NBER WORKING PAPER SERIES

INFLATION-INDEXED BONDS AND THE EXPECTATIONS HYPOTHESIS

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Working Paper 16903
http://www.nber.org/papers/w16903

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
March 2011

Pflueger, CE, Viceira, LM. 2011. "Inflation-Indexed Bonds and the Expectations Hypothesis." Annu. Rev. Econ. 3: Submitted. Doi:10.1146/annurev-financial-102710-144843.

We are grateful to seminar participants at the HBS-Harvard Economics Finance Lunch, John Campbell, Graig Fantuzzi, Josh Gottlieb, Robin Greenwood and Jeremy Stein for helpful comments and suggestions. We are also grateful to Martin Duffell and Anna Christie from the UK Debt Management Office for their help providing us with UK bond data. This material is based upon work supported by the Harvard Business School Research Funding. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

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NBER Working Paper No. 16903
March 2011
JEL No. G12

ABSTRACT

This paper empirically analyzes the Expectations Hypothesis (EH) in inflation-indexed (or real) bonds and in nominal bonds in the US and in the UK. We strongly reject the EH in inflation-indexed bonds, and also confirm and update the existing evidence rejecting the EH in nominal bonds. This rejection implies that the risk premium on both real and nominal bonds varies predictably over time. We also find strong evidence that the spread between the nominal and the real bond risk premium, or the break-even inflation risk premium, also varies over time. We argue that the time variation in real bond risk premia mostly likely reflects both a changing real interest rate risk premium and a changing liquidity risk premium, and that the variability in the nominal bond risk premia reflects a changing inflation risk premium. We estimate significant time series variability in the magnitude and sign of bond risk premia.

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1 Introduction

This article conducts an empirical exploration of the magnitude and time variation of risk premia in inflation-indexed and nominal government bonds, using data on US Treasury bonds and UK gilts. Understanding bond risk premia is fundamental in thinking about the term structure of interest rates. It is also of first order importance for bond issuers, since public debt constitutes one of the main sources of government financing, and for users, whether central banks or investors. Central banks use government bonds as a key instrument in the execution of monetary policy, while investors use them as the anchor of their fixed income allocations.

The most common form of government bonds are nominal bonds that pay fixed coupons and principal. However, in recent times governments around the world, including the U.S. Treasury, have started issuing significant amounts of inflation-indexed bonds (Campbell, Shiller, and Viceira 2009). Inflation-indexed bonds, which in the U.S. are known as Treasury Inflation Protected Securities (TIPS), are bonds whose coupons and principal adjust automatically with the evolution of a consumer price index[2]. They aim to pay investors a fixed inflation-adjusted coupon and principal. For this reason they are also known as real bonds, and their yields are typically considered the best proxy for the term structure of real interest rates in the economy.

Although government bonds in large stable economics are generally free from default risk, they expose investors to other risks. Investors holding either inflation-indexed or nominal government bonds are exposed to the risk of changing real interest rates. For any investor the riskless asset is an inflation-indexed bond whose cash flows match his consumption plan (Campbell and Viceira 2001, Wachter 2003). If future real interest rates are uncertain, investors will view bonds not matching the timing and length of their consumption plans as risky, leading to a risk premium for holding such bonds. This real interest rate risk premium will be a function of investors' risk tolerance, and it can be time-varying if investors' tolerance for risk changes over the business cycle (Campbell and Cochrane 1999, Wachter 2006). A time-varying correlation of real interest rates with investor well-being can also make the real interest rate risk premium vary over time (Campbell, Sunderam, and Viceira 2010).

[2] In the US, TIPS payments are linked to the Consumer Price Index for All Urban Consumers (CPI-U). The relevant index in the UK is the Retail Price Index (RPI).

In addition to real interest rate risk, nominal government bonds expose investors to inflation risk. When future inflation is uncertain, the coupons and principal of nominal bonds can suffer from the eroding effects of inflationary surprises. If inflation is negatively correlated with economic conditions, as in times of stagflation, the real payoffs of nominal bonds will tend to decline when economic conditions worsen. Risk averse investors will therefore demand a positive inflation risk premium for holding nominal bonds. But if inflation is positively correlated with economic conditions, nominal bonds will have hedging value to risk-averse investors (Piazzesi and Schneider 2007, Campbell, Sunderam, and Viceira 2010). By contrast, inflation-indexed bonds are not exposed to inflation risk, since their coupons and principal adjust automatically with inflation.[3]

The starting point of our empirical investigation of bond risk premia is the expectations hypothesis of interest rates (EH for short). The EH postulates that the risk premium on long-term bonds, or the expected excess return on long-term bonds over short-term bonds, should be constant over time. If the EH holds for inflation-indexed bonds, this implies that the real interest rate risk premium is constant. In that case the yield on long-term inflation-indexed bonds is equal to the average expected short-term real interest rate over the life of the bond plus a constant. Investors cannot earn predictable returns by shifting between long-maturity and short-maturity real bonds.

The implications of the EH for nominal bonds are stronger. If it holds, both the inflation risk premium and the real interest rate risk premium are constant[4]. In that case the yield on long-term nominal bonds is equal to the average expected future short-term nominal interest rate up to a constant. A rejection of the nominal expectations hypothesis can be the result of a time-varying inflation risk premium, a time-varying real interest rate risk premium, or both. Without independent observation of real bond prices it is hard to distinguish between those sources of time variation in nominal bond risk premia.

In our analysis we adopt a flexible empirical approach that does not rely on a tightly parameterized model[5]. The EH has been tested and rejected on U.S. nominal

[3]Tax regulations in some countries, including the US, make the after-tax income and capital gains from inflation-indexed bonds not fully inflation indexed. This effect can be exacerbated at times of high accelerating inflation. See Section 2.

[4]Unless we are in the unlikely case where time-variation in the inflation risk premium and the real interest rate risk premium exactly cancel each other out.

[5]See Adrian and Wu (2009), Buraschi and Jiltsov (2004), Campbell, Sunderam, and Viceira (2010), Christensen, Lopez, and Rudebusch (2010) and Evans (2003) for formal models of the term

Treasury bonds numerous times, but previous tests for inflation-indexed bonds only had significantly shorter samples at their disposal and were not able to reject the expectations hypothesis (Barr and Campbell 1997). Campbell and Shiller (1991) present regression results for different combinations of maturities and holding periods and resoundingly reject the expectations hypothesis for U.S. nominal bonds. Fama and Bliss (1987), Cochrane and Piazzesi (2005) and others have also presented robust empirical evidence that nominal Treasury bond risk premia vary over time. However, Campbell (1999) presents evidence that the expectations hypothesis is harder to reject on nominal government bonds in a cross-section of other developed economies.

The structure of this article is as follows. Section 2 describes the mechanics of inflation-indexed bonds. Section 3 formalizes the expectations hypothesis of the term structure of interest rates and expected inflation. Section 4 tests the expectations hypothesis in real and nominal bonds. Section 5 provides evidence on real and nominal bond return predictability from the tent-shaped linear combination of nominal interest rates proposed by Cochrane and Piazzesi (2005). Section 6 shows estimates of bond risk premia and their variation over time. Finally, section 7 offers some concluding remarks and suggestions for future research.

2 Inflation-Indexed Bonds

Inflation-indexed bonds have been available in the UK since 1983 and in the US since 1997. US inflation-indexed bonds are called Treasury Inflation Protected Securities (TIPS). They are designed to approximate real bonds with payouts that are constant despite inflation surprises. They are quoted in terms of a real interest rate and are issued mostly at long maturities greater than 10 years. The principal on these bonds grows with a pre-specified price index, which in the U.S. is the Consumer Price Index (CPI-U) and in the UK is the Retail Price Index (RPI). The coupons are equal to the inflation-adjusted principal on the bond times a fixed coupon rate. Thus the coupons on these bonds also fluctuate with inflation.

Of course, the price index might not grow over time. For instance the CPI decreased by almost 4% between September 2008 and December 2008. In the US, the final payment of principal on a TIPS is protected against deflation and it can never

structure of interest rates that analyze and estimate inflation and real interest rate risk premia using data on both real and nominal bonds.

be smaller than the stated nominal value at issuance. However, its coupons are not: the inflation-adjusted value of the principal for coupon computation purposes can fall below the initial value at issuance. In contrast, neither the principal nor the coupons on inflation-linked gilts in the UK are protected from deflation.

Further details complicate the pricing of these bonds. Since inflation figures in the US and in the UK are published with a lag, the principal value of inflation-indexed bonds adjusts with a 3 month lag. UK inflation-linked gilts that were issued prior to the financial year 2005-06 follow an 8 month lagged indexing procedure while more recent issues follow a 3 month lagged methodology. The tax treatment of these bonds also differs. In the UK principal adjustments of inflation-linked gilts are not taxed. This gives inflation-linked gilts a tax advantage over nominal gilts, a larger share of whose cash flows come in the form of taxable nominal coupon payments. In the US, on the other hand, inflation-adjustments of principal are considered ordinary income for tax purposes. As a result the tax obligations associated with holding a TIPS increase when inflation is high so that on an after-tax basis U.S. TIPS are not fully indexed to inflation. More details on TIPS can be found in Viceira (2001), Roll (2004) and Gurkaynak, Sack, and Wright (2010). Campbell and Shiller (1996) offer a discussion of the taxation of inflation-indexed bonds. Campbell, Shiller, and Viceira (2009) provide an overview of the history of inflation-indexed bonds in the US and the UK.

3 The Expectations Hypothesis

The expectations hypothesis of the term structure of interest rates says that the excess return on an n-period bond over a 1-period bond should be constant over time. There should not be any particularly good time to hold short-term or long-term bonds. Equivalently, the expectations hypothesis says that if short yields are anticipated to rise in the future then this should already be reflected in current long yields. The expectations hypothesis is usually stated for nominal bonds. We formulate expectations hypotheses for nominal bonds, real bonds and for inflation expectations. We show that these different interpretations of the expectations hypothesis are closely related to real interest rate risk, inflation risk and liquidity premia and derive empirical predictions that we will test subsequently.

3.1 Bond Notation and Definitions

We start by establishing some notation and definitions that will be used throughout the article. We denote by $p^{\$}_{n,t}$ the log price of a zero-coupon n-period nominal bond, and by $y^{\$}_{n,t}$ the bond's log (or continuously compounded) yield. For zero-coupon bonds, log price and yield are related according to

$$y^{\$}_{n,t} = -\left(\frac{1}{n}\right) p^{\$}_{n,t}. \tag{1}$$

The yield spread is the difference between a long-term yield and a short-term yield, $s^{\$}_{n,t} = y^{\$}_{n,t} - y^{\$}_{1,t}$.

The log return on a zero-coupon n-period bond if it is held for one period and sold before maturity is given by the change in its price, i.e.

$$\begin{aligned} r^{\$}_{n,t+1} &= p^{\$}_{n-1,t+1} - p^{\$}_{n,t} \\ &= ny^{\$}_{n,t} - (n-1)\, y^{\$}_{n-1,t+1}, \end{aligned} \tag{2}$$

where the second equality follows immediately from (1).

We use the superscript $TIPS$ to denote the corresponding quantities for both US and UK inflation-indexed bonds. Inflation-indexed bonds are commonly quoted in terms of *real* yields. That is $p^{TIPS}_{n,t}$ is the *real* log price of an indexed bond, $y^{TIPS}_{n,t}$ is the *real* yield and $r^{TIPS}_{n,t+t}$ is the *real* one-period log return. The nominal one-period log return on an inflation-indexed bond is then given by $r^{TIPS}_{n,t+1} + \pi_{1t}$, where π_{1t} denotes the 1-period log inflation rate from period t to period $t+1$.

3.2 Nominal Expectations Hypothesis

The nominal EH states that the expected log excess return on long-term nominal bonds over short-term nominal bonds, or bond risk premium, is constant over time:

$$\mathrm{E}_t \left[r^{\$}_{n,t+1} - y^{\$}_{1,t} \right] = \mu^{\$}_n, \tag{3}$$

where the constant bond risk premium $\mu^{\$}_n$ can depend on maturity n. The advantage of formulating the expectations hypothesis in logs is that the log expectations hypothesis for one holding period is consistent with the log expectations hypothesis for any other holding period.[6]

The EH can be represented in a number of different ways that obtain by simple algebraic manipulation of (2) and (3).[7] A popular equivalent representation of the nominal EH relates the yield on a n-period zero-coupon nominal bond at time t to expected future short-term nominal interest rates:

$$y^{\$}_{n,t} = \theta^{\$}_{n} + \frac{1}{n} \mathrm{E}_t \sum_{i=0}^{n-1} y^{\$}_{1,t+i}. \tag{4}$$

Equation (4) says that the current n-period yield should be equal to the expected average short yields over its maturity up to a time-invariant constant $\theta^{\$}_{n}$. The constant $\theta^{\$}_{n}$ is simply the average of bond risk premia for maturities up to n periods, i.e., $\theta^{\$}_{n} = \sum_{i=2}^{n} \mu^{\$}_{i}/n$. A second equivalent representation of the nominal EH relates changes in long-term yields to the yield spread

$$\mathrm{E}_t \left[y^{\$}_{n-1,t+1} - y^{\$}_{n,t} \right] = \left(\theta^{\$}_{n-1} - \frac{n}{n-1} \theta^{\$}_{n} \right) + \frac{1}{n-1} s^{\$}_{n,t}. \tag{5}$$

Although these alternative equivalent representations of the EH provide useful intuition to understand the meaning and implications of the EH, we choose to work with the return-based definition (3) in our empirical exploration of the EH. This approach allows for transparent interpretation of empirical results in terms of return predictability, and it is flexible enough to easily accommodate a complementary analysis of liquidity premia and supply pressures in the bond market.

The EH says that $r^{\$}_{n,t+1} - y^{\$}_{1,t}$ cannot be predicted. However, early tests of the EH based on (5) found robust evidence that the nominal term spread—or an equivalent combination of forward rates—predicts nominal excess returns positively (Campbell and Shiller 1991, Fama and Bliss 1987). That is, whenever the term spread is high

[6] Another version of the expectations hypothesis, the so-called pure expectations hypothesis (PEH), considers a formulation of (3) in terms of *simple* returns as opposed to *log* returns, and sets expected excess simple returns to zero (Campbell, Lo, and MacKinlay 1997). The intuition of the PEH is that if investors are risk neutral then they should adjust positions until the expected one-period returns for short nominal bonds and long nominal bonds are equalized. The log EH (3) is less constraining in that it allows for a non-zero bond risk premium.

[7] For a detailed discussion of equivalent formulations of the expectations hypothesis see Campbell, Lo, and MacKinlay (1997, Chapter 10) or Cochrane (2005, Chapter 19).

the risk premium on long nominal bonds is higher.[8] Building on this prior work, we test in our data whether the term spread contains a time-varying risk premium by running the regression test

$$r^{\$}_{n,t+1} - y^{\$}_{1,t} = \alpha^{\$} + \beta^{\$} s^{\$}_{n,t} + \varepsilon^{\$}_{t+1}, \tag{6}$$

where $\beta^{\$} = 0$ under the null that the EH holds. Of course, failing to reject $\beta^{\$} = 0$ in (6) does not imply that we fail to reject the EH, as other state variables might forecast bond excess returns. Thus we also include in (6) other variables that have been shown to forecast bond excess returns in our empirical analysis.

3.3 Real Expectations Hypothesis

The EH has traditionally been formulated and tested in terms of nominal bonds but it appears at least as plausible to formulate the hypothesis in terms of real bonds. The nominal EH supposes that the bond risk premium on nominal bonds, consisting of both inflation risk and real interest rate risk, is constant over time. The EH for inflation-indexed bonds is strictly weaker in that it only supposes that real interest rate risk is constant.

Expressed in terms of returns the EH for inflation-indexed zero-coupon bonds says that

$$E_t\left[r^{TIPS}_{n,t+1} - y^{TIPS}_{1,t}\right] = \mu^{TIPS}_{n}, \tag{7}$$

Analogously to the nominal EH we test the real EH by testing whether the real term spread predicts excess returns on real bonds:

$$r^{TIPS}_{n,t+1} - y^{TIPS}_{1,t} = \alpha^{TIPS} + \beta^{TIPS} s^{TIPS}_{n,t} + \varepsilon^{TIPS}_{t+1} \tag{8}$$

where $s^{TIPS}_{n,t} = y^{TIPS}_{n,t} - y^{TIPS}_{1,t}$ is the TIPS bond spread. The real EH hypothesis implies that the coefficient of real excess log returns of inflation-indexed bonds on the real term spread should be zero. If $\beta^{TIPS} \neq 0$ then we can infer that the real yield reflects time-varying real risk premia and μ^{TIPS}_{n} is time-varying. The TIPS bond spread is a natural candidate regressor due to its similarity to the nominal bond spread. Since TIPS are not exposed to inflation surprises the TIPS yield spread should not reflect

[8] This is equivalent to finding a negative slope in a regression of changes in the yield on long-term bonds on $s^{\$}_{n,t}/(n-1)$.

inflation risk, although it might reflect other risk premia such as real interest rate risk and liquidity premia. Hence, if any of these premia are important in driving the rejection of the nominal expectations hypothesis they would be likely to be reflected in terms of a nonzero coefficient β^{TIPS}.

3.4 Breakeven Inflation and the Inflation Expectation Hypothesis

We now look at the difference between nominal and indexed yields, known by bond market participants as "breakeven inflation:"

$$b_{n,t} = y^{\$}_{n,t} - y^{TIPS}_{n,t} \tag{9}$$

Most simply n-period breakeven inflation is the inflation rate over the next n periods that would make a nominal bond and an indexed bond of maturity n earn the exact same buy-and-hold return. The nominal bond outperforms the inflation-indexed bond if realized inflation over the life of the bonds turns out to be smaller than breakeven inflation, and underperforms it if realized inflation turns out to be larger.

Bond market participants often use breakeven inflation as a measure of expected inflation. However, the identification of breakeven inflation with expected inflation is not entirely correct. In order to understand this point, it is useful to think about the components of bond yields, both nominal and inflation-indexed. Economic logic, formally corroborated by models of the term structure of interest rates,[9] suggests that we can decompose the yield–or equivalently, the price—on an inflation-indexed bond into a component that reflects current expectations of future real interest rates, and a component that reflects a real interest rate risk premium. Similarly, we can think of the yield on a nominal bond as composed of the yield on a real bond plus additional components reflecting expectations of future inflation and an inflation risk premium. Thus the spread between both yields, or breakeven inflation, reflects both expected inflation and the inflation risk premium embedded in the nominal bond yield.

If institutional, behavioral, or liquidity factors affect the nominal bond market and the inflation-indexed bond market differently, breakeven inflation will also reflect the differential impact of these factors on yields (Pflueger and Viceira 2010). For example, we think of the market for inflation-indexed bonds to be less liquid than the market for

[9] See references in footnote 5.

nominal bonds. If investors apply a liquidity discount to the price of inflation-indexed bonds, or a liquidity premium to the price of nominal bonds, breakeven inflation will be lower than it would be otherwise, since prices and yields move inversely.[10] When changes in the liquidity differential are correlated with aggregate economic conditions, breakeven inflation will also reflect an additional liquidity risk premium.

Of course, expected inflation, the inflation risk premium, the liquidity differential, and the liquidity risk premium need not be constant over time, causing realized breakeven inflation to move over time. More importantly, time variation in the inflation risk premium or in the liquidity premium can also cause the expected excess return on breakeven inflation, or the difference between the excess return on nominal bonds and the excess return on inflation-indexed bonds of identical maturity, to vary over time. Mechanically, the excess return on breakeven inflation is given by

$$r^b_{t+1} \equiv \left(r^{\$}_{n,t+1} - y^{\$}_{1,t}\right) - \left(r^{TIPS}_{n,t+1} - y^{TIPS}_{1,t}\right) = nb_{n,t} - (n-1)\, b_{n-1,t+1} - b_{1,t}. \qquad (10)$$

Under the assumption of constant inflation and liquidity risk premia, the left-hand side of equation (10) equals a constant plus the expression $n\pi^e_{n,t} - (n-1)\,\pi^e_{n-1,t+1} - \pi_{1,t}$, where $\pi^e_{n,t}$ denotes n-period expected inflation at time t. This expression is zero when inflation expectations are rational. To see this, note that realized inflation verifies

$$n\pi_{n,t} - (n-1)\,\pi_{n-1,t+1} - \pi_{1,t} = 0, \qquad (11)$$

since both $n\pi_{n,t+1}$ and $(n-1)\,\pi_{n-1,t+1} + \pi_{1,t}$ denote cumulative inflation from time t to time $t+n$. Therefore under rational expectations equation (11) must also hold ex-ante.

We call the joint hypothesis of rational inflation expectations and a constant inflation risk premium the inflation expectations hypothesis. By analogy with our tests of the nominal and real EH, we run the regression

$$r^b_{t+1} = \alpha^b + \beta^b s^b_{n,t} + \varepsilon^b_{t+1}, \qquad (12)$$

[10] Campbell, Shiller, and Viceira (2009) document an episode of "flight to liquidity" during the recent financial crisis. In the Fall of 2008 the price of nominal Treasury bonds increased rapidly, while the price of TIPS declined, causing a dramatic narrowing of breakeven inflation, which at some point became even negative. They provide evidence that this change in prices did not reflect a sudden change in the outlook for inflation towards massive deflation, but rather an increase in the liquidity differential between both markets, as investors around the world flew into nominal Treasuries.

where $s^b_{n,t} = b_{n,t} - b_{1,t}$ is the breakeven inflation spread, and test whether $\beta^b = 0$. If the inflation risk premium or the liquidity risk premium are time varying, and they are correlated with the breakeven inflation spread, we would expect to find a nonzero regression slope coefficient β^b in (12). In particular, the breakeven spread $s^b_{n,t}$ should reflect the inflation risk premium contained in the nominal yield spread $s^\$_{n,t}$.

Since the breakeven inflation spread, the nominal term spread, and the real term spread are mechanically related by $s^\$_{n,t} = s^b_{n,t} + s^{TIPS}_{n,t}$, it also makes sense to test whether both the real term spread and the breakeven inflation spread jointly forecast the return on breakeven inflation. It is important to note that neither (12) nor the expanded version of the equation that includes $s^{TIPS}_{n,t}$ are redundant with respect to the standard EH regressions (8) and (6), except of course in the trivial case where the spreads do not forecast bond excess returns and thus all slope coefficients are zero.

4 Testing the Expectations Hypothesis in Real and Nominal Government Bonds

4.1 Data

We conduct tests of the real and nominal EH using government bond data from both the US and UK. For the US we use an expanded version of the Gurkaynak, Sack, and Wright (2007) and Gurkaynak, Sack, and Wright (2010, GSW henceforth) data set. GSW have constructed a zero-coupon yield curve starting in January 1961 for nominal bonds and starting in January 1999 for TIPS by fitting a smoothed yield curve. We expand their data back to 1951 using the McCulloch, Houston, and Kwon (1993) data for US nominal zero coupon yields from January 1951 through December 1960. The GSW data set contains constant maturity yields for maturities of 2 to 20 years. Our empirical tests will focus on the 10-year nominal and real yields, because this maturity bracket has the longest and most continuous history of TIPS outstanding. We measure U.S. inflation with the all-urban seasonally adjusted CPI, and the short-term nominal interest rate with the 3 month T-bill rate from the Fama-Bliss riskless interest rate file from CRSP. TIPS payouts are linked to the all-urban non seasonally adjusted CPI and our results become slightly stronger when using the non seasonally adjusted CPI instead.

For the UK we use zero-coupon yield curves from the Bank of England. Anderson and Sleath (2001) describe the spline-based techniques used to estimate the yield curves. Nominal yields are available starting in 1970 for 0.5 to 20 years to maturity. Real yields are available starting in 1985 for 2.5 to 25 years to maturity. We focus on the 20-year nominal and real yields because they are available from 1985, while other maturities are available only since 1991.We measure inflation by the non seasonally-adjusted Retail Price Index, which serves as the measure of inflation for inflation indexed bond payouts.

In all regressions we approximate $y^{\$}_{n-1,t+1}$ and $y^{TIPS}_{n-1,t+1}$ with $y^{\$}_{n,t+1}$ and $y^{TIPS}_{n,t+1}$. Because neither the US nor the UK governments issue inflation-indexed bills, we need to resort to an empirical procedure to build a hypothetical short-term real interest rate. We describe this procedure in Section 4.2. Finally, although our yield data sets are available at a monthly frequency, we sample our data at a quarterly frequency in order to reduce the influence of high-frequency noise in observed inflation and short-term nominal interest rate volatility in our tests.

4.2 Construction of the Short-Term Real Interest Rate

While three-month nominal T-bills are issued in the US and in the UK, there exists no equivalent short-term instrument with fixed real payoffs. Apart from technical difficulties, the demand would probably not exist simply because inflation risk in both countries has been historically negligible over such a short horizon. However, we need a proxy for a short-term real rate for our tests of the expectations hypothesis. We follow Campbell and Shiller's (1996) analysis of hypothetical TIPS to construct an ex-ante measure of the short-term real interest rate.

We start by assuming zero inflation risk and liquidity premium over 1 quarter. Therefore, the ex-ante short-term real interest rate is given by

$$y^{TIPS}_{1,t} = y^{\$}_{1,t} - \pi^{e}_{1,t}.$$

Next we assume that inflation expectations over the next quarter are rational and proxy for the ex-ante real short rate as the fitted value from the regression of this quarter's realized real rate $y^{\$}_{1,t} - \pi_{1,t+1}$ onto last quarter's realized real rate $y^{\$}_{1,t-1} - \pi_{1,t}$, the nominal short rate $y^{\$}_{1,t}$, and annual inflation up to time t.

Table 1 shows the monthly predictive regressions for the US and the UK. It reports the point estimates of the slope coefficients as well as Newey-West heteroskedasticity and autocorrelation consistent (h.a.c.) standard errors with four lags in parenthesis. The table shows that the main determinant of the ex-ante real rate is the nominal rate, with a positive coefficient of about 0.5 in both the US and the UK. The regressions can explain 44% of the real interest rate variation in the US and 18% of the real interest rate variation in the UK, respectively, and the regressors are jointly significant in both regressions.

Figure 1 shows the predicted and realized US real short rate together with the nominal short rate. It shows that the predicted real short rate very much just follows the nominal short rate and smooths out fluctuations in the ex-post real rate caused by short-term volatility in realized inflation. The estimate is conservative in the sense that it barely relies on lagged realized inflation and it does not attempt to predict high-frequency fluctuations in inflation.

Table 2 presents summary statistics for inflation, short-term nominal and real interest rates, nominal and real yield spreads, breakeven inflation, and bond returns for the US (Panel A) and the UK (Panel B). Because the sample period and bond maturity in each table are different, it is hard to do comparisons across panels. Nonetheless, the average excess return on nominal bonds is similar across both countries, while the average excess return on inflation-indexed bonds have been larger in the US. Bond return volatilities and correlations are generally comparable across both countries, controlling for maturity differentials. The average excess returns and volatilities reported in Table 2 imply sample Sharpe ratios on US real and nominal bonds of 0.392 and 0.542, respectively. These are larger than the corresponding Sharpe ratios for UK real and nominal bonds, at 0.236 and 0.179 respectively.

4.3 The Nominal Expectations Hypothesis in the US

Tables 3 report tests of the nominal EH in the US using our preferred return-based regression test (6). Thus we test whether nominal log excess returns are predictable from the nominal term spread. The objective of this table is to analyze changes in the predictability of nominal bond returns since Campbell and Shiller (1991) reported tests of the nominal EH. Campbell and Shiller (1991) found that they were able to clearly reject the expectations hypothesis for almost all of their maturity combinations for the sample period 1952-1987. Table 3 reruns those same regressions for our full sample period (1951.12-2009.12) with the 10-year constant maturity zero-coupon bond. For comparison we also report them for the Campbell-Shiller sample period and the sample period from 1987 until present.[11] The table reports the point estimates of the slope coefficients and Newey-West standard errors with 3 lags.

Table 3 shows that the full time period 1952-2009 yields an even stronger rejection of the expectations hypothesis than the earlier sample period 1952-1987. At the same time, using the second part of the sample only it is harder to reject the expectations hypothesis at conventional significance levels. Stock and Watson (2002) document a break in the mid-1980s in a number of macroeconomic time series. If the predictability of bond returns is linked to macroeconomic processes, it is conceivable that bond return predictability also experienced a break at the same time.

Following this intuition, the last column of Table 3 examines more closely whether there was a structural change in bond return predictability in 1987. We add the term spread interacted with a dummy for the second sub period, $s_{n,t}^{\$} \times d_{1987-2008}$ to the regression in order to allow for different slope coefficients before 1987 and after 1987. The interaction term does not enter significantly the regression, indicating that we cannot reject the hypothesis of a stable relationship across sub samples. Moreover, the full sample period and the Campbell-Shiller sample period yield very similar regression coefficients and the coefficient is more accurately measured using the full sample period.

Thus the addition of the 1987-2009 period to the early sample period contributes to reinforce the empirical evidence towards rejection of the nominal EH. It also emphasizes the difficulty of detecting this type of bond return predictability in smaller sample sizes, even if the sample comprises more than 20 years of data. This qualification is particularly important for our subsequent analysis of the real EH, because even our longest series of inflation-indexed bonds only spans a 24 year period from 1985 to 2009.

4.4 Expectations Hypothesis Real and Nominal

Table 4 present our main regression tests for the nominal, real and inflation expectations hypothesis in the US and in the UK. Columns 1 through 4 in each panel in

[11] Campbell and Shiller (1991) used the McCulloch, Huston, and Kwon (1993) data of zero coupon yields for their entire period so that our results differ slightly from theirs due to our different data source.

the table report coefficients from the return-based regressions (6), (8), (12) and its expanded version, respectively. The data consists of monthly data of overlapping quarterly returns. Newey-West standard errors are based on 3 lags to adjust for overlapping returns.

Panel A reports the regression tests for the US data from 1999 to 2009. According to the nominal EH the coefficient in column 1 should be zero. We cannot reject the nominal EH over this particular time period at conventional significance levels. However, this rejection is somewhat marginal—the significance level is 15%—and the results in Table 3 indicate that this may well be related to the short sample size rather than a change in the predictive relationship. Column 2 of the panel tests whether excess returns on inflation-indexed bonds are predictable. The coefficient on the real spread is large compared to the coefficient on the nominal spread reported in column 1, and statistically significant at the 1% level. This strong rejection of the real EH is particularly striking in light of the weak rejection of the nominal EH in column 1. It suggests that factors specific to the TIPS market such as liquidity might be driving expected excess return on TIPS, besides real interest rate risk.[12]

Column 3 of Panel A tests the inflation EH in the US. We find that the breakeven spread predicts the difference in nominal and inflation-indexed bond excess returns. Assuming that bond market participants' inflation expectations are rational and that liquidity premia are constant, this result is consistent with a time-varying inflation risk premium. Column 4 also controls for the real term spread in the regression and shows that adding this variable does not affect the predictive power or the coefficient estimate of the breakeven spread. These results suggest that when the breakeven spread increases, inflation risk also increases and investors demand a higher inflation risk premium from nominal bonds.

Interestingly, the real term spread appears to predict breakeven returns negatively in the US. Thus a widening of the real term spread forecasts a decrease in the spread between nominal bond risk premia and inflation-indexed bond risk premia. One might expect that if the real term spread proxies for the real interest rate risk premium, its coefficient should be zero; that is, increases in the real interest rate risk premium should affect approximately in the same proportion the prices of both inflation-indexed bonds and nominal bonds. The rejection of the null hypothesis that

[12]Results ommitted here to save space show that, interestingly, the nominal term spread does not forecast TIPS excess returns, while the real term spread does not forecast nominal bond excess returns.

it is zero suggests that the effect of the real term spread on breakeven inflation returns might be related to liquidity factors (Pflueger and Viceira 2010).

Panel B in Table 4 reports the corresponding results for the UK bond market. The pattern of results is remarkably consistent with the results shown in Panel A for the US bond market, with the exception that the real term spread does not appear to predict breakeven returns.

Overall, the results in Table 4 provide strong support for the predictability of nominal and real bond returns and for the predictability of their difference in US and UK bond data. These results provide support for the hypothesis that the risk premium on nominal bonds is driven by both a time-varying inflation risk premium and a time-varying real interest rate risk premium. An increase in breakeven inflation forecasts positively an increase in nominal bond risk premia relative to inflation-indexed bond risk premia. The US results also show the striking result that the real term spread forecasts negatively the spread between the nominal bond risk premium and the inflation-indexed bond risk premium. Pflueger and Viceira (2010) present empirical evidence that this is the result of a time-varying liquidity risk premium in inflation-indexed bonds.

5 Cochrane and Piazzesi Bond Return Predictability and the Inflation Risk Premium

In recent work Cochrane and Piazzesi (2005, CP) show that a tent-shaped linear combination of nominal forward rates is a good predictor of excess nominal bond returns for a wide range of bond maturities. Their findings imply that nominal bond risk premia are high when intermediate-term nominal interest rates are high relative to both shorter-term and longer-term rates. In the context of a non-linear model of the term structure of interest rates, Campbell, Sunderam, and Viceira (2010) interpret their findings as reflecting a time-varying transitory inflation risk premium.

We explore this interpretation by examining whether the CP tent-shaped combination of nominal forward rates forecasts inflation-indexed bond excess returns in addition to nominal bond excess returns. If the Cochrane Piazzesi factor reflects inflation risk premia it should not predict returns on inflation-indexed bonds.

We construct the CP factor from one- to five-year Fama-Bliss zero coupon nominal bond yields, available from CRSP. Let $f^{\$}_{n,t}$ denote the log 1 year nominal forward rate at time t for loans between $n-1$ and n years in the future. We obtain the CP factor using the optimal weights found in Cochrane, Piazzesi (2005) as $CP_t = -2.14f^{\$}_{1,t} + 0.81f^{\$}_{2,t} + 3.00f^{\$}_{3,t} + 0.80f^{\$}_{4,t} - 2.08f^{\$}_{5,t}$. Unfortunately we do not have enough richness in the term structure of TIPS rates to construct a CP variable based on TIPS yields. We also limit our analysis to the US.

Panel A in Table 5 reproduces the CP predictability results for our data set, using the 1952-2009 sample period and a one-quarter forecasting horizon. Column 1 in the panel shows that CP is significant and forecasts nominal bond excess returns with a respectable R^2 of 4% at a quarterly horizon. However, column 2 in the panel shows that the variable loses its statistical significance once we control for the yield spread.

Panel B in Table 5 shows that CP does not forecast nominal bond excess returns, TIPS excess returns, and breakeven inflation over our 1999-2009 sample period. Panel B also shows that the inclusion of CP in the nominal and real EH regressions does not change our basic results. The factor enters significantly and with a positive sign only in the last column. Comparing this to column 4 of Table 4 shows that CP also increases the R^2 from 20% to 27%. When CP is high, nominal bond excess returns are expected to be larger than inflation-indexed bond excess returns. This result is consistent with Campbell, Sunderam, and Viceira (2010)'s interpretation of CP as a proxy for a time-varying inflation risk premium.

6 Historical Fitted Risk Premia

We now look at the fitted risk premia in order to better understand the economic significance of the bond return predictability examined in this article. Table 6 shows the mean and standard deviation of the fitted excess log returns from the EH regressions shown in Table 4.[13] Panel A reports results for the US, while Panel B reports results for the UK.

Panel A in Table 6 shows that TIPS have had a high average risk premium over our sample period. This premium is also larger than the average risk premium on nominal

[13]Since the regressions include a constant, the mean of the fitted values coincide with the mean excess log return reported in Table 2.

bonds, which results in a negative average breakeven inflation risk premium. Pflueger and Viceira (2010) show evidence that this negative premium is mostly driven by a positive liquidity risk premium in TIPS, not by a negative inflation risk premium in nominal Treasury bonds. In fact, Panel B shows that the average breakeven inflation risk premium in the UK is positive, consistent with the notion that the inflation risk premium is positive on average. Columns 2 and 3 in each panel show that bond risk premia exhibit significant variability over time, although this variability is small relative to the overall variability of realized bond excess returns.

Figure 2 illustrates the time series of the fitted bond risk premia and their difference—the breakeven inflation risk premium—in the US (Panel A) and in the UK (Panel B). Panel A in the figure shows that the nominal and TIPS risk premia have generally moved together, and that they exhibit significant variability over time. Bond risk premia declined during the period following the stock market crash of the early 2000's, increased during 2002 and 2003, and declined and became even negative in the subsequent period until they increased again at the onset of the recent financial crisis.

However, the breakeven inflation risk premium also shows significant time series variation, implying that the magnitude of the changes in nominal and real bond risk premia was not identical. There were times at which they even moved in opposite directions. The breakeven inflation risk premium was markedly negative at the beginning of the sample, when TIPS were first issued and investors might not have been familiar with them, and during the recent financial crisis, when the TIPS risk premium increased dramatically.

Panel B in Figure 2 shows the time series of the fitted UK risk premia. The nominal, real and breakeven risk premia have moved together over the period 1985 to 2009 and, consistent with the results shown in Table 6, the nominal bond risk premium has been above the real bond risk premium for most of the sample. In contrast to the US bond market, both the nominal bond risk premium and the real bond risk premium shot up during the financial crisis. The nominal bond risk premium increased more than the real bond risk premium, causing the breakeven inflation risk premium to increase during the crisis. As in the case of the US bond market, the risk premium on UK bonds, both real and nominal, is not necessarily positive at all times. There are periods of negative bond risk premia, most notably the turn of the 1990's for both real and nominal bonds and the period 2004-2008 for real bonds.

7 Conclusion

This article explores the EH of the term structure of interest rates in the US and in the UK government real and nominal bond markets. It documents predictability of excess returns in inflation-indexed bonds and in nominal bonds in both markets, thus rejecting the EH, both real and nominal. While return predictability in US Treasury nominal bonds has been well-documented in the past, to our knowledge this is the first article to provide direct empirical evidence for predictability of returns in real bonds. We also find robust evidence that breakeven inflation returns, or the spread between nominal bond excess returns and inflation-indexed bond excess returns, are predictable.

The rejection of the real EH implies that investors in the inflation-indexed bond market face a time-varying risk premium that reflects a time-varying real interest rate risk premium and possibly also a time-varying liquidity premium. The rejection of the nominal EH and particularly the rejection that expected breakeven inflation returns are constant suggests that inflation risk, and the premium that investors demand for bearing it, also varies over time. Real and nominal bond risk premia appear to be positively related to the real and nominal term spread, respectively. When the real term spread increases, expected returns on inflation-indexed bond returns increase and, interestingly, real bonds are also expected to outperform nominal bonds. When the nominal term spread increases, expected excess returns on nominal bonds increase.

The evidence against the real and nominal EH suggests that increases in the yields of long-term bonds, whether real or nominal, do not necessarily imply that expected future short-term interest rates have risen. The increase in yields, or the decline in bond prices, could be the result of an increase in the risk of long-term bonds and the risk premium that investors demand for holding them. Thus investors should be cautious in interpreting increasing yields in long-term bonds as a signal of future higher interest rates.

In recent work, Campbell, Sunderam, and Viceira (2010) show that bond risk premia can move over time and take either sign depending on whether investors see bonds as safe assets or risky assets. Our estimates show significant variation over time of real and nominal bond risk premia, with periods of positive bond risk premia and periods of negative bond risk premia, suggesting a changing investor perception of the risk of real and nominal bonds.

In particular, the risk premium on TIPS has been large on average since they were first issued in 1997, more so than the average risk premium on nominal Treasury bonds, but there have been periods where it has been negative, notably the period between 2004 and the onset of the financial crisis. The historical large positive average of the TIPS risk premium appears to be driven by two particular periods: the years following the creation of TIPS in the late 1990's and most recently during the recent financial crisis. Campbell, Shiller, and Viceira (2009) and Pflueger and Viceira (2010) show evidence that these episodes are linked to periods in which the TIPS market was particularly illiquid, and investors might have demanded a large liquidity premium for holding them.

Our estimates also suggest that investors demand a risk premium on nominal bonds that also varies over time. Consistent with the evidence in Campbell, Sunderam and Viceira (2010), this premium might reflect the changing perception of inflation risk by investors.

Our results suggest several directions for future research. First, they suggest a more detailed analysis of the economic sources of risk in real and nominal bonds, along the lines of Campbell, Sunderam, and Viceira (2010). Second, one could also explore if the return predictability in the inflation-indexed bond market is the result of price pressure and supply imbalances caused by limited arbitrage and preferred-habitat investors in the bond market, along the lines of the preferred-habitat hypothesis of Modigliani and Sutch (1966), formalized in Vayanos and Vila (2009) and Greenwood and Vayanos (2008, 2009).

Arguably the inflation-indexed bond market is a natural candidate to look for segmentation effects in the bond market. Just as investors might differ in their preference for bond maturities, they might also differ in their preference for holding inflation-indexed or nominal bonds. For example, some investors such as traditional defined-benefit pension funds in the US with a mature liability structure have liabilities which are mostly nominal, while other investors such as less mature defined-benefit pension funds or individuals investing for retirement face liabilities which are mostly indexed. Pflueger and Viceira (2010) further explore this hypothesis.

Finally, it would be interesting to explore the implications of our findings for portfolio management and pension investing and how these implications vary by investment horizon and the investor's share of real and nominal liabilities.

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Table 1
Forecasted Real Short Rate

$y^{\$}_{1,t} - \pi_{t+1}$	US	UK
$y^{\$}_{1,t}$	0.57**	0.46
	(0.22)	(0.29)
$y^{\$}_{1,t-1} - \pi_t$	0.08	−0.11
	(0.08)	(0.07)
$(\pi_{t-3} + \pi_{t-2} + \pi_{t-1} + \pi_t)/4$	0.08	0.03
	(0.09)	(0.09)
$p - value$	0.00	0.00
R^2	0.44	0.18

Overlapping quarterly real short rate returns onto the nominal short rate, last quarter's real short rate return and inflation over the past year.
Monthly data 1982.1-2009.12.
Newey-West standard errors with 4 lags in brackets.
* and ** denote significance at the 5% and 1% level respectively.
p-value of the F-test for no predictability.

Table 2
Sample Moments of Inflation, Interest Rates, and Bond Returns

A: US 10 YR

	π_t	$y^{\$}_{1,t}$	$y^{TIPS}_{1,t}$	$y^{\$}_{n,t} - y^{\$}_{1,t}$	$y^{TIPS}_{n,t} - y^{TIPS}_{1,t}$	$b_{n,t} - b_{1,t}$	$xr^{\$}_{n,t+1}$	$xr^{TIPS}_{n,t+1}$	$r^{b}_{n,t+1}$
Mean	2.56	2.87	0.50	1.86	2.04	−0.17	3.26	4.16	−0.91
Std	1.50	0.96	0.72	0.72	0.61	0.37	8.57	7.67	7.22

Return Correlations

	$xr^{\$}_{n,t+1}$	$xr^{TIPS}_{n,t+1}$	$r^{b}_{n,t+1}$
$xr^{\$}_{n,t+1}$	1	0.61	0.54
$xr^{TIPS}_{n,t+1}$	.	1	−0.34
$r^{b}_{n,t+1}$	.	.	1

B: UK 20 YR

	π_t	$y^{\$}_{1,t}$	$y^{TIPS}_{1,t}$	$y^{\$}_{n,t} - y^{\$}_{1,t}$	$y^{TIPS}_{n,t} - y^{TIPS}_{1,t}$	$b_{n,t} - b_{1,t}$	$xr^{\$}_{n,t+1}$	$xr^{TIPS}_{n,t+1}$	$r^{b}_{n,t+1}$
Mean	3.47	6.55	3.14	−0.24	−0.37	0.13	3.47	1.66	1.81
Std	1.84	1.52	0.77	0.97	0.58	0.57	14.67	9.25	11.97

Return Correlations

	$xr^{\$}_{n,t+1}$	$xr^{TIPS}_{n,t+1}$	$r^{b}_{n,t+1}$
$xr^{\$}_{n,t+1}$	1	0.58	0.78
$xr^{TIPS}_{n,t+1}$	.	1	−0.06
$r^{b}_{n,t+1}$	.	.	1

Annualized (%). Monthly data of quarterly overlapping returns and inflation.
US data is montly 1999.4-2009.12. UK data is monthly 1985.4-2009.12.

$xr^{\$}_{n,t+1} = r^{\$}_{n,t+1} - y^{\$}_{1,t}$

$xr^{TIPS}_{n,t+1} = r^{TIPS}_{n,t+1} - y^{TIPS}_{1,t}$

$r^{b}_{n,t+1} = xr^{\$}_{n,t+1} - xr^{TIPS}_{n,t+1}$

Table 3
Tests of the Nominal EH: Long Sample

$xr^{\$}_{n,t+1}$	$1952.1-2009.12$	$1952.1-1987.2$	$1987.3-2009.12$	$1952.1-2009.12$
$\left(y^{\$}_{n,t}-y^{\$}_{1,t}\right)$	3.57^{**}	4.85^{*}	1.81	4.85^{*}
	(1.12)	(1.95)	(1.18)	(1.95)
$\left(y^{\$}_{n,t}-y^{\$}_{1,t}\right)\times d_{1987-2009}$				-3.04
				(2.28)
$d_{1987-2009}$				0.01
				(0.01)
$p-value$	0.00	0.01	0.13	0.01
R^2	0.05	0.07	0.02	0.06

Overlapping quarterly returns $r^{\$}_{n,t+1}$ onto $y^{\$}_{n,t}-y^{\$}_{1,t}$. Monthly data 1952.1-2009.12.
$d_{1987-2009}$ equals 1 in 1987.3-2009.12 and zero otherwise.
Newey-West standard errors with 3 lags in brackets.
* and ** denote significance at the 5% and 1% level respectively.
p-value of the F-test for no predictability.
See Table 2 for definition of $xr^{\$}_{n,t+1}$.

Table 4
Tests of the Real and Nominal EH: Common Sample

A: US 10 YR

	$xr^{\$}_{n,t+1}$	$xr^{TIPS}_{n,t+1}$	$r^{b}_{n,t+1}$	$r^{b}_{n,t+1}$
$y^{\$}_{n,t} - y^{\$}_{1,t}$	2.17			
	(1.49)			
$y^{TIPS}_{n,t} - y^{TIPS}_{1,t}$		4.45**		−3.10*
		(1.37)		(1.22)
$b_{n,t} - b_{1,t}$			7.24*	7.43*
			(3.13)	(2.45)
$p - value$	0.15	0.00	0.02	0.01
R^2	0.03	0.12	0.13	0.20

B: UK 20 YR

	$xr^{\$}_{n,t+1}$	$xr^{TIPS}_{n,t+1}$	$r^{b}_{n,t+1}$	$r^{b}_{n,t+1}$
$y^{\$}_{n,t} - y^{\$}_{1,t}$	3.21*			
	(1.53)			
$y^{TIPS}_{n,t} - y^{TIPS}_{1,t}$		3.16*		−1.31
		(1.30)		(2.05)
$b_{n,t} - b_{1,t}$			4.31*	4.89*
			(1.99)	(2.33)
$p - value$	0.04	0.02	0.03	0.10
R^2	0.05	0.04	0.04	0.05

Overlapping quarterly returns. US data is monthly 1999.4-2009.12.
UK data is monthly 1985.4-2009.12.
Newey-West standard errors with 3 lags in brackets.
* and ** denote significance at the 5% and 1% level respectively.
p-value of the F-test for no predictability.
See Table 2 for definition of $xr^{\$}_{n,t+1}$, $xr^{TIPS}_{n,t+1}$, and $r^{b}_{n,t+1}$.

Table 5
The Real and Nominal EH and the Cochrane-Piazzesi Factor

	A: 1952.9 − 2009.12		**B:** 1999.4 − 2009.12					
	$xr^{\$}_{n,t+1}$	$xr^{\$}_{n,t+1}$	$xr^{\$}_{n,t+1}$	$xr^{TIPS}_{n,t+1}$	$r^{b}_{n,t+1}$	$xr^{\$}_{n,t+1}$	$xr^{TIPS}_{n,t+1}$	$r^{b}_{n,t+1}$
$y^{\$}_{n,t} - y^{S}_{1,t}$		2.74^{*}				1.88		
		(1.23)				(1.69)		
$y^{TIPS}_{n,t} - y^{TIPS}_{1,t}$							5.06^{*}	-4.33^{**}
							(1.54)	(1.20)
$b_{n,t} - b_{1,t}$								7.65^{*}
								(3.09)
CP_t	0.41^{**}	0.23	0.31	0.01	0.29	0.20	−0.29	0.57^{*}
	(0.13)	(0.13)	(0.37)	(0.37)	(0.26)	(0.38)	(0.29)	(0.22)
$p - value$	0.00	0.00	0.41	0.97	0.27	0.27	0.00	0.00
R^2	0.04	0.06	0.02	0.00	0.02	0.04	0.14	0.27

$CP_t = -2.14 f^{\$}_{1,t} + 0.81 f^{\$}_{2,t} + 3.00 f^{\$}_{3,t} + 0.80 f^{\$}_{4,t} - 2.08 f^{\$}_{5,t}$

Overlapping quarterly returns. Newey-West standard errors with 3 lags in brackets.

* and ** denote significance at the 5% and 1% level respectively.

p-value of the F-test for no predictability.

See Table 2 for definition of $xr^{\$}_{n,t+1}$, $xr^{TIPS}_{n,t+1}$, and $r^{b}_{n,t+1}$.

Table 6
Moments of Fitted Bond Risk Premia

A: Fitted Risk Premia US

y	$E(\widehat{y})$	$\sigma(\hat{y})$	$\sigma^2(\hat{y})/\sigma^2\left(xr^{\$}_{n,t}\right)$	$\sigma^2(\hat{y})/\sigma^2\left(xr^{TIPS}_{n,t}\right)$
Nominal Bonds	3.26	1.56	3%	
TIPS	4.16	2.70	10%	12%
Breakeven Inflation	−0.91	3.24	14%	

B: Fitted Risk Premia UK

y	$E(\widehat{y})$	$\sigma(\hat{y})$	$\sigma^2(\hat{y})/\sigma^2\left(xr^{\$}_{n,t}\right)$	$\sigma^2(\hat{y})/\sigma^2\left(xr^{TIPS}_{n,t}\right)$
Nominal Gilts	3.47	3.13	5%	
Inflation-Linked Gilts	1.66	1.84	2%	4%
Breakeven Inflation	1.81	2.55	3%	

Annualized (%). Columns 1 and 2 show mean and standard deviation of fitted values.
Risk Premia in A correspond to fitted values in Table 4A, columns 1, 2 and 4.
Risk Premia in B correspond to fitted values in Table 4B, columns 1, 2 and 4.
See Table 2 for definition of $xr^{\$}_{n,t+1}$ and $xr^{TIPS}_{n,t+1}$.

Figure 1: US Realized and Predicted Real Short Rate

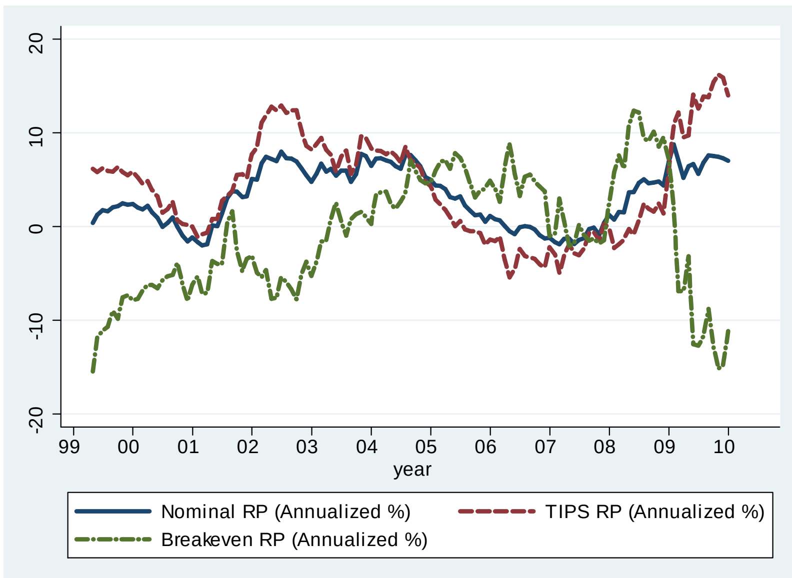

Figure 2A: Fitted US Risk Premia

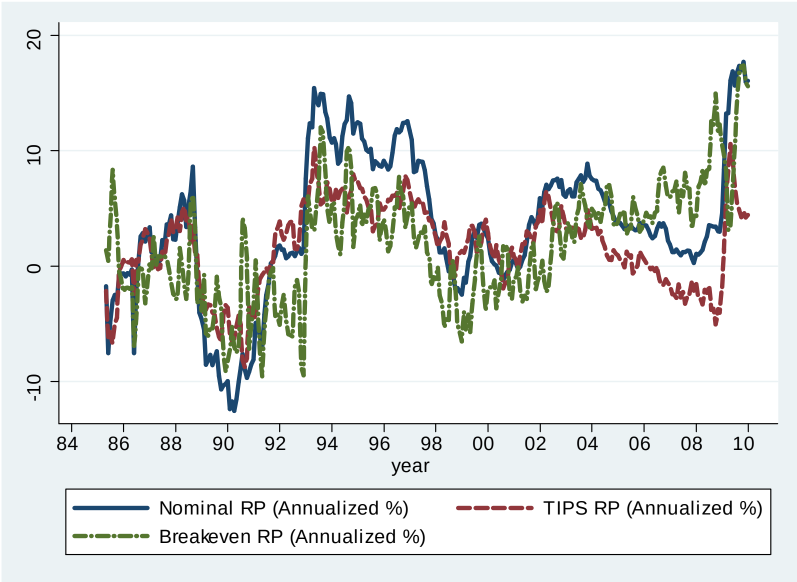

Figure 2B: Fitted UK Risk Premia