LPr. \quad (2)$$

The observed “break-even deviation” ( $i - r - E\pi$ ) depends positively on the inflation risk premium and negatively on the liquidity premium on real bonds. The break-even deviation is likely to be stationary, even if nominal interest rates and inflation expectations are not.

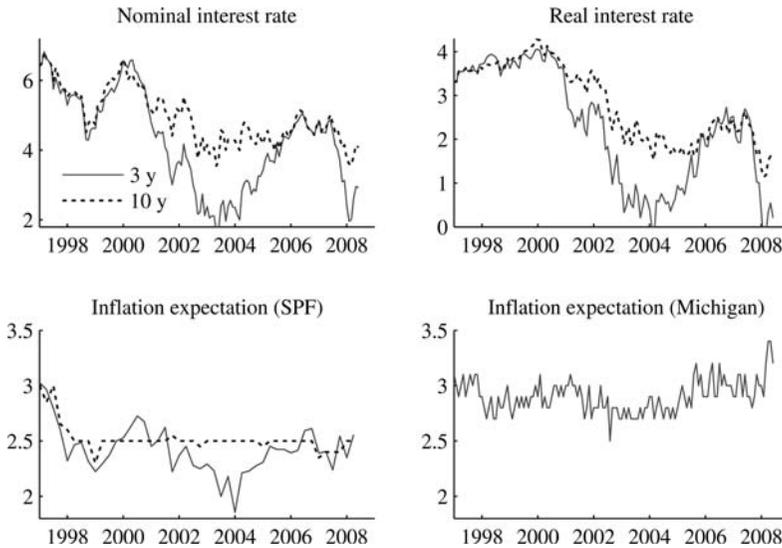
Central banks often calculate break-even inflation as the difference between nominal and real yields ( $i - r$ )—with the purpose of approximating the market’s inflation expectations. If the inflation risk premium and the liquidity premium in the Fisher equation (2) are constant, then the break-even inflation rate differs from the inflation expectations by a constant: changes in the break-even inflation rate are then precise measures of changes in inflation expectations. Otherwise, an increased inflation risk premium increases the break-even inflation rate, while an increased real liquidity premium decreases it—and these movements may hurt the informational value of the break-even inflation rate.

The objective of this paper is to find proxies for the inflation risk premium and the real liquidity premium in order to understand the pricing of bonds and to improve upon the practice of calculating break-even inflation.

## 2.2 Data

The regressions estimated below are based on equation (2), and this section discusses how the variables are constructed.

**Figure 1. Interest Rates (Nominal and Real) and Inflation Expectations**



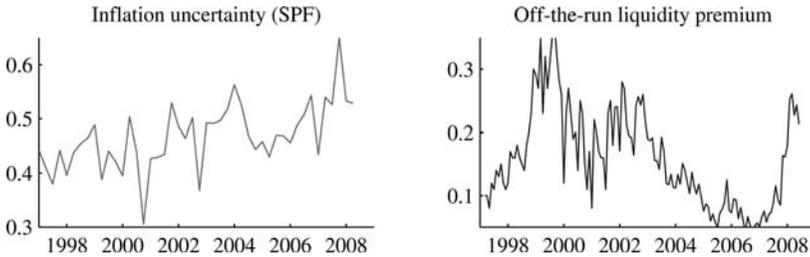
**Note:** This figure shows estimated nominal and real zero-coupon rates from McCulloch's home page, as well as inflation expectations from the SPF and the Michigan survey.

The three- and ten-year nominal and real (zero-coupon) interest rates from McCulloch (2008) are shown in the upper panels of figure 1. I choose to focus mostly on the horizons of three and ten years: the real rates for shorter maturities are less reliable, for instance, because there have occasionally been few outstanding index-linked bonds with short maturities. Other maturities are used in the robustness analysis and briefly discussed in the text. The sample starts in 1997:M1 since this is when the Treasury Inflation-Protected Securities (TIPS) were first issued, and the data is available on a monthly frequency.<sup>1</sup>

The main measures of inflation expectations and inflation risk uncertainty are from the Survey of Professional Forecasters (SPF)

<sup>1</sup>The data from Gürkaynak, Sack, and Wright (2008) are very similar. For instance, the end-of-month break-even inflation rates (for the ten-year horizon) have a correlation of 0.97 with those from McCulloch.

**Figure 2. Inflation Uncertainty and Off-the-Run Liquidity Premium**



**Note:** This figure shows the inflation uncertainty from the SPF and the off-the-run liquidity premium from the Federal Reserve Bank of Cleveland.

at the Federal Reserve Bank of Philadelphia (2010). The SPF is a quarterly survey of forecasters' views on key economic variables. The respondents, who supply anonymous answers, are professional forecasters from the business and financial community. The survey asks for, among other things, the next-year and the ten-year CPI inflation forecasts, but also for probability distributions (histograms) of GDP deflator inflation. The deadline for the survey is approximately in the middle of the quarter.<sup>2</sup>

The lower-left panel of figure 1 shows three- and ten-year inflation expectations constructed from the median (across forecasters) CPI inflation forecasts. The three-year expectation is approximated by linear interpolation of the forecasts for the next calendar year and for the next ten years. There are substantial movements in the three-year expectations, while the ten-year inflation expectations are virtually flat after 1999.

The left panel of figure 2 shows inflation uncertainty estimated from the probability distributions of inflation in the SPF. This variable measures the average uncertainty about future inflation—as reported by the participants of the SPF. It has the great advantage of being a direct measure of inflation uncertainty, rather than some proxy (like inflation disagreement/forecast dispersion or implied volatility from bond options).

<sup>2</sup>While deflator inflation and CPI inflation differ in many respects, they tend to be strongly correlated in the medium run. For instance, the correlation of four-quarter inflation is 0.94 on data from 1970 through 2008.

The estimation of inflation uncertainty involves fitting distributions to the histograms in the SPF (there is one histogram per forecaster in each quarter). If only one bin is used (the respondent puts 100 percent of the probability on one of the prespecified bins), then a triangular distribution within that bin is assumed. If two or more bins are used, then a normal distribution is estimated by minimizing the sum of the squared deviations of the theoretical from the observed probabilities. (See Giordani and Söderlind 2003 for an early application and García and Manzanares 2007 for a critique of the least-squares criterion.) Clearly, the analysis of long-term interest rates asks for information about long-run uncertainty. Unfortunately, the SPF contains only information on short-run uncertainty. I am therefore left with using the short-run information—hoping that long-run uncertainty can be approximated by (linear functions of) short-term uncertainty.<sup>3</sup>

These estimations generate a panel of subjective standard deviations of future inflation. However, there is a lot of cross-sectional (across forecasters) dispersion in the estimation results—some of which appears to be caused by typos and other data errors. To get robust estimates of the average individual uncertainty, I use the cross-sectional trimmed mean (20 percent trimming from both bottom and top) of the individual standard deviations. (Using the median gives very similar results and using the mean produces fairly similar, but more erratic, results.)

An additional complication is that the probability distributions are for year-on-year inflation (the value in a calendar year divided by the value in the previous calendar year, minus one). This means that the forecasting horizon varies across the sample: the current-year forecast made in Q1 has a four-quarter horizon, the forecast made in Q2 has a three-quarter horizon, and so forth. The estimated uncertainty therefore has clear seasonality—as the effective forecasting horizon decreases over the calendar year. My measure of inflation uncertainty is therefore deseasonalized using X12 (assuming

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<sup>3</sup>The SPF also contains histograms about inflation during the next calendar year, but that seems to convey essentially the same information—except that it appears more noisy. The uncertainty about the next calendar year is of course higher, but the correlation of year 1 and 2 is strong (around 0.75)—and the regression results are similar (not tabulated).

multiplicative seasonality). The resulting series (in figure 2) still appears a bit noisy, so it should come as no surprise that the regression analysis (see below) favors an average of the current and lagged uncertainty as a regressor.

The right panel of figure 2 shows the off-the-run liquidity premium: the yield difference between less and more liquid (“off-the-run” and “on-the-run”) ten-year nominal Treasury bonds. The Federal Reserve Bank of Cleveland (2010) calculates an adjusted break-even inflation rate by adding a real liquidity premium ( $LPr$ ), that is, as  $i - (r - LPr)$ .<sup>4</sup> To construct the real liquidity premium (which is not directly observable), the Federal Reserve Bank of Cleveland (2010) argues that it is likely to be strongly related to the off-the-run premium according to a linear-quadratic function.<sup>5</sup> This function has a negative constant which is meant to capture a constant inflation risk premium of the nominal bond. For the sort of off-the-run premia that we see in the sample, the function is actually almost linear with a slope of approximately 3.5, except for some rare cases (the peak in 1999, when the quadratic term dampens the effect). The publication of the  $LPr$  was discontinued in autumn 2008, as it was deemed unreliable during the financial crisis. Clearly, liquidity premia behaved distinctly different during the crisis, so I choose to end my sample at the same time as the Federal Reserve Bank of Cleveland (in 2008:Q2).<sup>6</sup>

In the main specification, I use the data described above. The additional analysis also considers several other proxies for expected inflation, inflation uncertainty, and the real liquidity premium. This provides a robustness analysis and explores the possibility of using the monthly (instead of quarterly) data presented below.

The lower-right panel of figure 1 shows the median five-year inflation expectations according to the Survey of Consumers at

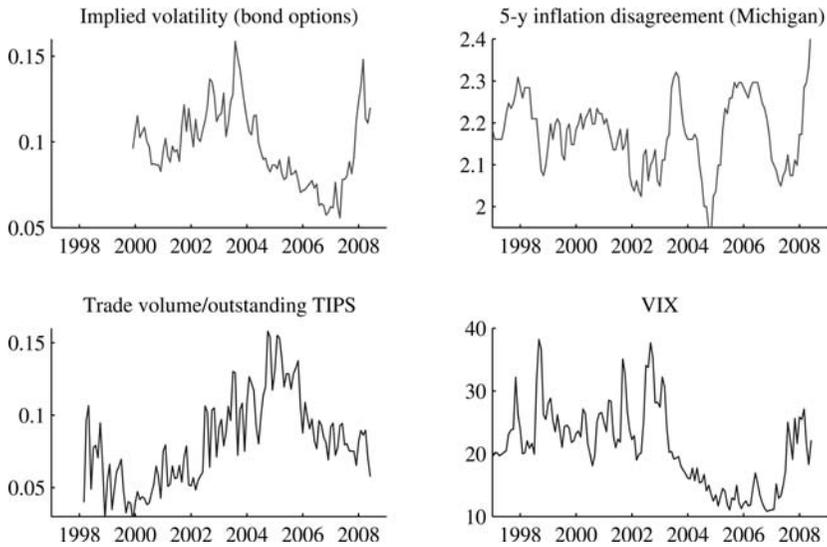
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<sup>4</sup>See also Graveline and McBrady (2006) for a discussion of the off-on yield spread.

<sup>5</sup>The functional form is  $LPr = -0.948 + 12.71LPO - 20.9(LPO)^2$ , where  $LPO$  is the off-the-run premium.

<sup>6</sup>On October 31, 2008, the Federal Reserve Bank of Cleveland (2010) stated: “We have discontinued the liquidity-adjusted TIPS expected inflation estimates for the time being. The adjustment was designed for more normal liquidity premiums. We believe that the extreme rush to liquidity is affecting the accuracy of the estimates.”

**Figure 3. Alternative Proxies for Inflation Uncertainty and Liquidity Premium**



**Note:** This figure shows the implied volatilities from bond options, the disagreement of five-year inflation forecasts in the Michigan survey, the TIPS trade as a fraction of the outstanding volume, and the VIX.

Reuters/University of Michigan (2010). The Michigan survey is a monthly survey of approximately 500 randomly chosen consumers. The preliminary data is released in the middle of the month. Compared with the SPF, the inflation expectations appear to be somewhat higher (hovering around 3 percent instead of 2.5 percent). However, the general movements appear to be in line with the SPF—with a variability somewhere between that of the three- and ten-year expectations (except, possibly, toward the end of the sample, where the Michigan survey increases substantially).

The upper panels of figure 3 show two alternative proxies for inflation uncertainty. The upper-left subfigure shows (monthly averages of) implied volatilities from CME's options on bond futures.<sup>7</sup>

<sup>7</sup>The futures are on a thirty-year Treasury bond and are available since December 1999. Data for options on bonds with shorter maturities are available only for a shorter sample.

Similar to the SPF inflation uncertainty in figure 2, there are local peaks in 2002, 2004, and toward the end of the sample. The upper-right subfigure shows the disagreement (cross-sectional interquartile range) of the five-year inflation forecasts in the monthly Michigan survey—the idea being that disagreement may be correlated with uncertainty about future inflation (see, for instance, Giordani and Söderlind 2003 for a critical assessment).<sup>8</sup> The disagreement shares some movements with the other measures of inflation risk, but shows some idiosyncratic patterns—for instance, the local peak in 2006. (Similar proxies for inflation uncertainty have previously been used by D’Amico, Kim, and Wei 2008, Gürkaynak, Sack, and Wright 2008, and Ciccarelli and García 2009.)

The lower panels of figure 3 show two alternative (monthly) proxies for the liquidity premium on real bonds: the TIPS trade volume from the Federal Reserve Bank of New York (2010) in relation to the volume of outstanding TIPS from the U.S. Treasury (2010) and the Chicago Board of Exchanges’s volatility index VIX (derived from options on the S&P 500). Both variables have some similarities with the off-the-run premium (with a reversed sign for the VIX).<sup>9</sup>

### 3. Empirical Results

#### 3.1 Long-Term Break-Even Inflation

Figure 4 (left panel) shows the “break-even deviation” ( $i - r - E\pi$ ) for the ten- and three-year horizons—which are the dependent variables in the regressions below (except in some of the subsequent robustness analysis). These deviations peak in 1997, 2000, and 2004–08, with troughs in 1999 and 2002–03.

Table 1 reports results from a number of regressions of the ten-year break-even deviation based on model (2). The sample is quarterly (since the SPF is) and covers the period 1997:Q1–2008:Q2.

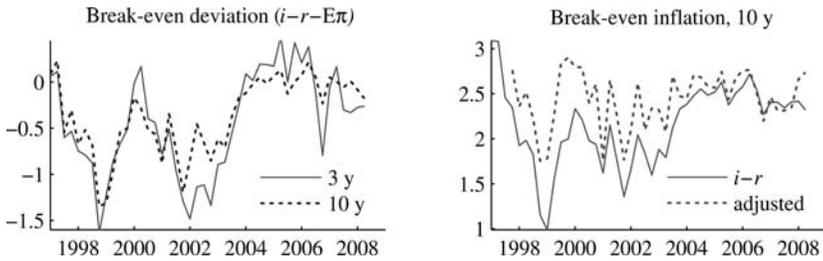
The first column shows that the off-the-run premium has a coefficient of  $-3.07$ , which is close to the slope in the Federal Reserve Bank of Cleveland (2010) discussed above, and that the inflation

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<sup>8</sup>It can be shown that the disagreement about one-year inflation gives similar results.

<sup>9</sup>See Fleming and Krishnan (2009) for a discussion of the TIPS market.

**Figure 4. “Break-Even Deviation” and Break-Even Inflation**



**Note:** This figure shows the break-even deviation (nominal interest rate minus the real interest rate minus the inflation expectations according to the SPF) and the break-even inflation (nominal minus real interest rate, with/without adjustment).

**Table 1. Regression Results, Break-Even Deviation for the Ten-Year Maturity, Quarterly Data**

	(1)	(2)	(3)	(4)	(5)
Inflation Uncertainty	2.77 (3.81)	2.38 (3.02)	1.94 (2.56)	2.36 (2.81)	3.19 (4.24)
Implied Volatility				-3.81 (-1.22)	
Inflation Disagreement					0.69 (1.48)
Off-the-Run Premium	-3.07 (-3.68)	-2.88 (-3.43)	-0.79 (-1.27)	-2.18 (-2.03)	-2.95 (-3.70)
TIPS Trade		1.59 (1.04)			
VIX			-0.04 (-5.81)		
Constant	-0.38 (-7.33)	-0.37 (-7.00)	-0.38 (-9.82)	-0.34 (-6.59)	-0.38 (-7.60)
R <sup>2</sup>	0.45	0.46	0.67	0.42	0.47
Observations	43.00	41.00	43.00	34.00	43.00

**Notes:** The table shows regression coefficients and *t*-statistics (in parentheses) for quarterly data 1997:Q1–2008:Q2. The dependent variable is the nominal interest rate minus the real interest rate and minus expected inflation (ten-year horizon). All regressors (except the constant) are demeaned. The *t*-statistics are based on a Newey-West estimator with one lag.

uncertainty has a coefficient of 2.77. According to Newey-West standard errors, both coefficients are significant at any traditional significance level. Based on the signs of the coefficients, these variables can be thought of as capturing the real liquidity premium and the inflation risk premium, respectively. In this and all subsequent regressions, “inflation uncertainty” is measured as the moving average over the current and lagged quarter. The reason appears to be that quarterly data is fairly noisy, but the broader movements of subjective beliefs about future inflation are strongly related to the break-even deviation.

According to these estimates, the real liquidity premium and the inflation risk premia contribute significantly to the movements of the break-even deviation seen in figure 4. For instance, the off-the-run premium and the inflation uncertainty both have a range of 0.2 (see figure 2). Multiplying by 3 (the coefficients are  $-3.07$  and  $2.77$ , respectively) suggests that each component moves the fitted values by 0.6, which is around a third of the observed movements of the break-even deviation.

To be more precise, the trough of the break-even deviation in 1999 (see figure 4) is mostly due to a high real liquidity premium: the off-the-run liquidity premium is high then (perhaps related to the Y2K scare). The real liquidity premium falls back over the next year, creating a local peak in the break-even deviation in 2000. The moderately low break-even deviation in 2002–03 (corresponding roughly to the period of deflation scare) is similar to the trough in 1999 (that is, mostly driven by a high liquidity premium), except that the increase in the inflation risk premium prevents the break-even deviation from falling very much. The very high break-even deviation in 2004–07 is initially driven by a low liquidity premium—and later increased further by a higher inflation risk premium.

The implications for break-even inflation are shown in the right panel of figure 4. By reshuffling (2) we have

$$i - r + LPr - IRP = E\pi. \quad (3)$$

The figure shows both the traditional break-even inflation rate ( $i - r$ ) and an adjusted one ( $i - r + LPr - IRP$ ). The adjustment amounts to making the troughs in 1999 and 2002–03 much less pronounced but the peak in 2000 higher.

The policy relevance of these findings is hard to judge. Clearly, policy analysis and decisions are based on a very large information set, and break-even inflation is only one piece. However, if we were to entertain the idea that break-even inflation is a key number, then the findings in figure 4 have important implications. In particular, they suggest that monetary policy should have been tighter during much of the early part of the sample.

The other four columns of table 1 provide variations on the same specification by adding other proxies. It is worth noticing that inflation uncertainty stays significantly positive in all variations and that the off-the-run premium is significantly negative in all but one case.

Columns 2 and 3 add alternative proxies for the real liquidity premium. In column 2, the trading volume of TIPS (as a fraction of the outstanding volume) has a positive point estimate (indicating a negative relation with the liquidity premium of the real interest rate), but it is far from being statistically significant. In column 3, the VIX has a negative (and strongly significant) coefficient—suggesting that the liquidity premium of the real interest rate increases when equity market volatility does. In fact, it seems as if the VIX dominates the off-the-run premium in accounting for the real liquidity premium (without destroying the importance of the inflation risk variable). Still, these variables seem to be close substitutes—and the off-the-run premium is by now a reasonably well-established proxy (see the Federal Reserve Bank of Cleveland 2010) and has the appeal of focusing on the liquidity on the Treasury bond market, rather than general financial turbulence.

Columns 4 and 5 of table 1 add alternative proxies for inflation uncertainty. In column 4, the implied volatility from bond options shows up with the wrong sign and is far from significant. In column 5, the disagreement (measured as the cross-sectional interquartile range) among the respondents of the survey has the expected positive sign, but it is also not significant. It can also be shown (not tabulated) that uncertainty of future output growth (according to the distributions reported to the SPF) is not significant.

Overall, table 1 suggests a simple specification where the inflation risk premium is approximated by the inflation uncertainty from the SPF and the real liquidity premium is approximated by either the off-the-run premium or the VIX. All other proxies are insignificant.

**Table 2. Regression Results, Break-Even Deviation for the Three-Year Maturity, Quarterly Data**

	(1)	(2)	(3)	(4)	(5)
Inflation Uncertainty	2.38 (1.93)	1.65 (1.28)	1.23 (1.16)	1.61 (1.12)	3.18 (2.62)
Implied Volatility				-2.67 (-0.54)	
Inflation Disagreement					1.32 (1.36)
Off-the-Run Premium	-3.85 (-3.27)	-3.46 (-3.02)	-0.71 (-0.94)	-4.10 (-1.82)	-3.62 (-3.24)
TIPS Trade		3.12 (1.00)			
VIX			-0.05 (-7.28)		
Constant	-0.45 (-5.17)	-0.44 (-4.94)	-0.45 (-6.70)	-0.42 (-3.77)	-0.45 (-5.36)
R <sup>2</sup>	0.32	0.34	0.54	0.30	0.36
Observations	43.00	41.00	43.00	34.00	43.00

**Notes:** The table shows regression coefficients and *t*-statistics (in parentheses) for quarterly data 1997:Q1–2008:Q2. The dependent variable is the nominal interest rate minus the real interest rate and minus expected inflation (three-year horizon). All regressors (except the constant) are demeaned. The *t*-statistics are based on a Newey-West estimator with one lag.

### 3.2 Comparison across Maturities

Table 2 is similar to table 1, except that it studies the three-year horizon. The point estimates are very similar to those for the ten-year horizon, but the significance of inflation uncertainty is weaker (the liquidity premium and the VIX are still strongly significant).

Results for other maturities (not tabulated) indicate that the five-year horizon looks very similar to the ten-year horizon (this is also true for the five-year “forward rate” starting five years ahead). In contrast, the one-year horizon (with all the caveats about the quality of the TIPS data for short maturities) is fairly similar to the three-year horizon. Overall, it seems as if liquidity premia and the VIX are important for all maturities, but inflation uncertainty is important only for medium and long maturities (five years and up).

### 3.3 *Sensitivity Analysis*

The results reported so far are based on quarterly data (since the SPF is a quarterly survey). As a sensitivity analysis, this section takes a look at monthly data. The inflation expectations here are from the Michigan survey and are for five-year inflation (and therefore combined with five-year interest rates). The Michigan survey has no direct information about inflation uncertainty, but it turns out that the implied volatility of bond options provides a proxy. (Recall that in table 1, the implied volatility is dominated by the inflation uncertainty.)

The basic specification is therefore to regress the five-year break-even deviation on the implied bond volatility and the off-the-run premium—and then to consider various extensions. Table 3 shows the results. Column 1 suggests that the basic specification does a decent job: the implied bond volatility has a significantly positive coefficient and might therefore capture the inflation risk premium, while the off-the-run premium has a significantly negative coefficient (as before).

Columns 2 and 3 add different proxies for the real liquidity premium: both the TIPS trading volume and the VIX have the expected signs and are significant. Columns 4 and 5 instead add alternative proxies for inflation risk. In column 5, the disagreement among the Michigan survey participants is (again) not significant. However, column 4 shows that a fitted monthly series of inflation uncertainty is. This series is created by first regressing the (quarterly) SPF series on inflation uncertainty on the (monthly) implied volatility and inflation disagreement—and then filling in the missing values with the fitted values.

Overall, the sensitivity analysis indicates that the quarterly and monthly frequencies give fairly similar results—although the lack of a clean measure of inflation uncertainty is a drawback of the monthly data.

## 4. **Break-Even Inflation in Other Economies**

Break-even inflation is used in many countries—and some even have extensive survey data on inflation uncertainty. This section briefly discusses that data for the United Kingdom and the euro area.

**Table 3. Regression Results, Break-Even Deviation for the Five-Year Maturity, Monthly Data**

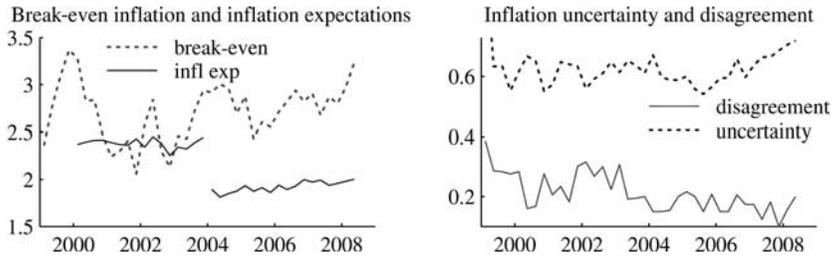
	(1)	(2)	(3)	(4)	(5)
Inflation				2.37	
Uncertainty (Fitted)				(2.54)	
Implied Volatility	3.17	0.84	5.60	2.93	3.66
	(2.30)	(0.67)	(3.37)	(2.25)	(2.60)
Inflation					-0.59
Disagreement					(-1.69)
Off-the-Run	-3.41	-1.93	-1.55	-3.25	-3.59
Premium	(-6.80)	(-3.28)	(-2.63)	(-6.95)	(-7.02)
TIPS Trade		4.70			
		(4.32)			
VIX			-0.03		
			(-4.98)		
Constant	-0.76	-0.76	-0.77	-0.76	-0.77
	(-21.42)	(-22.53)	(-25.12)	(-22.69)	(-21.79)
R <sup>2</sup>	0.32	0.44	0.50	0.36	0.35
Observations	103.00	103.00	103.00	103.00	103.00

**Notes:** This table shows regression coefficients and *t*-statistics (in parentheses) for monthly data 1997:M1–2008:M6. The dependent variable is the nominal interest rate minus the real interest rate and minus expected inflation (five-year horizon). All regressors (except the constant) are demeaned. The *t*-statistics are based on a Newey-West estimator with one lag.

The left panel of figure 5 shows UK break-even inflation (four years) and inflation expectations (two years), while the right panel shows inflation uncertainty and disagreement (based on the Bank of England's [BoE's] survey of external forecasters, also two-year horizon) from Boero, Smith, and Wallis (2008).<sup>10</sup> The survey data has a shorter horizon than the break-even inflation since the BoE only

<sup>10</sup>The break-even inflation rates are from the Bank of England's home page, [www.bankofengland.co.uk/statistics/yieldcurve/archive.htm](http://www.bankofengland.co.uk/statistics/yieldcurve/archive.htm). The point forecasts are based on the average probabilities published in the Inflation Report (various issues). The data on uncertainty and disagreement was kindly provided by Kenneth F. Wallis. (The Bank of England does not yet publish the individual data from their survey.)

**Figure 5. Data for UK Inflation: Break-Even Inflation, Inflation Expectations, and a Measure of Inflation Uncertainty**



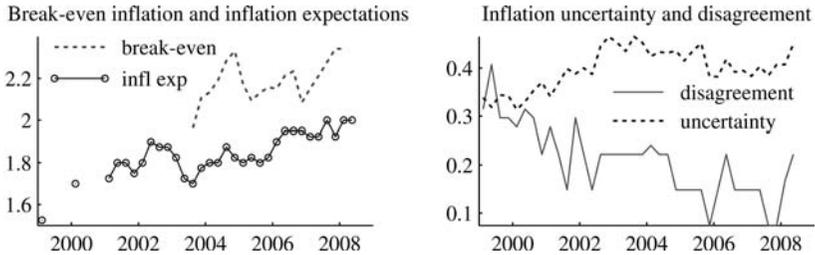
**Notes:** The left subfigure shows the four-year break-even inflation and the two-year inflation expectations (from the BoE survey of external forecasters). The right subfigure shows the inflation uncertainty and disagreement estimated from the individual answers (in the BoE survey of external forecasters) for the two-year horizon. The BoE asked about RPIX until November 2003 and CPI after that. The break-even inflation refers to RPI.

started asking about somewhat longer horizons in 2006. In addition, there is a break in the inflation expectations since the survey switched in early 2004 from asking about RPIX to CPI. In spite of these issues, there are interesting features of the data.

First, break-even inflation appears to vary much more than inflation expectations. This suggests that inflation risk and liquidity premia may have played an important role. For instance, break-even inflation moves away from inflation expectations—around the same time as uncertainty and disagreement are high. Second, both break-even inflation and inflation uncertainty seem to be somewhat more stable in the United Kingdom than in the United States (compare figures 2 and 4)—although the levels cannot be compared, as they refer to different horizons. This gives some additional support to Gürkaynak, Levin, and Swanson (2010), who argue that inflation expectations are more firmly anchored in the (inflation-targeting) United Kingdom than in the United States. (However, UK inflation uncertainty was distinctly higher before 2000—and the 1999:Q1 uncertainty is actually outside the chart.) In any case, this data deserves to be analyzed further.

Figure 6 shows similar data for the euro area. The break-even inflation rates are from inflation swaps from Beechey, Johannsen, and Levin (2010), and the other data is based on the individual

**Figure 6. Data for Euro Inflation: Break-Even Inflation, Inflation Expectations, and Measures of Inflation Uncertainty and Disagreement**



**Notes:** The left subfigure shows the break-even inflation (from inflation swaps) and the corresponding inflation expectations (from the ECB SPF) for a four-year period starting one year ahead. The right subfigure shows the inflation uncertainty and disagreement estimated from the individual answers (in the ECB SPF) for the two-year horizon.

answers to the ECB Survey of Professional Forecasters.<sup>11</sup> As for the United Kingdom and United States, the break-even inflation rates are for a longer horizon than the survey data.

Once again, break-even inflation moves more than inflation expectations—and there are some indications that the deviation is related to inflation uncertainty (although the sample is short). It also seems as if the euro-area break-even inflation rates and inflation uncertainty are somewhat more stable than in the United States.

Some work has been done on using the survey data in explaining the euro-area break-even inflation rates. In particular, García and Werner (2010) show, in an estimated no-arbitrage yield-curve model, that it is perhaps not inflation uncertainty, but the perceived asymmetry (skewness) of inflation risks, that affects inflation risk premia.

## 5. Concluding Remarks

This paper tries to explain the observed “break-even deviation” (the difference between break-even inflation and survey data on inflation expectations) by the off-the-run liquidity premium and the

<sup>11</sup>The data is available at [www.aeaweb.org/forthcoming/output/accepted\\_MAC.php](http://www.aeaweb.org/forthcoming/output/accepted_MAC.php) and [www.ecb.int/stats/prices/indic/forecast/html/index.en.html](http://www.ecb.int/stats/prices/indic/forecast/html/index.en.html).

survey data (from the Survey of Professional Forecasters) on inflation uncertainty. It is found that these variables are statistically and economically significant. Inflation uncertainty seems to capture an inflation risk premium, while the off-the-run liquidity premium proxies the real liquidity premium. This leads to important adjustments of break-even inflation.

The major comparative advantage of break-even inflation (relative to inflation surveys) is being a fast source of information. In particular, it helps analysts and policymakers to quickly gauge inflation expectations after important events. The findings in this paper suggest ways to adjust break-even inflation to get a better proxy of inflation expectations. In particular, if the event is associated with financial market turbulence, then this is likely to raise the real liquidity premium—which tends to decrease break-even inflation. The regression results presented above suggest how to adjust break-even inflation upward. In contrast, if the event is likely to increase inflation uncertainty, then this will drive up nominal rates—increasing break-even inflation. The regression results then show how to adjust break-even inflation down.

The main database of the paper—the Survey of Professional Forecasters—is only quarterly. Therefore, I also studied the monthly Reuters/Michigan Survey of Consumers, which contains inflation expectations but no direct measure of inflation uncertainty. The results suggest, however, that information from bond option prices may provide a reasonable proxy for inflation uncertainty, while data on disagreement (among the survey participants) about future inflation forecasts does not. There is also some evidence that the TIPS trading volume and the VIX index may help explain the liquidity premium of real bonds.

I hope that this paper contributes to the understanding of the economic factors behind the inflation risk and liquidity premia. It could also be of help to central bank staff and others who need to adjust break-even inflation. Further research might be able to find better high-frequency proxies for inflation uncertainty and thereby further improve current practices.

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