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RETURN PREDICTABILITY IN THE TREASURY MARKET:
REAL RATES, INFLATION, AND LIQUIDITY

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ABSTRACT

This paper decomposes excess return predictability in U.S. and U.K. inflation-indexed and nominal government bonds. We find that nominal bonds reflect time-varying inflation and real rate risk premia, while inflation-indexed bonds reflect time-varying real rate and liquidity risk premia. These three risk premia exhibit quantitatively similar degrees of time variation. We estimate a systematic liquidity premium in U.S. inflation-indexed yields over nominal yields, which declined from 100 bps in 1999 to 30 bps in 2005 and spiked to over 150 bps during the crisis 2008-2009. We find no evidence that shocks to relative inflation-indexed bond issuance generate return predictability.

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There is wide consensus among financial economists that returns on nominal U.S. Treasury bonds in excess of Treasury bills are predictable at different investment horizons. Predictor variables include forward rates (Fama and Bliss, 1987), the slope of the yield curve (Campbell and Shiller, 1991), and a linear combination of forward rates (Cochrane and Piazzesi, 2005). This paper conducts a joint empirical analysis of the sources of excess bond return predictability in both nominal and inflation-indexed bonds in the U.S. and the U.K. Importantly, this joint examination helps to distinguish between different explanations that have been proposed for excess return predictability in nominal bonds.

The question of whether expected excess returns on inflation-indexed bonds are time-varying is also important on its own. This question remains relatively unexplored, partly due to the short history of U.S. inflation-indexed bonds (Campbell, Shiller, and Viceira, 2009). Pflueger and Viceira (2011) show preliminary evidence of excess return predictability in U.S. Treasury Inflation-Protected Securities (or TIPS) but do not identify its sources. We examine three potential sources of excess return predictability in inflation-indexed bonds: time-varying real interest rate risk, time-varying liquidity risk, and market segmentation between inflation-indexed and nominal bond markets.

We find strong evidence that both time-varying real rate risk premia and time-varying inflation risk premia contribute to return predictability in nominal government bond excess returns. Inflation risk premia explain as much time variation in predicted nominal bond excess returns as do real rate risk premia both in the U.S. and the U.K., suggesting that a complete theory of nominal bond return predictability needs to incorporate both time-varying nominal and real risks.

Liquidity explains a substantial fraction of the variation in U.S. and U.K. breakeven, or

the spread between nominal and inflation-indexed bond yields of similar maturity. Novel and unique to our paper is the finding that the liquidity component in breakeven predicts the return differential between nominal and inflation-indexed bonds due to liquidity. The U.S. estimated return differential due to liquidity exhibits a highly significantly positive CAPM beta with respect to the stock market, but its U.K. counterpart does not. This finding suggests that U.S. TIPS investors bear systematic risk due to time-varying liquidity and should be compensated in terms of a return premium.

Although there is wide consensus among financial economists that nominal bond excess returns are predictable, there is no agreement about what drives this predictability. Proposed theories of nominal bond excess return predictability differ dramatically in the weights on real and nominal factors and in the sources of real risk premia.

One hypothesis is that excess return predictability results from time variation in the aggregate price of risk. Campbell and Cochrane (1999) propose a model where the representative investor exhibits difference habit preferences over aggregate consumption. Their model generates a time-varying price of risk, and matches the evidence on predictability in aggregate stock returns from the aggregate price-dividend ratio. Building on this work, Wachter (2006) shows that a model with time-varying real interest rates can generate nominal bond excess return predictability from the yield spread of the type documented in Campbell and Shiller (1991).

A second hypothesis is that excess return predictability results from time variation in expected aggregate consumption growth or its volatility. The long-run consumption risk model of Bansal and Yaron (2004) and Bansal, Kiku, and Yaron (2010) emphasizes this possibility. Bansal and Shaliastovich (2012) show that this, combined with time-varying

inflation volatility, can explain nominal Treasury bond predictability.

If excess bond return predictability is entirely due to time-varying habit or long-run consumption risk, then we should observe excess return predictability in real (or inflation-indexed) bonds, since real, not nominal, factors drive the predictability of excess nominal bond returns. Moreover, the excess return on nominal bonds over inflation-indexed bonds should not be predictable.

A third hypothesis is that the nominal nature of bonds is an important source of time-varying risk premia. In this case, we should find that the wedge between nominal and inflation-indexed bond returns is predictable. Time-varying inflation risk drives bond return predictability in the time-varying rare disasters framework of Gabaix (2012). Bansal and Shaliastovich (2013) report that without the inflation risk channel the amount of return predictability in their model is greatly reduced. In the model of Buraschi and Jiltsov (2005), both time-varying real and nominal risk premia are important sources of bond excess return predictability. Campbell, Sunderam, and Viceira (2013) propose a model of the term structure of interest rates in which a time-varying covariance of inflation with the real stochastic discount factor generates a time-varying systematic inflation risk premium and nominal bond excess return predictability. Piazzesi and Schneider (2006) model the slope of the nominal yield curve when inflation is a predictor of consumption growth.

We contribute to this discussion by providing a new set of empirical phenomena, which a well specified model of bond return predictability should aim to match: substantial predictability in both real bond excess returns and in the differential between nominal and real bond excess returns. Moreover, we find that time-varying real rate risk premia and time-varying inflation risk premia can switch sign. Both types of risk premia can contribute either

positively or negatively to expected nominal bond returns.

This paper differs from nominal term structure models, such as Campbell, Sunderam, and Viceira (2013), in one key respect: we quantify time variation in inflation and real rate risk premia without relying on specific modeling restrictions. In contrast, our decomposition of bond risk premia should be valid for a wide range of nominal term structure models. This paper also differs from Campbell, Sunderam, and Viceira (2013) in that it finds and corrects for an economically significant liquidity risk premium, which could otherwise distort estimates of inflation and real rate risk premia.

Our empirical exercise carefully addresses two potentially confounding reasons of price divergence between nominal and inflation-indexed bonds. First, market participants and financial economists have argued that the market for U.S. inflation-indexed bonds is not as liquid as the market for nominal bonds.² It is natural to expect that TIPS might have been less liquid than nominal Treasury bonds in their early years of learning and supply buildup. In addition, liquidity differentials between the nominal bond market and the inflation-indexed bond market might persist even as inflation-indexed bond markets mature. For any investor the riskless asset is an inflation-indexed bond whose cash flows match his consumption plan (Campbell and Viceira, 2001, Wachter, 2003), so that inflation-indexed bonds should typically be held by buy-and-hold investors.

This liquidity differential might result in a liquidity discount on inflation-indexed bonds relative to nominal bonds and a return differential between both types of bonds controlling

²For evidence of relatively lower liquidity in TIPS see D’Amico, Kim, and Wei (2008), Campbell, Shiller, and Viceira (2009), Fleckenstein, Longstaff, and Lustig (2010), Fleming and Krishnan (2009), Dudley, Roush, and Steinberg Ezer (2009), Gurkaynak, Sack, and Wright (2010), Christensen and Gillan (2011), and Haubrich, Pennacchi, and Ritchken (2011).

for all other sources of return. Indeed, over the 11-year period starting in 1999 the average annualized excess log return on 10 year U.S. TIPS equaled a substantial 4.7%, almost half a percentage point higher than that on comparable nominal U.S. Treasury bonds. What portion of this return differential is attributable to differential liquidity? Does the liquidity differential between both markets move over time? Is there a similar liquidity differential in the older and more established market for U.K. inflation-indexed bonds?

We estimate the liquidity differential between inflation-indexed and nominal bond yields using an empirically flexible approach. We regress breakeven onto liquidity proxies while controlling for proxies of inflation expectations. Liquidity proxies can explain almost as much variation in U.S. breakeven as can inflation expectation proxies, consistent with similar results in Gurkaynak, Sack, and Wright (2010) and D’Amico, Kim, and Wei (2010). Liquidity variables have smaller, but still significant, explanatory power for U.K. breakeven. After adjusting for liquidity, our findings suggest that U.S. liquidity-adjusted breakeven inflation has been quite stable and close to three percent over our sample period, while U.K. breakeven inflation has trended upwards from three to four percent. U.S. liquidity-adjusted breakeven inflation remained above 1.7% during the financial crisis, while realized breakeven inflation was close to zero or even negative for some maturities, suggesting that low realized breakeven inflation may not have reflected investors’ long-term deflationary fears but relative illiquidity in U.S. TIPS.

We find a statistically significant and economically important time-varying liquidity component in U.S. breakeven. Over our sample period the yield on U.S. TIPS has been about 69 basis points larger on average than it would have been if TIPS had been as liquid as nominal Treasury bonds. This high average reflects extraordinary events associated with

very low liquidity in this market. We find a high liquidity discount in the years following the introduction of TIPS (about 70 to 100 bps), which we attribute to learning and low trading volume, and during the fall of 2008 at the height of the financial crisis (beyond 150 bps). We estimate a much lower but still significant liquidity discount of between 30 to 70 bps between 2004 and 2007 and after the crisis. The liquidity premium in U.K. inflation-indexed gilt yields has been lower on average at 50 bps and has steadily declined over time.

A second complication in using inflation-indexed bonds to identify the systematic sources of bond excess return predictability is the possibility that the inflation-indexed bond market and the nominal bond market might be segmented. Recent research has emphasized the role of limited arbitrage and bond investors' habitat preferences to explain predictability in nominal bond returns (Modigliani and Sutch, 1966, Vayanos and Vila, 2009). It seems plausible that the preference of certain investors, such as pension funds with inflation-indexed liabilities, for real bonds and the preference of others, such as pension funds with nominal liabilities, for nominal bonds might lead to imperfect market integration between nominal and inflation-indexed markets.

We investigate this market segmentation hypothesis using the approach of Greenwood and Vayanos (2008) and Hamilton and Wu (2010). We find no evidence that market segmentation and bond supply effects explain breakeven or generate predictability in the relative returns of inflation-indexed and nominal bonds in the U.S. or the U.K. One potential interpretation for this finding could be that governments adjust issuance according to investor demand for the different types of securities, effectively acting as arbitrageurs between the two markets.

Conditional on our estimates of liquidity-adjusted returns, we test whether nominal bond excess return predictability is due to time-varying real interest risk or time-varying infla-

tion risk. Prices of both inflation-indexed and nominal government bonds change with the economy-wide real interest rate. Consequently, nominal and inflation-indexed bond risk premia will reflect investors' perception of real interest rate risk, which may vary over time. Prices of nominal government bonds, but not inflation-indexed government bonds, also vary with expected inflation, so inflation risk will impact their risk premia. Adjusting for liquidity differentials, we find that excess returns on nominal bonds over inflation-indexed bonds are predictable from the term spread in breakeven inflation both in the U.S. and the U.K. We interpret this empirical finding as evidence that time-varying inflation risk premia are a source of return predictability in nominal government bonds. We also find that liquidity-adjusted excess returns on inflation-indexed bonds are predictable from the inflation-indexed term spread, even though this empirical finding is only marginally statistically significant for the U.S. We interpret this second finding as evidence that time-varying real risk contributes to return predictability in nominal government bond excess returns. Finally, we find that time-varying liquidity risk contributes statistically and economically significantly to excess returns on inflation-indexed bond excess returns.

The structure of this paper is as follows. Section I estimates liquidity premia in U.S. and U.K. inflation-indexed bond yields over nominal bond yields. Section II tests the market segmentation hypothesis in the U.S. and the U.K. Section III tests for and quantifies time-varying real interest rate risk premia, inflation risk premia, and liquidity risk premia. Section IV concludes.

I Bond Data and Definitions

A Bond Notation and Definitions

We denote by $y_{n,t}^{\$}$ and $y_{n,t}^{TIPS}$ the log (or continuously compounded) yield with n periods to maturity for nominal and inflation-indexed bonds, respectively. We use the superscript *TIPS* for both U.S. and U.K. inflation-indexed bonds. We define breakeven inflation as the difference between nominal and inflation-indexed bond yields:

$$b_{n,t} = y_{n,t}^{\$} - y_{n,t}^{TIPS}. \quad (1)$$

Log excess returns on nominal and inflation-indexed zero-coupon n -period bonds held for one period before maturity are given by:

$$xr_{n,t+1}^{\$} = ny_{n,t}^{\$} - (n-1)y_{n-1,t+1}^{\$} - y_{1,t}^{\$}, \quad (2)$$

$$xr_{n,t+1}^{TIPS} = ny_{n,t}^{TIPS} - (n-1)y_{n-1,t+1}^{TIPS} - y_{1,t}^{TIPS}. \quad (3)$$

The log excess one-period holding return on breakeven inflation is equal to:

$$xr_{n,t+1}^b = xr_{n,t+1}^{\$} - xr_{n,t+1}^{TIPS}. \quad (4)$$

Note that this is essentially the return on a portfolio long long-term nominal bonds and short long-term inflation-indexed bonds. This portfolio will have positive returns when breakeven inflation declines, and negative returns when it increases.

The yield spread is the difference between a long-term yield and a short-term yield:

$$s_{n,t}^{\$} = y_{n,t}^{\$} - y_{1,t}^{\$}, \quad (5)$$

$$s_{n,t}^{TIPS} = y_{n,t}^{TIPS} - y_{1,t}^{TIPS}, \quad (6)$$

$$s_{n,t}^b = b_{n,t} - b_{1,t}. \quad (7)$$

Inflation-indexed bonds are commonly quoted in terms of *real* yields, but since $xr_{n,t+1}^{TIPS}$ is an excess return over the *real* short rate it can be interpreted as a real or nominal excess return. We approximate $y_{n-1,t+1}^{\$}$ and $y_{n-1,t+1}^{TIPS}$ with $y_{n,t+1}^{\$}$ and $y_{n,t+1}^{TIPS}$.

B Yield Data

For the U.S., we use yields from Gurkaynak, Sack, and Wright (2007) and Gurkaynak, Sack, and Wright (2010, GSW henceforth). GSW construct constant-maturity zero-coupon off-the-run yields for nominal bonds starting January 1961 and for TIPS starting January 1999 by fitting smoothed yield curves. We focus on 10-year nominal and real yields, because this maturity 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. Our sample period for yields is 1999.3-2010.12, while that for quarterly excess returns starts in 1999.6.

The principal of inflation-indexed bonds adjusts automatically with a consumer price index, which in the U.S. is the Consumer Price Index (CPI-U) and in the U.K. is the

Retail Price Index (RPI). Inflation-indexed bond coupons adjust with inflation and equal the inflation-adjusted principal on the bond times a fixed coupon rate.³

The nominal principal value of U.S. TIPS is guaranteed to never fall below its original nominal face value. Consequently, a recently issued TIPS, whose nominal face value is close to its original nominal face values, has a deflation option built into it that is more valuable than that in a less recently issued TIPS with the same remaining time to maturity. Grishchenko, Vanden, and Zhang (2011) study the deflationary expectations reflected in the pricing of the TIPS deflation floor. During normal times the probability of a severe and prolonged deflation is negligible so that those bonds trade at identical prices, but Wright (2009) points out some dramatic price discrepancies between recently issued and seasoned five-year TIPS during the financial crisis. Appendix Figure A.1 illustrates the GSW 10 year TIPS yield with yields of 10 year TIPS issued at different reference CPI. The GSW yield is closest to TIPS yields with low reference CPIs. We conclude that the 10 year GSW TIPS yield does not reflect a significant deflation option.

We use U.K. constant-maturity zero-coupon yield curves from the Bank of England, which are estimated with spline-based techniques (Anderson and Sleath, 2001). Nominal yields are available starting in 1970 and real yields are available starting in 1985. We use 20-year yields because those have the longest history.⁴ In contrast to the U.S., U.K. inflation-indexed bonds contain no deflation option. We use the sample period 1999.11-2010.12 for U.K. yields and 2000.2-2010.12 for U.K. quarterly excess returns because liquidity variables

³There are further details such as in inflation lags in principal updating and tax treatment of the coupons that slightly complicate the pricing of these bonds. More details on TIPS can be found in Viceira (2001), Roll (2004), Campbell, Shiller, and Viceira (2009) and Gurkaynak, Sack, and Wright (2010). Campbell and Shiller (1996) offer a discussion of the taxation of inflation-indexed bonds.

⁴For some months the 20 year yields are not available and instead we use the longest maturity available. The maturity used for the 20 year yield series drops down to 16.5 years for a short period in 1991.

only become available at the end of 1999. We measure inflation with the non seasonally adjusted Retail Price Index, which is also used to calculate inflation-indexed bond payouts. U.K. three month Treasury bill rates are from the Bank of England (IUMAJNB).

Since neither the U.S. nor the U.K. governments issue inflation-indexed bills, we build a hypothetical short-term real interest rate following Campbell and Shiller (1996) as the predicted real return on the nominal three month T-bill. Our predictor variables include the lagged real return on the nominal three month T-bill, the lagged nominal T-bill, and lagged four quarter inflation. Appendix Figure A.2 shows hypothetical short-term real interest rates and the corresponding regressions are reported in Appendix Table A.I. For simplicity we assume a zero liquidity premium on one-quarter real bonds. Appendix Table A.VIII shows that our results are similar if we replace TIPS returns in excess of the estimated real interest rate with nominal TIPS returns in excess of the nominal T-bill rate.

Finally, although our yield data is available monthly, we focus on quarterly overlapping bond returns to reduce the influence of high-frequency noise in observed inflation and short-term nominal interest rate volatility in our tests.

II Estimating the Liquidity Differential Between Inflation-Indexed and Nominal Bond Yields

Breakeven inflation, or the yield spread between nominal and inflation-indexed bonds with identical timing of cash flows, should reflect investors' inflation expectations plus any compensation for bearing inflation risk, if markets are perfectly liquid. However, if the inflation-

indexed bond market is not as liquid as the nominal bond market, inflation-indexed bond yields might reflect a liquidity premium relative to nominal bond yields.

We pursue an empirical approach to identify the liquidity differential between inflation-indexed and nominal bond markets in the U.S. and the U.K. We estimate the liquidity differential by regressing breakeven inflation on measures of liquidity as in Gurkaynak, Sack, and Wright (2010), while controlling for inflation expectation proxies. We capture different notions of liquidity through three different liquidity proxies: the nominal off-the-run spread, relative transaction volume of inflation-indexed bonds and nominal bonds, and proxies for the cost of funding a levered investment in inflation-indexed bonds.

Time-varying market-wide desire to hold only the most liquid securities might drive part of the liquidity differential between nominal and inflation-indexed bonds. In "flight to liquidity" episodes some market participants suddenly prefer highly liquid securities rather than less liquid securities. For the U.S., we measure this desire to hold only the most liquid securities by the nominal off-the-run spread. The Treasury regularly issues new 10 year nominal notes and the newest "on-the-run" 10 year note is considered the most liquidly traded security in the Treasury bond market. After the Treasury issues a new 10-year note, the prior note goes "off-the-run". The off-the-run bond typically trades at a discount over the on-the-run bond – i.e., it trades at a higher yield – despite the fact that it offers almost identical cash flows (Krishnamurthy, 2002).⁵ The U.K. Treasury market does not have on-the-run and off-the-run bonds in a strict sense, since the Treasury typically reopens existing bonds to issue additional debt. We capture liquidity in the U.K. nominal government bond

⁵In the search model with partially segmented markets of Vayanos and Wang (2001) short-horizon traders endogenously concentrate in one asset, making it more liquid. Vayanos (2004) presents a model of financial intermediaries and exogenous transaction costs, where preference for liquidity is time-varying and increasing with volatility.

market with the difference between a fitted par yield and the yield on the most recently issued 10 year nominal bond. This measure of the smoothness of the nominal yield curve is similar to Hu, Pan, and Wang (2012). Hu, Pan, and Wang (2012) show that such a measure can proxy for market-wide liquidity and the availability of arbitrage capital. Due to its close relation, we refer to this U.K. measure as the “off-the-run spread” for simplicity.

Liquidity developments specific to inflation-indexed bond markets might also generate liquidity premia. For instance, when U.S. TIPS were first issued in 1997, investors might have had to learn about them and the TIPS market might have taken time to get established. More generally, following Duffie, Garleanu and Pedersen (2005, 2007) and Weill (2007), one can think of the transaction volume of inflation-indexed bonds as a measure of illiquidity due to search frictions.⁶ We proxy for this idea with the transaction volume of inflation-indexed bonds relative to nominal bonds for the U.S. and the U.K., a measure previously used by Gurkaynak, Sack, and Wright (2010) for U.S. TIPS. Fleming and Krishnan (2009) previously found that trading activity is a good measure of cross-sectional TIPS liquidity, lending credibility to relative transaction volume as a time series liquidity proxy.

Finally, we want to capture the cost of arbitraging between inflation-indexed and nominal bond markets for levered investors, and more generally the availability of arbitrage capital and the shadow cost of capital (Garleanu and Pedersen, 2011). In the U.S., levered investors looking for TIPS exposure can either borrow by putting the TIPS on repo or enter into an asset-swap, which requires no initial capital. An asset-swap is a derivative contract between two parties, where one party receives the cash flows on a particular government bond (TIPS or nominal) and pays *LIBOR* plus the asset-swap spread (*ASW*), which can be positive

⁶See Duffie, Garleanu, and Pedersen (2005, 2007) and Weill (2007) for models of over-the-counter markets, in which traders need to search for counter parties and incur opportunity or other costs while doing so.

or negative. We use the difference between the asset-swap spreads for TIPS and nominal Treasuries:

$$ASW_{n,t}^{spread} = ASW_{n,t}^{TIPS} - ASW_{n,t}^{\$}. \quad (8)$$

A non-levered investor who perceives TIPS to be under priced relative to nominal Treasuries can enter a zero price portfolio long one dollar of TIPS and short one dollar of nominal Treasuries. A levered investor can similarly enter a position long one TIPS asset-swap and short one nominal Treasury asset-swap. This levered investor pays the relative spread (8), which is typically positive, for the privilege of not having to put up any initial capital. Since the levered investor holds a portfolio with a theoretical price of zero, this spread reflects the current and expected relative financing costs of holding the bond position.

The asset-swap spread is likely related to specialness of nominal Treasuries in the repo market and the lack of specialness of TIPS, which can vary over time.⁷ Differences in specialness might be the result of variation in the relative liquidity of securities, which make some securities easier to liquidate and hence more attractive to hold than others.

As a robustness analysis, we consider the spread between synthetic breakeven and cash breakeven. Synthetic breakeven inflation is the fixed rate in a zero-coupon inflation swap. Zero-coupon inflation swaps are contracts where one party pays the other cumulative CPI inflation at the end of maturity in exchange for a pre-determined fixed rate. Entering a zero-coupon inflation swap does not require any initial capital, similarly to entering a TIPS asset-swap and going short a nominal Treasury asset-swap. The difference between synthetic

⁷Holders of certain bonds may be able to borrow at ‘special’ collateralized loan rates below general market interest rates (Duffie, 1996, Buraschi and Menini, 2002). In private email conversations Michael Fleming and Neel Krishnan report that for the period Feb. 4, 2004 to the end of 2010 average repo specialness was as follows. On-the-run coupon securities: 35 bps; off-the-run coupon securities: 6 bps; T-Bills: 13 bps; TIPS: 0 bps.

breakeven (or breakeven in the inflation swap market) and cash breakeven is therefore the flip side of the asset-swap spread (Viceira, 2011). We use the asset-swap spread as our benchmark variable, since it most closely captures the relative financing cost and specialness of TIPS over nominal Treasuries.

U.K. asset-swap spread or inflation swap data is not available. We use the LIBOR-general collateral (GC) repo interest-rate spread, which Garleanu and Pedersen (2011) suggest as a proxy for arbitrageurs' shadow cost of capital. In contrast to the asset-swap spread, this measure cannot capture time-varying margin requirements of inflation-indexed bonds relative to nominal bonds.

The liquidity differential between inflation-indexed and nominal bond markets can also give rise to a liquidity risk premium: If the liquidity of inflation-indexed bonds deteriorates during periods when investors would like to sell, as in "flight to liquidity" episodes, risk averse investors will demand a liquidity risk premium for holding these bonds (Amihud, Mendelson, and Pedersen, 2005, Acharya and Pedersen, 2005). While the relative transaction volume of inflation-indexed bonds likely only captures the current ease of trading and therefore a liquidity premium, the off-the-run spread, the smoothness of the nominal yield curve, the asset-swap spread and the LIBOR-GC spread are likely to represent both the level of liquidity and liquidity risk. Our estimated liquidity premium is therefore likely to represent a combination of current ease of trading and the risk that liquidity might deteriorate.

In order to isolate the liquidity component in breakeven inflation, we control for inflation-expectations with survey inflation expectations and variables known to forecast inflation.

A Estimation Strategy

When inflation-indexed bonds are relatively less liquid than nominal bonds, we would expect inflation-indexed bond prices to decrease and inflation-indexed bond yields to increase relative to nominal bonds. Let $b_{n,t}$ be breakeven inflation, X_t a vector of liquidity proxies, and π_t^e a vector of inflation expectation proxies. To account for this premium, we estimate:

$$b_{n,t} = a_1 + a_2 X_t + a_3 \pi_t^e + \varepsilon_t, \quad (9)$$

Variables indicating less liquidity in the inflation-indexed bond market, such as the off-the-run spread, the smoothness of the nominal yield curve, the asset-swap spread, and the LIBOR-GC spread, should enter negatively in (9). Higher relative transaction volume in the inflation-indexed bond market should enter positively.

Our liquidity variables are normalized to go to zero in a world of perfect liquidity. When liquidity is perfect, the off-the-run spread, the smoothness of the nominal yield curve, the asset-swap spread, and the LIBOR-GC spread should equal zero. U.S. and U.K. relative transaction volumes are normalized to a maximum of zero. Intuitively, we assume that the U.S. liquidity premium attributable to low transaction volume was negligible during 2004-2007.

We obtain the liquidity premium in inflation-indexed yields relative to nominal yields as the negative of the variation in $b_{n,t}$ explained by the liquidity variables:

$$\hat{L}_{n,t} = -\hat{a}_2 X_t. \quad (10)$$

\hat{a}_2 is the vector of slope estimates in (9). Thus an increase in $\hat{L}_{n,t}$ reflects a reduction in the liquidity of inflation-indexed bonds relative to nominal bonds.

While our liquidity estimate most likely reflects liquidity fluctuations in both nominal bonds and in inflation-indexed bonds, we have to make an assumption in computing liquidity-adjusted inflation-indexed bond yields. We could assume that all of the liquidity premium is in nominal bonds, in which case we would not need to correct inflation-indexed bond yields. Alternatively, we could assume that the relative liquidity premium is entirely attributable to inflation-indexed bond illiquidity. To allow for comparison between these two possibilities, we calculate inflation-indexed bond yields under the second assumption. We refer to the following variables as liquidity-adjusted inflation-indexed bond yields and liquidity-adjusted breakeven:

$$y_{n,t}^{TIPS,adj} = y_{n,t}^{TIPS} - \hat{L}_{n,t}, \quad (11)$$

$$b_{n,t}^{adj} = b_{n,t} + \hat{L}_{n,t}. \quad (12)$$

B Data on Liquidity and Inflation Expectation Proxies

We obtain the U.S. off-the-run spread by subtracting the on-the-run yield to maturity for a generic 10 year nominal Treasury bond from Bloomberg (USGG10YR) from the 10 year GSW off-the-run par yield. The U.K. “off-the-run spread” is the difference between the fitted 10 year nominal par yield available from the Bank of England (IUMMPY) and the generic 10 year nominal U.K. bond yield from Bloomberg.

We calculate U.S. relative transaction volume as $\log(Trans_t^{TIPS}/Trans_t^{\$})$. $Trans_t^{TIPS}$

denotes the average weekly Primary Dealers' transactions volume over the past month and $Trans_t^{\$}$ the corresponding figure for nominal bonds from the New York Federal Reserve FR-2004 survey. We use the transaction volume for nominal coupon bonds with a long time to maturity because we aim to capture the differential liquidity of TIPS with respect to 10 year nominal bonds. Including all maturities or even T-bills would also reflect liquidity of short-term instruments versus long-term instruments. We smooth relative transaction volume over the past three months because we think of it as capturing secular learning effects rather than short-term fluctuations in liquidity.⁸ We normalize the maximum relative transaction volume to zero. We construct U.K. transaction volume of inflation-indexed gilts relative to conventional gilts analogously.⁹

[FIGURE 1 ABOUT HERE]

We obtain asset-swap spread data from Barclays Live. We only have data on $ASW_{n,t}^{spread}$ from January 2004, and set it to its January 2004 value of 28 bps before that date. We obtain 10 year zero-coupon inflation swap data from Bloomberg (USDSW10Y) from July 2004. The U.K. LIBOR-GC spread is the difference between three month British Pound LIBOR and three month British Pound GC rates from Bloomberg.

Figures 1A and 1B plot the time series of the U.S. and U.K. liquidity variables. The U.S. off-the-run spread was high during the late 1990s, declined during 2005-2007, and jumped to

⁸In 2001 the Federal Reserve changed the maturity cutoffs for which the transaction volumes are reported. Before 6/28/2001 we use the transaction volume of Treasuries with 6 or more years to maturity while starting 6/28/2001 we use the transaction volume of Treasuries with 7 or more years to maturity. The series after the break is scaled so that the growth in $Trans^{\$}$ from 6/21/2001 to 6/28/2001 is equal to the growth in transaction volume of all government coupon securities.

⁹We are grateful to Martin Duffell from the U.K. Debt Management Office for providing us with turnover data.

over 50 bps during the financial crisis. U.S. relative transaction volume rises linearly through 2004, stabilizes, and declines modestly after the financial crisis. This pattern suggests that the liquidity premium due to the novelty of TIPS should have been modest in the period since 2004. Interestingly, the U.S. Treasury's renewed commitment to the TIPS issuance program (Bitsberger, 2003) and the development of synthetic markets occurred at a similar time.

Finally, the asset-swap spread $ASW_{n,t}^{spread}$ varies within a relatively narrow range of 21 basis point to 41 basis points from January 2004 through December 2006, and rises sharply during the financial crisis, reaching 130 bps in December 2008. That is, before the crisis financing a long position in TIPS was about 30 basis more expensive than financing one in nominal Treasury bonds, but this cost differential rose dramatically after the Lehman bankruptcy in September 2008. Campbell, Shiller, and Viceira (2009) argue that the Lehman bankruptcy significantly affected TIPS liquidity, because Lehman Brothers had been very active in the TIPS market. The unwinding of its large TIPS inventory in the weeks following its bankruptcy, combined with a sudden increase in the cost of financing long positions in TIPS appears to have induced unexpected downward price pressure in the TIPS market. This led to a liquidity-induced sharp tightening of breakeven inflation associated with a widening of the TIPS asset-swap spread. The asset-swap spread $ASW_{n,t}^{spread}$ and the differential between synthetic and cash breakeven inflation track very closely, as expected.

Figure 1B shows a steady increase in the U.K. relative transaction volume until 2005 and flat relative transaction volume thereafter. This increase in relative trading volume might at first seem surprising, since U.K. inflation-indexed gilts have been issued for significantly longer than their U.S. counterparts. However, Greenwood and Vayanos (2010) argue that the

U.K. pension reform of 2004, which required pension funds to discount future liabilities at long-term real rates, increased demand for inflation-indexed gilts and it seems plausible that the same reform also increased trading volume. Figure 1B also shows that the LIBOR-GC spread peaked during the financial crisis, similarly to the Asset-Swap-Spread in the U.S., consistent with the notion that arbitrageurs' capital was scarce during the financial crisis. The U.K. off-the-run spread is significantly smoother than in the U.S. This is unsurprising given the different market structures. The smoother U.K. off-the-run spread might also indicate that during flight-to-liquidity episodes investors have a preference for U.S. on-the-run nominal Treasuries.

We use two variables to proxy for U.S. inflation expectations. First, we use the median 10 year CPI inflation forecast from the Survey of Professional Forecasters (SPF), consistent with the 10 year maturity of U.S. breakeven.¹⁰ Long-term survey inflation expectations are extremely stable over our sample period. Second, we use the Chicago Fed National Activity Index (CFNAI) to account for the possibility that short-term inflation expectations enter into breakeven. The CFNAI provides reliable inflation forecasts over 12 month horizons (Stock and Watson, 1999). It is based on economic activity measures and should especially reflect inflation expectation fluctuations related to the aggregate economy.

We proxy for U.K. inflation expectations using the Bank of England Public Attitudes survey. We use the median response to the question “How much would you expect prices in the shops generally to change over the next 12 months?”. Unfortunately, this is the longest forecasting horizon available for our sample.

¹⁰SPF survey expectations are available at a quarterly frequency and are released towards the end of the middle month of the quarter. We create a monthly series by using the most recently released inflation forecast.

[TABLE I ABOUT HERE]

Table I shows summary statistics for bond yields, breakeven, excess returns, liquidity, and inflation expectation proxies. Over our sample period, U.S. average breakeven was 2.24% per annum (p.a.), average TIPS yields were 2.44% p.a., and average U.S. survey inflation was 2.47% p.a. In contrast, average U.K. breakeven exceeded survey inflation over the similar period 1999.11-2010.12.

Summary statistics suggest that there may have been a substantial liquidity premium in U.S. TIPS yields relative to nominal Treasury yields, or a substantial negative inflation risk premium in nominal yields. If breakeven exclusively reflected investors' inflation expectations, the negative gap between U.S. breakeven and survey inflation would be surprising. It would be even more surprising in light of findings that the SPF tends to under predict inflation when inflation is low (Ang, Bekaert, and Wei, 2007).

Realized log excess returns on U.S. TIPS have averaged 4.66% p.a., exceeding the average log excess returns on U.S. nominal government bonds by 48 basis points (bps) over our sample. Average log excess returns on U.K. inflation-indexed bonds have been substantially smaller at only 2.36% p.a., but have exceeded U.K. nominal log excess returns by 1.80% p.a.

C Estimating Differential Liquidity

Table II estimates the relative liquidity premium in inflation-indexed bonds according to (9). Panel A presents results for U.S. TIPS, and Panel B for U.K. inflation-linked bonds. We add

liquidity proxies one at a time. In both panels, column (4) presents our benchmark estimate with all liquidity proxies and inflation expectation controls over our full sample. The last two columns of each panel present results excluding the financial crisis.

[TABLE II ABOUT HERE]

Table IIA column (1) shows that inflation expectation proxies explain 39% of the variability in U.S. breakeven. CFNAI is statistically significant with a positive slope, suggesting that short-run inflation expectations influence investors' long-run inflation expectations. Table I shows that the SPF inflation expectations exhibit very little time variation. Table II suggests that this variation appears to be unrelated to breakeven inflation, after controlling for our liquidity proxies and CFNAI.

Panel A shows that liquidity measures explain a significant portion of the variability of U.S. breakeven inflation. The regression R^2 increases with the inclusion of every additional liquidity variable and reaches 70% in column (5). The off-the-run spread alone increases the regression R^2 regression to 60% from 39% as shown in column (2). Appendix Table A.II shows that each variable alone also explains significant variation in breakeven inflation.

Table IIA shows coefficients whose signs are consistent with intuition and statistically significant. Breakeven inflation moves negatively with the off-the-run spread with a large coefficient, suggesting that TIPS yields reflect a strong market-wide liquidity component. A one standard deviation move in the off-the-run spread of 11 bps tends to go along with a decrease in breakeven of 9.5 bps in our benchmark estimation (0.87×11 bps). These magnitudes are substantial relative to average breakeven of 224 bps. This empirical finding

indicates that while during a flight-to-liquidity episode investors rush into nominal on-the-run U.S. Treasuries, they do not buy U.S. TIPS to the same degree, even though both types of bonds are fully backed by the same issuer, the U.S. Treasury.

The positive and significant coefficient on relative TIPS trading volume indicates that the impact of search frictions on inflation-indexed bond prices were exacerbated during the early period of inflation-indexed bond issuance. As TIPS trading volume relative to nominal Treasury trading volume increased, TIPS yields fell relative to nominal bond yields. Our empirical estimates suggest that an increase in relative trading volume from its minimum in 1999 to its maximum in 2004 was associated with an economically significant decrease in the TIPS liquidity premium of 48 bps.

When the marginal investor in TIPS is a levered investor, we would expect breakeven to fall one for one in the asset-swap differential. The estimated slope on the asset-swap spread is at -0.86 well within one standard deviation of the theoretical value of -1. This result suggests that the buyers and sellers of asset-swaps may have acted to a large extent as the marginal buyers and sellers of TIPS. The negative and economically significant coefficient on the asset-swap spread suggests that disruptions to securities markets and constraints on levered investors were important in explaining the sharp fall in breakeven during the financial crisis, since the asset-swap spread differential behaves almost like a dummy variable that spikes up during the financial crisis. We obtain similar results estimating the regression with the synthetic minus cash breakeven spread instead of the asset-swap spread.

While bond market liquidity was especially variable during the financial crisis, we also find a strong relationship between breakeven and liquidity proxies during the pre-crisis period. Column (6) in Panel A shows that before 2007, proxies for inflation expectations explain

30% of the variability of breakeven inflation. Column (7) shows that adding liquidity proxies more than doubles the regression R^2 to 61% and that the off-the-run spread enters with a strongly negative and significant coefficient.

Since some of the liquidity variables are persistent, one might be concerned about spuriousness. If there is no slope vector so that the regression residuals are stationary, Ordinary Least Squares is quite likely to produce artificially large R^2 s and t-statistics (Granger and Newbold, 1974, Phillips, 1986, Hamilton, 1994). Table II shows that the augmented Dickey-Fuller test rejects the presence of a unit root in regression residuals for all regression specifications at conventional significance levels. Appendix Table A.III shows that the U.S. regression results in quarterly changes are very similar to those in levels, further alleviating concerns.

Our estimation of the liquidity premium might rely on extrapolation outside the range of historically observed liquidity events. The effect of liquidity proxies on the liquidity differential between inflation-indexed and nominal bonds might be nonlinear, especially during events of extreme liquidity or extreme illiquidity. Appendix Tables A.IV reports additional results including interaction terms. Appendix Table A.IV also reports regressions with the U.S. TIPS bid-ask spread as an additional natural liquidity. We find that the bid-ask spread does not enter, suggesting that the other liquidity proxies already incorporate the time-varying round-trip cost of buying and selling a TIPS.¹¹

Table IIB shows that U.K. survey inflation, which exhibits much larger time series volatility than its U.S counterpart, explains 51% of the variability in U.K. breakeven. Adding our

¹¹We are grateful to George Pennachi for making his proprietary data on TIPS bid-ask spreads available to us.

proxies for liquidity increases the regression R^2 to 65%. Liquidity proxies enter with the predicted signs. Interestingly, columns (5) and (6) in the panel show that prior to the financial crisis, liquidity variables have even greater explanatory power. In the pre-2007 sample, survey inflation explains 31% of the variability of breakeven inflation, and including the liquidity variables more than doubles the R^2 to 67%. While in the full sample only relative transaction volume is individually statistically significant, in the pre-2007 sample our measure of the smoothness of the nominal yield curve also becomes statistically significant. Again, the augmented Dickey-Fuller tests reject the presence of a unit root for all regression specifications in the panel. Overall these results suggest that liquidity factors are important for understanding the time series variability of breakeven inflation both in the U.S. and the U.K.

[FIGURES 2A AND 2B ABOUT HERE]

Figures 2A and 2B plot U.S. and U.K. liquidity premia as estimated in the benchmark regressions in Table II (4), Panels A and B. We obtain liquidity premia according to (10). Intuitively, liquidity premia equal the negative of the variation explained by liquidity variables in Table II.

The estimated U.S. liquidity premium, shown in Figure 2A, has averaged 69 bps with a standard deviation of 24 bps over our sample. Although this average is high, one must take into account that it reflects periods of very low liquidity in this market. Figure 2A shows a high liquidity premium in the early 2000's (about 70-100 bps), but a much lower liquidity premium between 2004 and 2007 (35-70 bps). The premium shoots up again beyond 150 bps

during the crisis, and finally comes down to 50 bps after the crisis.

The estimated liquidity time series is consistent with the findings in D’Amico, Kim, and Wei (2008) but in addition we provide an estimate of the liquidity premium during and after the financial crisis. In recent work Fleckenstein, Longstaff, and Lustig (2010) show evidence that inflation swaps, which allow investors to trade on inflation without putting up any initial capital, appear to be mispriced relative to breakeven inflation in the cash market for TIPS and nominal Treasury bonds. We account for their average mispricing time series through the difference between synthetic and cash breakeven in column (5) and through the closely linked asset swap spread in column (4).

The large liquidity premium in TIPS is puzzling given that bid-ask spreads on TIPS are small. Haubrich, Pennacchi, and Ritchken (2010) report TIPS bid-ask spreads between 0.5 bps up to 10 bps during the financial crisis. It seems implausible that the liquidity premium in TIPS yields simply serves to amortize transaction costs of a long-term investor.¹² As previously argued, TIPS should be held by buy-and-hold investors. In a simple model of liquidity, such as in Amihud, Mendelson and Pedersen (2005), transaction costs of 10 bps can only justify a 1 bp liquidity premium for 10 year TIPS held by buy-and-hold investors.

A simple calculation shows that the estimated liquidity premium in U.S. TIPS, though puzzlingly large when compared to bid-ask spreads, gives rise to liquidity returns in line with those on off-the-run nominal Treasuries. Table I shows that the average U.S. off-the-run spread over our sample period is 21 bps. However, the on-the-run off-the-run liquidity differential can be expected to converge in 6 months when the new on-the-run nominal 10 year bond is issued. Thus the average annualized return on the liquidity differential between

¹²See also Wright (2009).

10 year on-the-run and off-the-run nominal Treasury bonds is $21 \times 10 \times 2 \text{ bps} = 420 \text{ bps}$. In contrast, the 10 year U.S. TIPS liquidity premium might take as long as 10 years to converge, giving an average annualized return on U.S. TIPS liquidity of only 65 bps.

The estimated U.K. liquidity premium has a lower average (50 bps) but a similar standard deviation (24 bps) compared to U.S. liquidity. Figure 2B shows that the estimated U.K. liquidity premium was initially similar to the U.S. liquidity premium (around 100 bps) and stabilized around 40 bps after 2005. It even became negative during the financial crisis, reflecting extremely high relative transaction volume in U.K. inflation-indexed bonds.

[FIGURE 3 ABOUT HERE]

Figures 3A and 3B show liquidity-adjusted U.S. and U.K. breakeven inflation. Our U.S. benchmark estimation suggests that liquidity-adjusted U.S. breakeven averaged 2.93% with a standard deviation of 25 bps over our sample. Liquidity-adjusted U.S. breakeven was substantially more stable than raw U.S. breakeven. Both raw and liquidity-adjusted U.S. breakeven fell during the financial crisis but the drop was significantly smaller for liquidity-adjusted breakeven. Adjusting breakeven for liquidity therefore suggests that while investors' U.S. long-term inflation expectations fell during the crisis, there was never a period when investors feared substantial long-term deflation in the U.S.

Figure 3B partly attributes the strong upward trend in U.K. breakeven inflation to liquidity. However, even after adjusting for liquidity U.K. breakeven has trended upwards from around 3% at the beginning of our sample period to around 4% at the end of 2010. In contrast to the U.S., U.K. breakeven does not exhibit a pronounced drop during the financial

crisis. Both raw and liquidity-adjusted U.K. breakeven become substantially more volatile during 2008-2010, potentially due to increased U.K. inflation uncertainty.

III Testing for Preferred Habitat in U.S. and U.K. Inflation-Indexed and Nominal Bond Markets

Section II shows that liquidity, understood as market factors not directly related to real interest rate and inflation fundamentals, explains substantial variation in the yield differential between inflation-indexed and nominal government bonds in the U.S. and the U.K. However, before decomposing the fundamental sources of bond return predictability, we still need to test for one additional potential non-fundamental source of return predictability. This section tests whether between nominal and inflation-indexed bond markets are segmented due to preferred habitat preferences.

The preferred habitat hypothesis of Modigliani and Sutch (1966) states that the preference of certain types of investors for specific bond maturities might result in supply imbalances and price pressure in the bond market. In recent work Vayanos and Vila (2009) formalize this hypothesis in a theory where risk-averse arbitrageurs do not fully offset the price imbalances generated by preferred-habitat investors, leading to excess bond return predictability. Greenwood and Vayanos (2008) and Hamilton and Wu (2010) find empirical support for this theory using the relative supply of nominal Treasury bonds at different maturities as a proxy for supply shocks.

We consider a natural extension of the market segmentation hypothesis. Inflation-indexed

and nominal bond markets might be segmented due to different investor clienteles: Certain types of investors might have a natural preference for inflation-indexed bonds – for example, conservative long-term investors or pension funds with inflation-indexed liabilities – while others might have a natural preference for nominal bonds – for example, pension funds with nominal liabilities or global investors seeking highly liquid, non-defaultable securities denominated in a strong currency. If there is limited arbitrage capital keeping both markets tightly connected, we might observe temporary price divergences unrelated to fundamentals.

For example, breakeven inflation could be larger than implied by market expectations of inflation and inflation risk premia, if there is strong non-fundamental demand of inflation-indexed bonds. The Treasury can take advantage of this situation by issuing TIPS. Until it does so, TIPS bonds will appear overpriced relative to fundamentals and breakeven inflation will be large relative to fundamentals.¹³ Prices will correct once the Treasury increases the supply of TIPS, generating a decline in breakeven and negative returns for TIPS holders.

We test whether segmentation between inflation-indexed and nominal bond markets induces relative price fluctuations and return predictability in an empirical setup similar to Greenwood and Vayanos (2008). If supply is subject to exogenous shocks while clientele demand is stable over time we would expect increases in the relative supply of inflation-indexed bonds to be correlated with contemporary decreases in breakeven inflation, as the price of inflation-indexed bonds falls in response to excess supply. Subsequently we would expect to see positive returns on inflation-indexed bonds as their prices rebound.

¹³Greenwood and Vayanos (2010) analyze an episode of this nature in the U.K. The U.K. Pensions Act of 2004 provided pension funds with a strong incentive to buy long-maturity and inflation-linked government bonds. Pundits and market participants argued that this led to an overpricing of inflation-indexed bonds because the government did not immediately increase the issuance of these bonds to keep up with the regulatory driven excess demand for inflation linkers.

Alternatively, it could be the case that bond demand changes over time, while the government tries to accommodate changes in demand. This issuance behavior would be consistent with a debt management policy that tries to take advantage of interest rate differentials across both markets. In this case, the relative supply of inflation-indexed bonds might be unrelated to subsequent returns, and possibly even positively correlated with contemporaneous breakeven inflation.

Let D_t^{TIPS} denote the face value of inflation-indexed bonds outstanding and D_t the combined face value of nominal and inflation-indexed bonds outstanding at time t for either the U.S. or the U.K. We define relative supply $Supply_t$ and relative issuance $\Delta Supply_t$:

$$Supply_t = D_t^{TIPS} / D_t, \quad (13)$$

$$\Delta Supply_t = (D_t^{TIPS} - D_{t-1}^{TIPS}) / D_{t-1}^{TIPS} - (D_t - D_{t-1}) / D_{t-1}. \quad (14)$$

We also construct a measure of unexpected relative issuance ε_t^{Supply} .¹⁴ In Appendix Table A.XII we conduct Dickey-Fuller tests to find that in the U.S. we cannot reject a unit root in $Supply_t$ or in $\Delta Supply_t$. However, the year-over-year change in relative issuance appears stationary and we construct a supply shock ε_t^{Supply} as the residual from an autoregression of

¹⁴We measure the relative supply of inflation-indexed bonds in the U.S. as the nominal amount of TIPS outstanding relative to U.S. government TIPS, notes and bonds outstanding. U.K. relative supply is the total amount of inflation-linked gilts relative to the total amount of conventional gilts outstanding. The economic report of the president reports U.S. Treasury securities by kind of obligation and reports T-bills, Treasury notes, Treasury bonds and TIPS. The data can be found in Table 85 until 2000 and in Table 87 afterwards at <http://www.gpoaccess.gov/eop/download.html>. The face value of TIPS outstanding available in the data is the original face value at issuance times the inflation incurred since then and therefore it increases with inflation. The numbers include both privately held Treasury securities and Federal Reserve and intra-governmental holdings as in Greenwood and Vayanos (2008). We are deeply grateful to the U.K. Debt Management Office for providing us with data. Conventional U.K. gilts exclude floating-rate and double-dated gilts but include undated gilts. The face value of U.K. index-linked gilts does not include inflation-uptake and is reported as the original nominal issuance value.

$\Delta Supply_t - \Delta Supply_{t-12}$ with twelve lags. In the U.K. we can reject stationarity in relative issuance $\Delta Supply_t$, potentially reflecting the less regular U.K. bond issuance cycle. We therefore construct the U.K. supply shock ϵ_t^{Supply} as the residual from an autoregression of $\Delta Supply_t$ with twelve lags.

[FIGURE 4 ABOUT HERE]

Figure 4A plots the relative supply of U.S. TIPS and U.S. 10 year breakeven inflation. Starting from less than 2% in 1997 TIPS increased to represent over 14% of the U.S. Treasury coupon bond portfolio in 2008. Subsequently to the financial crisis the U.S. government issued substantial amounts of nominal notes and bonds, leading to a drop in the relative TIPS share to 9% in 2010. U.S. breakeven inflation remained relatively steady with a large drop in the fall of 2008.

Figure 4B illustrates that the relative share of U.K. linkers has increased from about 9% in 1985 to 16% in 2010. Over the same time period 20 year U.K. breakeven inflation has fallen, reaching a low of 2.1% in 1998. The increase in inflation-linked bonds outstanding accelerated noticeably after the U.K. Pension Reform of 2004.

[TABLE III ABOUT HERE]

Table III tests whether breakeven is related to the relative supply measures $Supply_t$, $\Delta Supply_t$, and ϵ_t^{Supply} . If markets are segmented and subject to exogenous supply shocks we would expect to find negative slope coefficients onto these measures. Panel A in the table

shows results for the U.S., and Panel B shows results for the U.K. We include controls for inflation expectations in all regressions.

Table IIIA shows that U.S. relative supply enters with a positive and significant coefficient, but the coefficient becomes insignificant when controlling for liquidity proxies and a time trend. Neither relative issuance nor relative supply shocks ε_t^{Supply} appear related to breakeven, either individually or when controlling for liquidity variables and a time trend.

Table IIIB shows similar empirical results for the U.K. The U.K. results are consistent between a significantly longer sample period, and a shorter sample period, for which liquidity controls are available. Relative supply enters with a positive and significant coefficient, but this coefficient becomes insignificant as we include a time trend in the regression. The time trend is highly statistically significant and dramatically increases the regression R^2 . Again, relative issuance or supply shocks ε_t^{Supply} do not enter significantly.

The positive coefficient onto relative supply for both countries could be consistent with the U.S. and the U.K. governments reacting to increased demand for inflation-linked bonds by issuing more inflation-indexed bonds, which is consistent with at least U.K. anecdotal evidence. Unlike the U.S. Treasury, the U.K. Debt Management Office has an irregular auction calendar and appears to take into account bond demand when deciding the size and characteristics of bond issues.

Our results in this section can be reconciled with Fleckenstein, Longstaff, and Lustig (2010), who argue that the supply of Treasury securities affects the relative mispricing of inflation-indexed and nominal bonds. We use the theoretically motivated relative supply of inflation-indexed bonds, while they include both the supply of TIPS and of Treasuries sepa-

rately in their regressions. They find that TIPS become relatively more expensive when the Treasury issues more TIPS, which seems inconsistent with a market segmentation hypothesis. They interpret their results as evidence that markets with liquid on-the-run securities allow arbitrageurs to drive prices together.

If markets are segmented in the sense of Greenwood and Vayanos (2008) a positive shock to the relative supply of inflation-indexed bonds should predict lower excess returns on nominal bonds over inflation-indexed bonds. Table IV finds no evidence that U.S. or U.K. supply variables predict bond excess returns. Table IV reports regressions of nominal, inflation-indexed and breakeven returns as defined in (2), (3) and (4) onto lagged relative supply. Campbell and Shiller (1996) show that the nominal term spread can predict excess returns on long-term nominal bonds. Moreover, Pflueger and Viceira (2011) show that TIPS term spreads and breakeven term spreads are significant predictors of the corresponding excess returns and therefore we control for these spreads in our regressions. We control for lagged relative inflation-indexed bonds liquidity to control for potentially time-varying liquidity risk premia.

[TABLE IV ABOUT HERE]

Table IV shows that even after controlling for supply effects, the nominal term spread forecasts positively nominal bond excess returns and its slope coefficient is significant in the U.K. over the longer sample period. The breakeven term spread predicts breakeven excess returns both in the U.S. and the U.K. The inflation-indexed bond term spread predicts inflation-indexed bond excess returns in the U.K. over the longer sample and is marginally significant in the U.S. and the U.K. over the shorter 11 year period. Relative supply shocks therefore cannot explain why term spreads predict excess returns on inflation-indexed bonds

and on nominal bonds in excess of inflation-indexed bonds.

In summary, there is no evidence of relative supply shocks predicting bond excess returns in either the U.S. or the U.K. These results do not seem consistent with segmented markets that are subject to exogenous supply shocks. Instead they might indicate that U.S and U.K. governments accommodate demand pressures from investors for nominal or inflation-indexed bonds.

IV Decomposing Time-Varying Bond Risk Premia

As shown in Section II, bond market liquidity proxies can explain substantial variation in the difference between nominal and inflation-indexed yields. This section provides new empirical evidence on excess bond return predictability using liquidity-adjusted inflation-indexed bond returns, liquidity-adjusted breakeven returns, and returns due to changes in bond market liquidity. In Section III, we found no evidence that relative supply shocks and preferred habitat with limits to arbitrage generate bond return predictability; we therefore interpret our predictability results as evidence of time variation in real interest rate risk premia, inflation risk premia, and liquidity risk premia.¹⁵

This section decomposes government bond excess returns into returns due to real interest rates, changing inflation expectations, and liquidity. We test for predictability in each com-

¹⁵Pflueger and Viceira (2011) find that TIPS returns are predicted by the TIPS term spread and that breakeven inflation returns are predicted by the breakeven term spread. However, they cannot test whether real rate risk premia and inflation risk premia are time-varying because they do not adjust for the substantial liquidity component in breakeven. See also Barr and Campbell (1997) and Evans (2003) for evidence on predictability in inflation-indexed bond excess returns using a significantly shorter U.K. sample with no liquidity adjustment.

ponent separately: Predictability in liquidity-adjusted real bond excess returns would indicate a time-varying real interest rate risk premium, while predictability in liquidity-adjusted breakeven returns would indicate a time-varying inflation risk premium. Predictability in the liquidity component of TIPS returns would indicate a time-varying liquidity risk premium.

We compute liquidity-adjusted inflation-indexed and breakeven excess returns by replacing inflation-indexed bond yields and breakeven with their liquidity-adjusted counterparts (11) and (12):

$$xr_{n,t+1}^{TIPS-L} = ny_{n,t}^{TIPS,adj} - (n-1)y_{n-1,t+1}^{TIPS,adj} - y_{1,t}^{TIPS}, \quad (15)$$

$$xr_{n,t+1}^{b+L} = xr_{n,t+1}^{\$} - xr_{n,t+1}^{TIPS-L}. \quad (16)$$

The expression (15) relies again on the assumption that the liquidity differential is entirely attributable to inflation-indexed bonds. The return on inflation-indexed bonds due to illiquidity is given by:

$$r_{n,t+1}^L = -(n-1)L_{n-1,t+1} + nL_{n,t}. \quad (17)$$

Table V regresses excess returns (15), (16), and (17) onto one-quarter lags of the liquidity-adjusted real term spread $(y_{n,t}^{TIPS} - L_{n,t}) - y_{1,t}^{TIPS}$, the liquidity-adjusted breakeven term spread $(b_{n,t} + L_{n,t}) - b_{1,t}$, and the estimated liquidity differential between inflation-indexed and nominal yields $L_{n,t}$. Intuitively, the three right-hand-side variables decompose the nominal term spread, used by Campbell and Shiller (1991) to predict nominal bond excess returns, into real term structure, inflation, and liquidity components. Table V reports Newey-West standard errors with three lags and one-sided bootstrap p-values, which account for the

fact that liquidity is estimated.¹⁶ For comparison, Appendix Table A.IX reports results for non-liquidity adjusted excess returns.

[TABLE V ABOUT HERE]

The first two columns in Panel A show that liquidity-adjusted TIPS excess returns are not statistically significantly predictable according to bootstrap p-values. Of course, this finding of no predictability might partly be due to our short U.S. sample, which reduces our statistical power. Columns (1) and (2) of Panel B provide additional evidence from the cross-section of international inflation-indexed bonds and show strong evidence for excess return predictability in the U.K. The U.K. real term spread enters with a positive and significant coefficient even when controlling for liquidity. The liquidity-adjusted breakeven term spread and lagged liquidity do not enter significantly in columns (1) or (2) either in the U.S. or the U.K., as one might expect if those variables are unrelated to real interest rate risk.

Columns (3) and (4) in Tables VA and VB show strong evidence that liquidity-adjusted breakeven excess returns are predictable. Liquidity-adjusted breakeven term spreads predict breakeven excess returns with coefficients that are large, statistically significant, and similar across both countries. This empirical finding indicates that that time-varying inflation risk premia are a source of predictability in nominal bond excess returns and that the nominal term spread partly reflects time-varying inflation risk premia.

Remarkably, liquidity does not predict liquidity-adjusted real bond or breakeven excess returns in the U.S. or the U.K. The estimated liquidity differential does not appear related to

¹⁶We use a non-parametric block bootstrap with block length 24 months and 2000 replications. See Horowitz (2001) for a survey of bootstrap methods.

fundamental bond cash-flow risk, alleviating concerns that estimated liquidity might capture time-varying inflation risk premia as a result of our estimation strategy.

The last two columns of Tables VA and VB show that liquidity $L_{n,t}$ predicts quarterly liquidity returns $r_{n,t+1}^L$ with large and highly significant coefficients. Both in the U.S. and the U.K., time-varying and predictable liquidity premia are a source of excess return predictability inflation-indexed bonds. The effect of the liquidity premium on returns is such that when liquidity in the inflation-indexed bond market is scarce, inflation-indexed bonds enjoy a higher expected return relatively to nominal bonds, rewarding investors who are willing to invest into a temporarily less liquid market.

Table V uses inflation-indexed bond returns in excess of a hypothetical real short rate. Appendix Table A.VII shows that return predictability regressions are very similar if we include interaction terms in the liquidity estimation. Appendix Table A.VIII shows that results hold up for tradeable nominal returns on inflation-indexed bond in excess of the nominal short rate.

The return predictability regressions in Table V provide empirical evidence of time variation in three different components of bond risk premia: real interest rate risk premia, inflation risk premia, and liquidity risk premia. The evidence for time-varying inflation risk premia and liquidity risk premia is highly statistically significant and consistent across U.S. and U.K. data.

A Economic Significance of Bond Risk Premia

[TABLE VI ABOUT HERE]

We now evaluate the economic significance of time-varying real rate risk premia, inflation risk premia, and liquidity risk premia. The first column of Table VI reports annualized average excess log returns on real bonds and breakeven, and average log liquidity returns. We note that our average return calculations are based on log returns with no variance adjustments for Jensen’s inequality. For simplicity we refer to the expected liquidity excess return as a liquidity risk premium, the expected liquidity-adjusted breakeven return as an inflation risk premium and expected liquidity-adjusted TIPS returns as a real rate risk premium. Note that the average excess return on inflation-indexed bonds equals the sum of the liquidity risk premium plus the real rate risk premium and that the average excess return on nominal bonds equals the sum of the inflation risk premium plus the real rate risk premium.

Table VIA shows that, at 99 bps, the liquidity risk premium accounts for almost one-fifth of the average realized total U.S. TIPS excess return over this period (see Table I). Although the average estimated inflation risk premium is economically significant at 52 bps, it is substantially smaller than the average real interest rate risk premium over the same time period. Table VIB shows that at 161 basis points, the average estimated liquidity risk premium is even more substantial in the U.K. Interestingly, the estimated inflation risk premium in U.K. nominal bonds is negative at -34 bps, helping to explain low average log excess returns on nominal U.K. bonds (Table I).¹⁷

Column (2) of Table VIA shows that U.S. liquidity-adjusted breakeven excess returns and liquidity-adjusted TIPS excess returns both have small and negative CAPM betas.¹⁸

¹⁷Our estimates suggest that the negative inflation risk premium estimated by Campbell, Sunderam and Viceira (2013) over our sample period might have been partly due to a relative TIPS liquidity premium.

¹⁸We compute CAPM betas using the stock market as the proxy for the wealth portfolio. The U.S. excess stock return is the log quarterly return on the value-weighted CRSP index, rebalanced annually, in excess of the log 3-month interest rate. The U.K. excess stock return is the log quarterly total return on the FTSE in excess of the log 3-month interest rate. In Appendix Table A.X, we find that raw breakeven returns exhibit

By contrast, the beta on U.S. liquidity returns is positive and significant. The positive liquidity beta implies that TIPS tend to become illiquid relative to nominal Treasury bonds – or conversely, nominal bonds become liquid relative to TIPS – during stock market drops.

The strong positive covariation between U.S. estimated liquidity returns and stock returns suggests that investors should expect to earn a premium on TIPS for bearing systematic variation in liquidity. Consistent with this notion, Appendix Table A.X shows that the market alpha of liquidity returns is small and insignificant over our full sample. This table also shows that during the pre-crisis period, liquidity returns have no market exposure and substantial alpha, suggesting that positive liquidity returns compensate TIPS holders for the risk that TIPS become less liquid during dramatic drops in the stock market. Appendix Table A.XI shows that TIPS liquidity returns are not related to innovations in the Pastor-Stambaugh factor, which captures stock market liquidity, or to the Fama-French factors.

In contrast, column (2) of Table VIB shows that the U.K. liquidity beta is indistinguishable from zero. The CAPM beta of U.K. liquidity-adjusted breakeven returns is large, negative, and statistically significant, suggesting that inflation expectations and thus nominal interest rates have been pro-cyclical during our sample period. The combined evidence of procyclical nominal interest rates and low inflation risk premia is consistent with a view that nominal Treasuries were safe assets and provided investors with sizable diversification benefits over our sample in the framework of Campbell, Sunderam, and Viceira (2013).

We find that time-varying real rate risk premia, time-varying inflation risk premia and time-varying liquidity premia are quantitatively equally important sources of return predictability. Column (3) of Table VI reports roughly similar standard deviations for estimated

a large and negative CAPM beta.

expected liquidity-adjusted real bond excess returns, liquidity-adjusted breakeven returns, and liquidity returns. The standard deviations in column (3) are in line with the standard deviation of predicted nominal excess bond returns estimated from standard Campbell and Shiller (1991) bond return forecasting regressions (Appendix Table A.IX), suggesting that estimated components of bond excess returns are as predictable as raw excess returns.

[FIGURE 5 ABOUT HERE]

Figure 5 shows predicted 3-month excess returns, labeled real rate risk premia, inflation risk premia, and liquidity risk premia. While magnitudes may appear large, Figure 5 shows predicted 3-month returns in annualized units and not predicted 12-month returns. Figure 5A shows that the U.S. inflation risk premium was small or negative 2000-2006. The inflation risk premium became positive during the period of high oil prices in 2008 and fell to almost -5% at the beginning of 2009, just when the U.S. real rate risk premium increased sharply. The U.S. liquidity risk premium was large in the early 2000s, declined steadily during the decade, and spiked during the financial crisis in the fall of 2008.

The negative U.S. inflation risk premium in 2009 indicates that investors were willing to accept negative expected breakeven returns. Investors should accept negative expected returns if they consider the nominal component of bond returns safe. Such would be the case if further economic deterioration is anticipated to go along with high breakeven returns and low inflation rather than high inflation. A large and positive real interest rate risk premium during the same time period indicates that real bonds were considered risky, so a deepening of the recession was considered likely to go along with high long-term real interest rates.

In contrast, Figure 5B suggests that the U.K. inflation risk premium shot up during the financial crisis. In the framework of Campbell, Sunderam, and Viceira (2013) this could indicate that while U.K. investors feared that further economic deterioration would go along with inflation, U.S. investors were concerned about low growth accompanied by low inflation or even deflation. The liquidity risk premium on real bonds relative to nominal bonds did not spike in the U.K. during the financial crisis, and in fact it declined, suggesting that investors did not consider U.K. real bonds risky due to illiquidity.

V Conclusion

This paper explores the sources of time variation in bond risk premia in nominal and inflation-indexed bonds in the U.S. and the U.K. We find strong empirical evidence in both markets that nominal bond excess return predictability is related to time variation in inflation risk premia. Inflation risk premia exhibit significant time variation, are low on average, and take both positive and negative values in our sample. We find strong evidence in U.K. data that predictability in nominal bond excess returns is also related to time-varying real interest rate risk premia.

We find strong empirical evidence for both time-varying real rate and time-varying liquidity risk premia in inflation-indexed bonds in both markets. Liquidity risk premia in U.S. TIPS exhibit a positive and statistically significant CAPM beta and account for 99 bps of TIPS excess returns over our sample. Our results suggest that bond investors receive a liquidity discount for holding inflation-indexed bonds, but that this discount varies with economic conditions and exposes them to systematic risk.

Survey inflation expectations and leading inflation indicators account for 39% of the time series variability in breakeven in the U.S., and 51% in the U.K. Time-varying liquidity explains substantial additional variation in breakeven, raising regression R^2 s to 70% in the U.S. and 65% in the U.K. Liquidity-adjusted U.S. breakeven has been stable around 3% over our sample period, suggesting that bond investors' U.S. long-term inflation expectations have not moved significantly, even during the financial crisis. U.K. breakeven inflation adjusted for liquidity exhibits an upward trend.

The estimated liquidity premium in U.S. TIPS yields relative to nominal yields is economically significant and strongly time-varying. We estimate a large premium early in the life of TIPS, a significant decline after 2004, and a sharp increase to over 150 bps during the height of the financial crisis in the fall of 2008 and winter of 2009. Since then, the premium has declined back to more normal levels of 50 to 70 bps.

The estimated relative liquidity premium might partly reflect a convenience yield on nominal bonds (Krishnamurthy and Vissing-Jorgensen, 2010), rather than a liquidity discount specific to TIPS. In this case, TIPS are not undervalued securities; instead investors appear to be willing to pay a liquidity premium on nominal Treasury bonds. The Treasury could take advantage of this premium by issuing more nominal Treasury bonds, but it would still be issuing TIPS at their fair value. If investors appropriately value TIPS, taking them off the market might have adverse welfare consequences for investors in need of the real interest rate hedge and inflation hedge offered by TIPS (Campbell and Viceira, 2001).

Estimated inflation risk premia, real rate risk premia and liquidity risk premia are roughly equally quantitatively important as sources of bond excess return predictability. The empirical results in this paper have important implications for modeling and understanding

predictability in bond excess returns. We find an important role for time-varying real interest rate risk, which can be modeled either in a model of time-varying habit (Wachter, 2006) or in a model of time variation in expected aggregate consumption growth or its volatility (Bansal and Yaron, 2004, Bansal, Kiku, and Yaron, 2010). However, our results indicate that time-varying inflation risk is equally important for understanding the time-varying risks of nominal government bonds. A model that aims to capture predictability in nominal government bond excess returns therefore has to integrate sources of real interest rate risk and inflation risk.

Our results suggest directions for future research. Different classes of investors have different degrees of exposure to time-varying liquidity risk, real interest rate risk and inflation risk. Exposures may vary with shares of real and nominal liabilities and time horizons. Understanding the sources of bond return predictability can therefore have potentially important implications for investors' portfolio management and pension investing.

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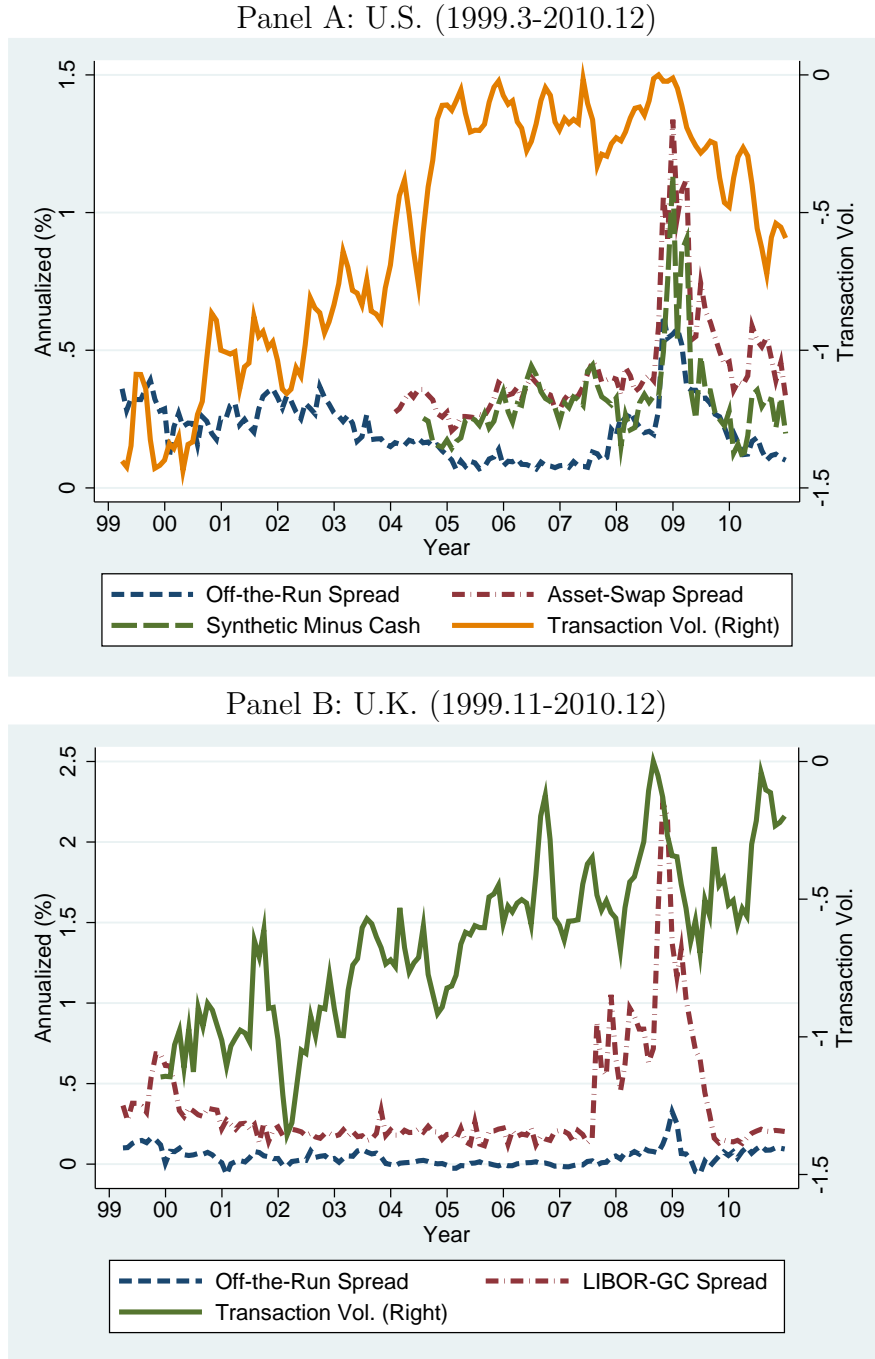


Figure 1: U.S. and U.K. Liquidity Proxies.

We use liquidity proxies to estimate differential liquidity between inflation-indexed and nominal government bonds. For the U.S., we use the spread between off-the-run and on-the-run 10 year nominal bond yields, the relative inflation-indexed bond log transaction volume, the asset-swap differential, and the difference between synthetic and cash breakeven. For the U.K., we use the the difference between a 10 year nominal fitted par yield and the 10 year nominal generic Bloomberg yield, denoted “off the run”. We normalize the maxima of relative transaction volumes to zero. The asset-swap spread differential, synthetic minus cash breakeven, and the GBP three-month LIBOR-GC spread proxy for the cost of funding a levered investment in inflation-indexed bonds.

Panel A: U.S. (1999.3-2010.12)



Panel B: U.K. (1999.11-2010.12)

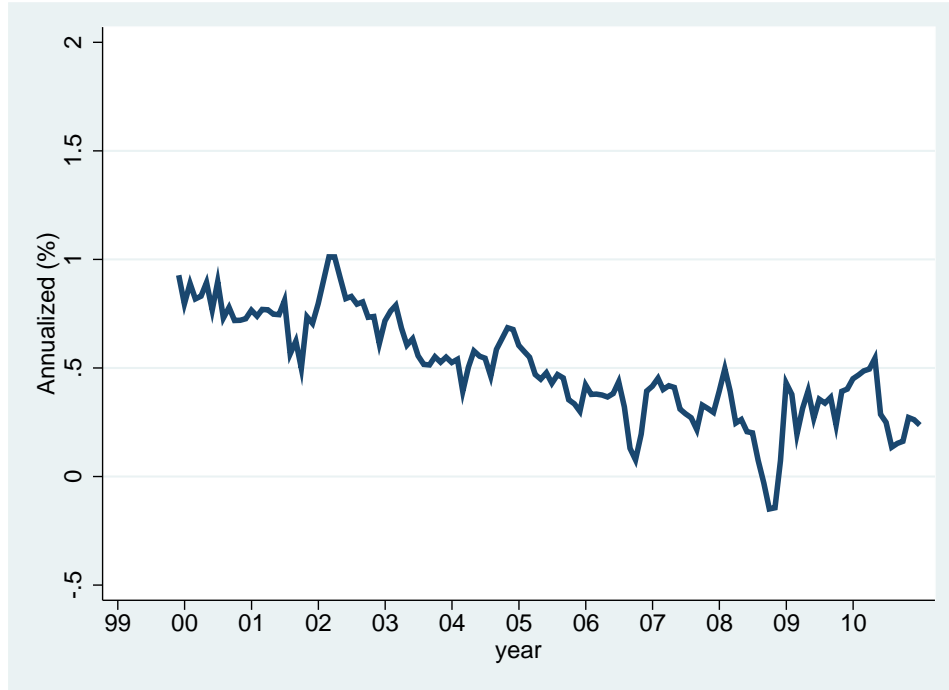
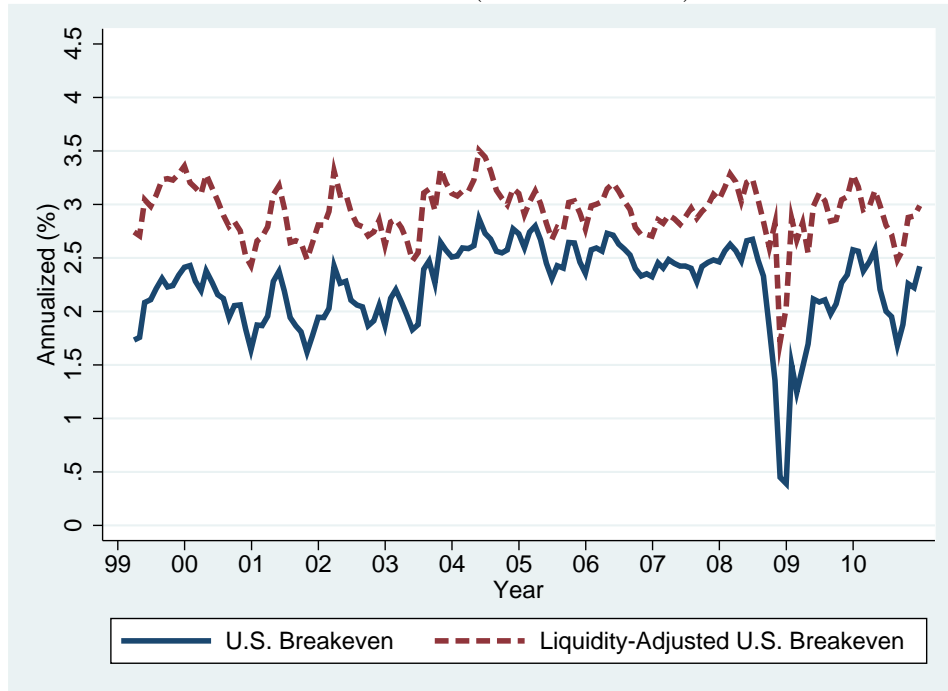


Figure 2: Estimated U.S. and U.K. Liquidity Premia.

We estimate liquidity premia as the negative of the variation in breakeven explained by liquidity proxies. Formally, $\hat{L}_{n,t} = -\hat{a}_2 X_t$, where X_t is the vector of liquidity variables and \hat{a}_2 is the vector of corresponding estimated coefficients in Table II(4), Panels A and B.

Panel A: U.S. (1999.3-2010.12)



Panel B: U.K. (1999.11-2010.12)

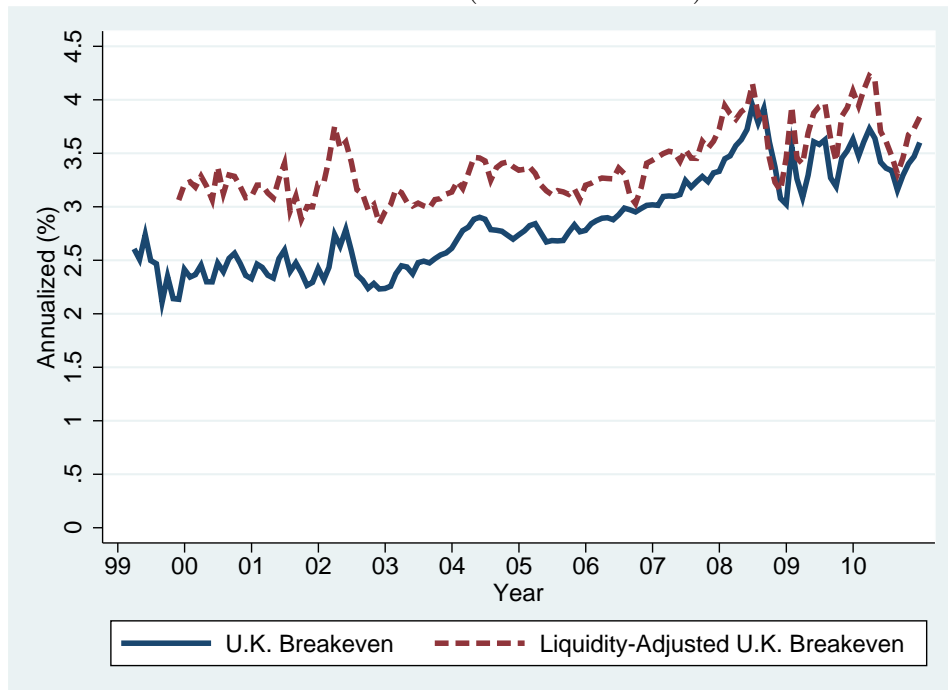
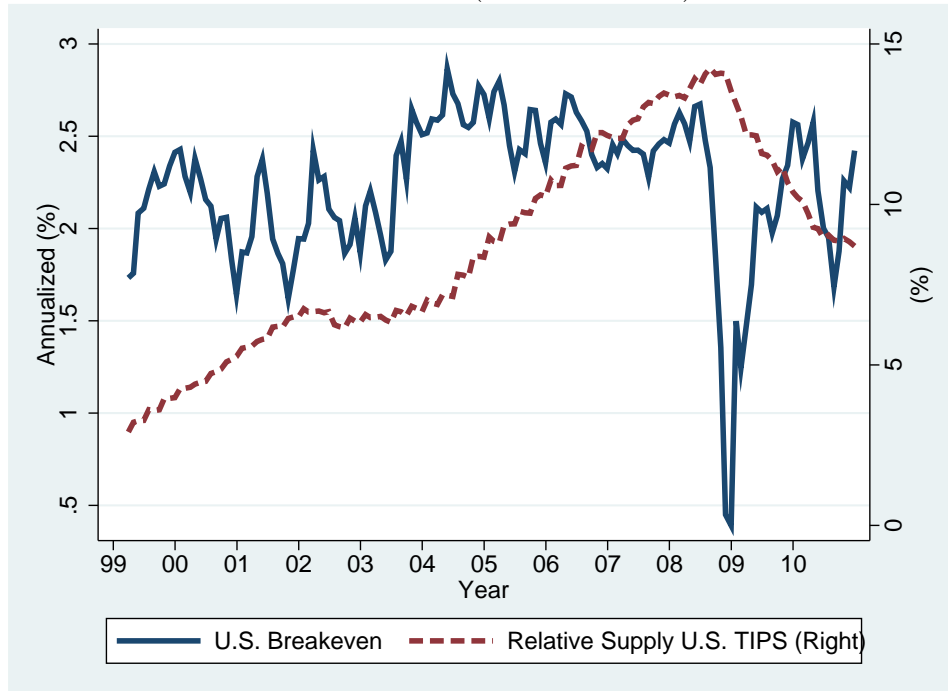


Figure 3: Liquidity-Adjusted U.S. 10 Year Breakeven and U.K. 20 Year Breakeven.

Liquidity-adjusted breakeven equals breakeven plus the liquidity premium shown in Figure 2.

Panel A: U.S. (2000.2-2010.12)



Panel B: U.K. (1986.1-2010.12)

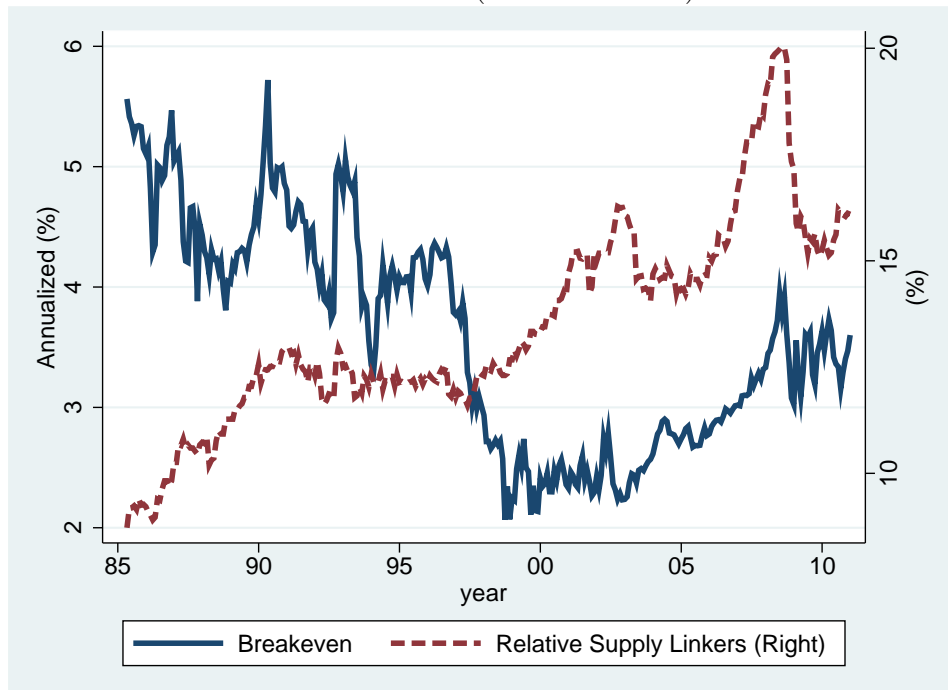
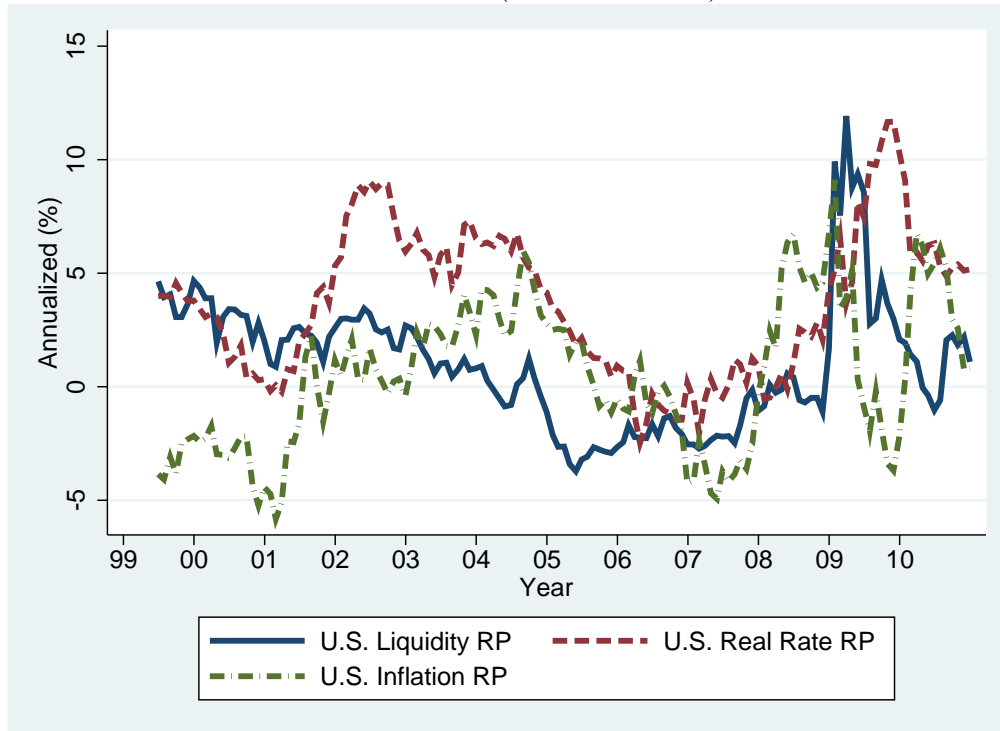


Figure 4: Relative Supply of Inflation-Indexed Bonds and Breakeven.

Relative supply shows the face value of inflation-indexed bonds outstanding relative to the face value of inflation-indexed and nominal bonds outstanding. We show 10 year U.S. breakeven and 20 year U.K. breakeven.

Panel A: U.S. (1999.6-2010.12)



Panel B: U.K. (2000.2-2010.12)

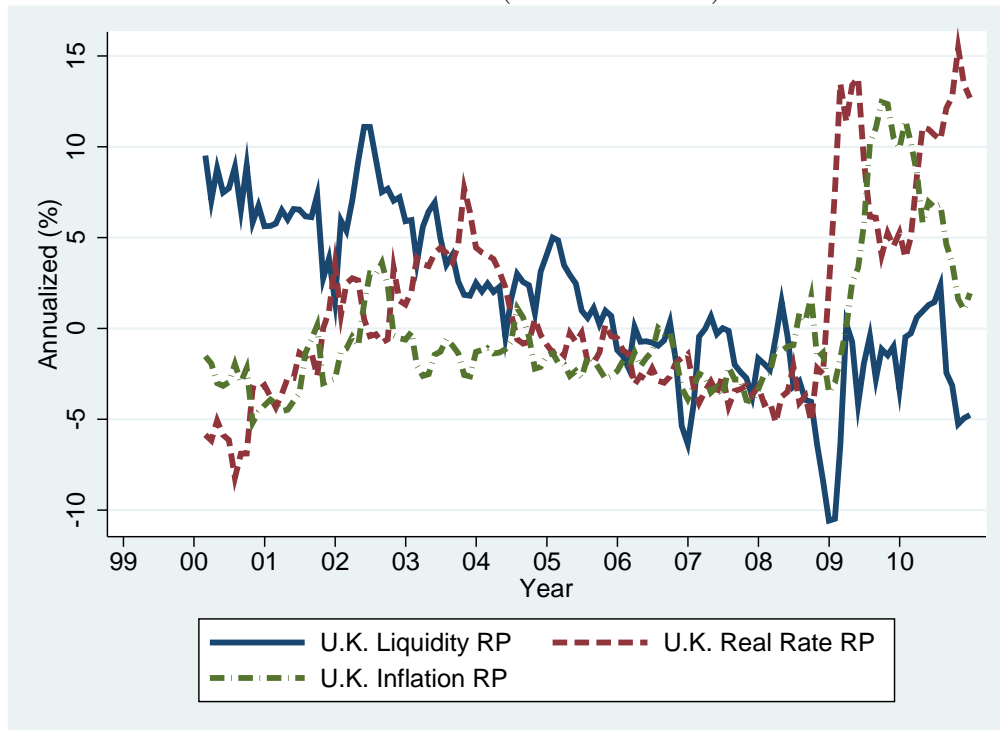


Figure 5: U.S. and U.K. Estimated Risk Premia.

Predicted 3-month excess returns in annualized units, labeled real rate risk premia, inflation risk premia, and liquidity risk premia. We obtain predicted excess returns as fitted values from the regressions shown in Tables V(1), V(3) and V(5), Panels A and B.

Table I: Summary Statistics.

Nominal and inflation-indexed bond yields, excess returns, inflation expectation proxies, and liquidity proxies. U.S. 10 year nominal and TIPS yields from Gurkaynak, Sack, and Wright (2010). U.K. 20 year nominal and inflation-indexed yields from Anderson and Sleath (2001). U.S. three-month log excess returns (1996.-2010.12) and U.K. three-month log excess returns (2000.2-2010.12) are approximated using zero-coupon log yields. U.S. survey inflation is the median 10 year CPI inflation forecast from the Survey of Professional Forecasters. The Chicago Fed National Activity Index (CFNAI) is as in Stock and Watson (1999). U.K. survey inflation reflects Bank of England Public Attitudes Survey 12 month inflation expectations. U.S. asset-swap spread (2004.1-2010.12), U.S. difference between synthetic and cash breakeven (2004.7-2010.12), and U.K. 3-month GBP LIBOR minus general collateral (GC) spread capture cost of arbitraging between nominal and inflation-indexed bonds. We normalize the maxima of relative transaction volumes to zero. The U.K. off-the-run spread reflects the spread between a fitted 10 year nominal par yield and the generic 10 year nominal U.K. bond yield from Bloomberg. Spreads and zero-coupon yields continuously compounded in annualized percent.

Panel A: U.S. (1999.3-2010.12)		Mean	Std	Min	Max
Nominal Yields	$y_{n,t}^{\$}$	4.68	0.87	2.66	6.70
Inflation-Indexed Yields	$y_{n,t}^{TIPS}$	2.44	0.91	0.59	4.29
Breakeven	$b_{n,t}$	2.24	0.39	0.39	2.87
Nominal Excess Ret.	$xr_{n,t+1}^{\$}$	4.19	8.75	-41.89	56.62
Infl.-Indexed Excess Ret.	$xr_{n,t+1}^{TIPS}$	4.66	7.63	-64.91	58.03
Breakeven Excess Ret.	$xr_{n,t+1}^b$	-0.48	7.30	-42.62	74.33
Survey Inflation	π^E	2.47	0.07	2.2	2.55
Chicago Fed Nat. Activity	CFNAI	-0.37	0.96	-4.46	1.08
Off-the-Run Spr.		0.21	0.11	0.07	0.63
Log Transaction Vol.		-0.57	0.44	-1.44	0.00
Asset-Swap Spr.		0.43	0.21	0.21	1.34
Synthetic - Cash		0.32	0.17	0.11	1.13
Panel B: U.K. (1999.11-2010.12)		Mean	Std	Min	Max
Nominal Yields	$y_{n,t}^{\$}$	4.41	0.25	3.79	5.01
Inflation-Indexed Yields	$y_{n,t}^{TIPS}$	1.53	0.52	0.57	2.44
Breakeven	$b_{n,t}$	2.88	0.46	2.14	3.95
Nominal Excess Ret.	$xr_{n,t+1}^{\$}$	0.50	10.09	-49.25	50.08
Infl.-Indexed Excess Ret.	$xr_{n,t+1}^{TIPS}$	2.46	8.39	-65.78	32.85
Breakeven Excess Ret.	$xr_{n,t+1}^b$	-1.96	7.96	-37.39	66.96
Survey Inflation	π^E	2.52	0.57	1.50	4.40
Off-the-Run Spr.		0.04	0.05	-0.06	0.32
Log Transaction Vol.		-0.65	0.29	-1.36	0.00
LIBOR-GC Spr.		0.35	0.36	0.11	2.25

Table II: Estimating Differential Liquidity.

We regress the difference between nominal and inflation-indexed bond yields (breakeven inflation) onto liquidity proxies. The variables are as described in Table I. Newey-West standard errors with three lags in parentheses. The p-value of the F-test for no predictability is shown. * and ** denote significance at the 5% and 1% level, respectively.

Panel A: U.S. (1999.3-2010.12)							
$y_{n,t}^{\$} - y_{n,t}^{TIPS}$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Off-the-Run Spr.		-2.07** (0.26)	-1.97** (0.26)	-0.87* (0.42)	-1.27** (0.32)		-1.46** (0.42)
Asset-Swap Spr.			-0.27 (0.24)	-0.86** (0.31)			0.78 (0.93)
Transaction Vol.				0.33** (0.10)	0.24** (0.07)		0.09 (0.09)
Synthetic-Cash					-1.13** (0.28)		
Survey Inflation	0.04 (0.46)	0.70 (0.49)	0.50 (0.49)	0.17 (0.41)	0.56 (0.39)	0.80 (1.62)	0.29 (0.82)
CFNAI	0.25** (0.05)	0.11** (0.04)	0.08** (0.04)	0.12** (0.03)	0.10** (0.03)	0.28** (0.05)	0.18** (0.04)
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R^2	0.39	0.60	0.61	0.66	0.70	0.30	0.61
ADF of Residuals	-4.17**	-4.45**	-4.27**	-4.73**	-5.08**	-4.58**	-4.75**
Period	Full	Full	Full	Full	Full	1999.3 – 2006.12	
Panel B: U.K. (1999.11-2010.12)							
$y_{n,t}^{\$} - y_{n,t}^{TIPS}$	(1)	(2)	(3)	(4)	(5)	(6)	
Off-the-Run Spr.		-0.45 (0.88)	-0.89 (1.14)	-1.25 (0.94)			-3.19** (0.57)
LIBOR-GC Spr.			0.16 (0.20)	0.18 (0.18)			0.39 (0.20)
Transaction Vol.				0.78** (0.17)			0.47** (0.11)
Survey Inflation	0.57** (0.06)	0.59** (0.06)	0.56** (0.06)	0.28** (0.08)		0.55** (0.12)	0.27** (0.08)
p-value	0.00	0.00	0.00	0.00		0.00	0.00
R^2	0.51	0.51	0.52	0.65		0.31	0.67
ADF of Residuals	-3.86*	-3.88*	-3.92*	-4.14**		-3.88*	-4.07**
Period	Full	Full	Full	Full		1999.11 – 2006.12	

Table III: Breakeven Inflation onto Relative Inflation-Indexed Bond Supply.

We regress the difference between nominal and inflation-indexed yields (breakeven inflation) onto relative supply of inflation-indexed bonds, while controlling for liquidity variables and a time trend. $Supply_t$ denotes the face value of inflation-indexed bonds outstanding relative to all nominal and inflation-indexed bonds outstanding. $\Delta Supply_t$ denotes the issuance of inflation-indexed bonds relative to all nominal and inflation-indexed bonds. ε_t^{Supply} is obtained as the residual in a 12-lag monthly autoregression of $\Delta Supply_t - \Delta Supply_{t-12}$ ($\Delta Supply_t$) in the U.S. (U.K.). Newey-West standard errors with three lags in parentheses. The p-value of the F-test for no predictability is shown. * and ** denote significance at the 5% and 1% level, respectively.

Panel A: U.S. (2000.2-2010.12)				
$y_{n,t}^{\$} - y_{n,t}^{TIPS}$	(1)	(2)	(3)	(4)
$Supply_t$	0.05**			0.03
	(0.01)			(0.02)
$\Delta Supply_t$		0.01		-0.00
		(0.01)		(0.01)
ε_t^{Supply}			0.01	0.01
			(0.01)	(0.01)
Off-the-run Spr.				-0.95*
				(0.44)
Asset-Swap-Spr.				-1.05**
				(0.31)
Transaction Vol.				0.07
				(0.16)
Survey Inflation	0.57	-0.07	0.05	0.68
	(0.45)	(0.49)	(0.48)	(0.56)
CFNAI	0.32**	0.26**	0.27**	0.12**
	(0.05)	(0.05)	(0.05)	(0.03)
$month$				0.00
				(0.00)
p-value	0.00	0.00	0.00	0.00
R^2	0.53	0.43	0.43	0.70
Sample		2000.2-2010.12		

Table III (continued)

Panel B: U.K. (1986.1-2010.12 and 1999.11-2010.12)

$y_{n,t}^S - y_{n,t}^{TIPS}$	(1)	(2)	(3)	(4)	(5)
$Supply_t$	0.07* (0.03)			0.03 (0.03)	0.01 (0.03)
$\Delta Supply_t$		0.00 (0.02)		-0.00 (0.05)	-0.02 (0.05)
ε_t^{Supply}			0.01 (0.02)	0.00 (0.05)	0.02 (0.05)
Off-the-run Spr.					-0.11 (0.11)
LIBOR-GC Spr.					0.02 (0.03)
Transaction Vol.					-0.00** (0.00)
Survey Inflation	0.11** (0.02)	0.14** (0.01)	0.14** (0.01)	0.04** (0.02)	0.06** (0.02)
$month$				0.01** (0.00)	0.01** (0.00)
p-value	0.00	0.00	0.00	0.00	0.00
R^2	0.54	0.51	0.51	0.87	0.88
Sample		1986.1 – 2010.12			1999.11 – 2010.12

Table IV: Excess Bond Returns onto Relative Supply of Inflation-Indexed Bonds.

We regress overlapping 3-month nominal, inflation-indexed, and breakeven log excess bond returns onto measures of relative supply, as defined in Table III. We control for the nominal term spread, the TIPS term spread, the breakeven term spread, and liquidity as estimated in Table II(4). Newey-West standard errors with three lags are provided in parentheses. The p-value of the F-test of no predictability is shown. * and ** denote significance at the 5% and 1% level, respectively.

Panel A: U.S. (2000.5-2010.12)

	(1) $xr_{n,t+1}^{\$}$	(2) $xr_{n,t+1}^{\$}$	(3) $xr_{n,t+1}^{TIPS}$	(4) $xr_{n,t+1}^b$
$Supply_t$	-0.21 (0.73)	-0.38 (0.68)	0.04 (0.71)	-0.42 (0.73)
$\Delta Supply_t$	0.26 (0.55)	0.22 (0.54)	0.28 (0.41)	-0.06 (0.30)
ε_t^{Supply}	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)
$L_{n,t}$	1.64 (9.87)	7.03 (11.82)	18.02 (10.20)	-10.99 (9.82)
$y_{n,t}^{\$} - y_{1,t}^{\$}$	2.11 (1.41)			
$y_{n,t}^{TIPS} - y_{1,t}^{TIPS}$		0.77 (2.12)	2.53 (1.39)	-1.76 (1.57)
$b_{n,t} - b_{1,t}$		4.18 (3.18)	-2.40 (2.43)	6.58* (2.68)
p-value	0.39	0.44	0.01	0.03
R^2	0.05	0.05	0.21	0.20
Sample	2000.5 – 2010.12			

Panel B: U.K. (1986.4-2010.12 and 2000.2-2010.12)

	(1) $xr_{n,t+1}^{\$}$	(2) $xr_{n,t+1}^{\$}$	(3) $xr_{n,t+1}^{TIPS}$	(4) $xr_{n,t+1}^b$	(5) $xr_{n,t+1}^{\$}$	(6) $xr_{n,t+1}^{\$}$	(7) $xr_{n,t+1}^{TIPS}$	(8) $xr_{n,t+1}^b$
$Supply_t$	-1.26 (1.09)	-1.11 (1.06)	-0.24 (0.78)	-0.87 (0.99)	-1.42 (1.67)	-1.58 (1.69)	-1.90 (1.69)	0.33 (2.05)
$\Delta Supply_t$	-3.05 (5.78)	-3.70 (5.92)	-3.79 (3.23)	0.09 (5.39)	3.55 (5.39)	2.72 (5.46)	3.51 (3.73)	-0.79 (5.24)
ε_t^{Supply}	2.46 (5.94)	2.94 (6.04)	3.73 (3.34)	-0.79 (5.53)	-4.82 (5.68)	-4.10 (5.68)	-3.91 (3.96)	-0.19 (5.67)
$L_{n,t}$					-10.77 (14.11)	-7.97 (14.61)	-13.26 (8.45)	5.29 (11.21)
$y_{n,t}^{\$} - y_{1,t}^{\$}$	3.02* (1.52)				2.05 (1.74)			
$y_{n,t}^{TIPS} - y_{1,t}^{TIPS}$		0.01 (3.27)	3.63* (1.75)	-3.62 (2.48)		0.02 (2.82)	2.76 (1.86)	-2.75 (2.15)
$b_{n,t} - b_{1,t}$		6.70 (3.73)	-2.30 (2.00)	9.00** (3.01)		4.40 (4.38)	0.03 (2.47)	4.37 (2.62)
p-value	0.17	0.20	0.23	0.03	0.32	0.41	0.15	0.35
R^2	0.06	0.07	0.05	0.10	0.07	0.08	0.06	0.05
Sample	1986.4 – 2010.12				2000.2 – 2010.12			

Table V: Liquidity-Adjusted Bond Return Predictability.

We predict 3-month overlapping liquidity-adjusted excess log returns of inflation-indexed bonds and of nominal bonds in excess of inflation-indexed bonds using the liquidity-adjusted inflation-indexed term spread, the liquidity-adjusted breakeven term spread, and the liquidity differential $L_{n,t}$. $L_{n,t}$ is estimated as the negative of the variation explained by liquidity variables in Table II(4). $r_{n,t+1}^L$ is the return on inflation-indexed bonds due to illiquidity. Newey-West standard errors with three lags in parentheses. The p-value of the F-test for no predictability is shown. We show one-sided bootstrap p-values from 2000 replications to account for the fact that liquidity is estimated. We use block bootstrap with block length 24 months.

Panel A: U.S. (1999.6-2010.12)

		(1) $xr_{n,t+1}^{TIPS-L}$	(2) $xr_{n,t+1}^{TIPS-L}$	(3) $xr_{n,t+1}^{b+L}$	(4) $xr_{n,t+1}^{b+L}$	(5) $r_{n,t+1}^L$	(6) $r_{n,t+1}^L$
$(y_{n,t}^{TIPS} - L_{n,t}) - y_{1,t}^{TIPS}$		3.04	2.31		-1.31		0.24
	Newey-West SE	(1.35)	(1.81)		(1.53)		(0.66)
	Bootstrap p-value	15.3%	23.9%		33.8%		44.5%
$(b_{n,t} + L_{n,t}) - b_{1,t}$			-0.22	4.55	5.20		-0.87
	Newey-West SE		(2.91)	(1.75)	(1.75)		(1.74)
	Bootstrap p-value		17.9%	0.1%	0.0%		32.5%
$L_{n,t}$			6.88		-6.76	11.49	11.03
	Newey-West SE		(10.14)		(7.50)	(2.92)	(3.53)
	Bootstrap p-value		23.0%		15.5%	0.1%	0.1%
$Const.$		-0.00	-0.01	-0.01	0.01	-0.02	-0.02
	Newey-West SE	(0.01)	(0.02)	(0.00)	(0.01)	(0.01)	(0.01)
	Bootstrap p-value	68.7%	10.0%	14.6%	6.4%	11.6%	15.9%
p-value		0.03	0.16	0.01	0.02	0.00	0.00
R^2		0.06	0.07	0.08	0.13	0.17	0.17
Sample		1999.6 – 2010.12					

Panel B: U.K. (2000.2-2010.12)

		(1) $xr_{n,t+1}^{TIPS-L}$	(2) $xr_{n,t+1}^{TIPS-L}$	(3) $xr_{n,t+1}^{b+L}$	(4) $xr_{n,t+1}^{b+L}$	(5) $r_{n,t+1}^L$	(6) $r_{n,t+1}^L$
$(y_{n,t}^{TIPS} - L_{n,t}) - y_{1,t}^{TIPS}$		4.99	5.52		-4.76		-2.44
	Newey-West SE	(2.13)	(2.71)		(3.16)		(1.75)
	Bootstrap p-value	4.1%	4.2%		4.2%		9.0%
$(b_{n,t} + L_{n,t}) - b_{1,t}$			-4.28	4.59	8.38		4.14
	Newey-West SE		(3.10)	(3.77)	(4.20)		(2.42)
	Bootstrap p-value		24.0%	0.7%	0.8%		17.6%
$L_{n,t}$			-20.42		14.16	18.67	17.93
	Newey-West SE		(12.02)		(14.17)	(7.15)	(7.24)
	Bootstrap p-value		8.3%		15.7%	0.0%	0.0%
$Const.$		0.00	0.04	-0.01	-0.04	-0.02	-0.03
	Newey-West SE	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
	Bootstrap p-value	31.7%	5.7%	1.8%	5.2%	2.3%	2.1%
p-value		0.02	0.00	0.23	0.01	0.01	0.00
R^2		0.06	0.13	0.03	0.12	0.13	0.19
Sample		2000.2 – 2010.12					

Table VI: Predicted Bond Returns.

We show summary statistics for 3-month overlapping log excess returns on real bonds and breakeven, and for average log liquidity returns. Realized log excess returns are denoted $xr_{n,t}$, while predicted returns are denoted $E_t(xr_{n,t+1})$. We show realized sample average returns $\hat{E}(xr_{n,t})$ and stock-market betas $\hat{\beta}(xr_{n,t})$. Betas are with respect to excess log stock returns including dividends. We obtain predicted excess returns as fitted values from the regressions shown in Tables V(1), V(3) and V(5). Numbers shown are annualized (%). Newey-West standard errors for $\hat{\beta}$ are computed with three lags. * and ** denote significance at the 5% and 1% level for $\hat{\beta}$, respectively.

Panel A: U.S. (1999.6-2010.12)	Sample Average $\hat{E}(xr_{n,t})$	Stock Market Beta $\hat{\beta}(xr_{n,t})$	Std. Predicted Exc. Return $\sigma(E_t xr_{n,t+1})$
Liq.-Adj. Exc. Log Ret. BEI	0.52	-0.08	1.62
Liq.-Adj. Exc. Log Ret. TIPS	3.67	-0.11	1.63
Log Return Liquidity	0.99	0.12**	1.41
Panel B: U.K. (2000.2-2010.12)	Sample Average $\hat{E}(xr_{n,t})$	Stock Market Beta $\hat{\beta}(xr_{n,t})$	Std. Predicted Exc. Return $\sigma(E_t xr_{n,t+1})$
Liq.-Adj. Exc. Log Ret. BEI	-0.34	-0.22*	1.93
Liq.-Adj. Exc. Log Ret. TIPS	0.85	0.14	2.61
Log Return Liquidity	1.61	-0.03	2.23

Appendix: Return Predictability in the Treasury Market: Real Rates, Inflation, and Liquidity

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Table A.I: Forecasted Real Short Rate.

Overlapping quarterly realized real return on nominal three month T-bill onto the nominal three month T-bill, three month lagged realized real return on three month T-bill and inflation over the past year. Newey-West standard errors with four lags in parentheses. * and ** denote significance at the 5% and 1% level.

	(1)	(2)
$y_{1,t}^{\$} - \pi_{t+1}$	U.S.	UK
$y_{1,t}^{\$}$	0.55**	0.79**
	(0.20)	(0.13)
$y_{1,t}^{\$} - \pi_t$	0.10	-0.08
	(0.08)	(0.05)
$(\pi_{t-3} + \pi_{t-2} + \pi_{t-1} + \pi_t) / 4$	0.10	-0.07
	(0.08)	(0.04)
<i>Const.</i>	-0.52**	-0.26*
	(0.09)	(0.12)
p-value	0.00	0.00
R^2	0.48	0.48
Sample	1982.1 – 2010.12	

Table A.II: Univariate Liquidity Regressions

Variables as in Table II. Newey-West standard errors with three lags in parentheses. The p-value of the F-test for no predictability is shown. * and ** denote significance at the 5% and 1% level.

Panel A. U.S. (1999.3 – 2010.12)

$y_{n,t}^{\$} - y_{n,t}^{TIPS}$	(1)	(2)	(3)	(4)	(5)	(6)
Off-the-Run Spr.	-2.54** (0.39)					
Asset-Swap Spr.		-1.24** (0.29)				
Transaction Vol.			0.19 (0.14)			
Synthetic-Cash				-1.85** (0.37)		
Survey Inflation					-0.00 (0.51)	
CFNAI						0.25** (0.05)
p-value	0.00	0.00	0.18	0.00	1.00	0.00
R^2	0.53	0.32	0.05	0.36	0.00	0.39
Sample	1999.3 – 2010.12					

Panel B: U.K. (1999.11-2010.12)

$y_{n,t}^{\$} - y_{n,t}^{TIPS}$	(1)	(2)	(3)	(4)
Off-the-Run Spr.	1.59 (1.00)			
LIBOR-GC Spr.		0.46** (0.15)		
Transaction Vol.			1.17** (0.13)	
Survey Inflation				0.57** (0.06)
p-value	0.11	0.00	0.00	0.00
R^2	0.03	0.13	0.56	0.51
Period	1999.11 – 2006.12			

Table A.III: Estimating Liquidity in Quarterly Changes

We replicate Table II using quarterly changes. Newey-West standard errors with three lags in parentheses. The p-value of the F-test for no predictability is shown. * and ** denote significance at the 5% and 1% level.

Panel A: U.S. (1999.6-2010.12)

$\Delta (y_{n,t}^{\$} - y_{n,t}^{TIPS})$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δ Off-the-Run Spr.		-2.47** (0.68)	-1.02* (0.47)	-1.02* (0.47)	-1.59** (0.49)		-0.95 (0.53)
Δ Asset-Swap Spr.			-1.24** (0.26)	-1.24** (0.27)			0.55 (0.76)
Δ Transaction Vol.				-0.04 (0.19)	-0.09 (0.19)		-0.19 (0.18)
Δ Synthetic-Cash					-1.16** (0.17)		
Δ Survey Inflation	-0.71 (0.55)	-0.34 (0.49)	-0.55 (0.50)	-0.53 (0.50)	-0.62 (0.49)	-0.00 (1.14)	0.24 (1.09)
Δ CFNAI	0.16** (0.05)	0.10** (0.03)	0.09** (0.03)	0.09** (0.03)	0.08** (0.03)	0.05 (0.04)	0.05 (0.04)
p-value	0.01	0.00	0.00	0.00	0.00	0.46	0.42
R^2	0.11	0.37	0.47	0.47	0.48	0.02	0.07
Sample	1999.6 – 2010.12					1999.6 – 2006.12	

Panel B: U.K. (2000.2-2010.12)

$\Delta (y_{n,t}^{\$} - y_{n,t}^{TIPS})$	(1)	(2)	(3)	(4)	(5)	(6)
Δ Off-the-Run Spr.		-0.61 (0.32)	-0.41 (0.33)	-0.20 (0.34)		0.24 (0.52)
Δ LIBOR-GC Spr.			-0.21* (0.08)	-0.22** (0.08)		0.42* (0.17)
Δ Transaction Vol.				-0.17 (0.10)		-0.04 (0.08)
Δ Survey Inflation	0.18* (0.08)	0.17* (0.07)	0.18** (0.06)	0.20** (0.05)	0.16* (0.07)	0.21** (0.07)
p-value	0.02	0.01	0.00	0.00	0.02	0.06
R^2	0.13	0.16	0.25	0.27	0.08	0.12
Sample	2000.2 – 2010.12				2000.2 – 2006.12	

Table A.IV: Estimating Liquidity with Additional Controls

We replicate Table II including interaction terms and the TIPS bid-ask spread. The TIPS bid-ask spread is from Tradeweb and available 2005.3-2010.6. We set to its 2005.3 value before 2005.3 and to its 2010.6 value after 2010.6. Newey-West standard errors with three lags in parentheses. The p-value of the F-test for no predictability is shown. * and ** denote significance at the 5% and 1% level.

Panel A. U.S. (1999.3 – 2010.12)				
$y_{n,t}^{\$} - y_{n,t}^{TIPS}$	(1)	(2)	(3)	(4)
Off-the-Run Spr.	1.40 (0.90)	1.66 (1.05)	1.50 (1.04)	−0.84 (0.43)
Asset-Swap Spr.	−0.59* (0.30)	−0.67* (0.31)	−0.75 (0.66)	−0.65* (0.30)
Transaction Vol.	0.39** (0.11)	0.32 (0.19)	0.39** (0.11)	0.32** (0.10)
Survey Inflation	0.22 (0.37)	0.19 (0.37)	0.18 (0.34)	0.02 (0.42)
CFNAI	0.14** (0.04)	0.14** (0.03)	0.14** (0.04)	0.12** (0.03)
(Off-the-Run) ²	−4.29** (1.53)	−4.36** (1.51)	−4.88 (3.09)	
Off-the-Run × Transaction Vol.		0.38 (0.79)		
Off-the-Run × Asset-Swap Spr.			0.46 (1.81)	
TIPS Bid-Ask Spread				−0.34 (0.26)
<i>const.</i>	2.15* (0.96)	2.19* (0.93)	2.28* (0.89)	2.87** (1.06)
p-value	0.00	0.00	0.00	0.00
R^2	0.69	0.69	0.69	0.67
Sample	1999.3 – 2010.12			

Table A.IV (continued)

Panel B. U.K. (1999.11 – 2010.12)			
$y_{n,t}^{\$} - y_{n,t}^{TIPS}$	(1)	(2)	(3)
Off-the-Run Spr.	−1.83 (1.43)	−2.02 (2.65)	−0.96 (1.27)
LIBOR-GC Spr.	0.16 (0.17)	0.16 (0.17)	0.60** (0.16)
Transaction Vol.	0.77** (0.17)	0.78** (0.19)	0.79** (0.18)
Survey Inflation	0.29** (0.08)	0.30** (0.09)	0.27** (0.08)
(Off-the-Run) ²	3.48 (3.94)	3.78 (5.67)	18.96** (5.00)
Off-the-Run × Transaction Vol.		−0.25 (2.26)	
Off-the-Run × LIBOR-GC Spr.			−5.16** (1.28)
<i>const.</i>	2.65** (0.33)	2.64** (0.34)	2.59** (0.32)
p-value	0.00	0.00	0.00
R^2	0.66	0.66	0.70
Sample		1999.3 – 2010.12	

Table A.V: Nominal Yields onto Liquidity Proxies U.S.

Variables as in Table II. Newey-West standard errors with three lags in parentheses. The p-value of the F-test for no predictability is shown. * and ** denote significance at the 5% and 1% level, respectively.

Panel A: U.S. (1999.3-2010.12)							
$y_{n,t}^s$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Off-the-Run Spr.		2.33*	3.24**	-0.67	-1.12		-2.45
		(0.99)	(1.00)	(1.46)	(1.11)		(1.48)
Asset-Swap Spr.			-2.37**	-0.27			4.21*
			(0.54)	(0.78)			(2.04)
Transaction Vol.				-1.17**	-1.27**		-1.81**
				(0.30)	(0.22)		(0.26)
Synthetic-Cash					0.52		
					(0.70)		
Survey Inflation	5.61**	4.87**	3.21**	4.38**	4.64**	1.34	1.18
	(1.23)	(1.13)	(1.06)	(1.26)	(1.35)	(3.16)	(1.48)
CFNAI	0.28**	0.44**	0.21*	0.08	0.12	-0.04	0.12
	(0.08)	(0.11)	(0.10)	(0.07)	(0.07)	(0.18)	(0.10)
p-value	0.00	0.00	0.00	0.00	0.00	0.87	0.00
R^2	0.30	0.36	0.47	0.60	0.61	0.00	0.63
Sample	1999.3 – 2010.12					1999.3 – 2006.12	

Panel B: U.K. (1999.11-2010.12)						
$y_{n,t}^s$	(1)	(2)	(3)	(4)	(5)	(6)
Off-the-Run Spr.		0.11	-0.16	0.04		2.01*
		(0.57)	(0.64)	(0.62)		(0.91)
LIBOR-GC Spr.			0.10	0.09		-1.03**
			(0.06)	(0.06)		(0.28)
Transaction Vol.				-0.45**		-0.58**
				(0.16)		(0.16)
Survey Inflation	0.02	0.02	0.00	0.16*	-0.07	0.07
	(0.06)	(0.06)	(0.06)	(0.06)	(0.19)	(0.16)
p-value	0.67	0.90	0.35	0.02	0.71	0.00
R^2	0.00	0.00	0.02	0.16	0.00	0.28
Sample	1999.11 – 2010.12				1999.11 – 2006.12	

Table A.VI: TIPS Yields onto Liquidity Proxies U.S.

Variables as in Table II. Newey-West standard errors with three lags in parentheses. The p-value of the F-test for no predictability is shown. * and ** denote significance at the 5% and 1% level, respectively.

$y_{n,t}^{TIPS}$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Off-the-Run Spr.		4.40** (0.92)	5.21** (0.95)	0.20 (1.29)	0.14 (1.07)		-0.99 (1.34)
Asset-Swap Spr.			-2.09** (0.60)	0.59 (0.68)			3.43 (2.16)
Transaction Vol.				-1.49** (0.27)	-1.51** (0.21)		-1.90** (0.24)
Synthetic-Cash					1.66** (0.61)		
Survey Inflation	5.56** (1.15)	4.17** (1.02)	2.70** (1.01)	4.21** (1.17)	4.08** (1.11)	0.55 (4.44)	0.88 (1.42)
CFNAI	0.03 (0.10)	0.33** (0.11)	0.12 (0.11)	-0.03 (0.07)	0.02 (0.07)	-0.32 (0.20)	-0.06 (0.09)
p-value	0.00	0.00	0.00	0.00	0.00	0.28	0.00
R^2	0.19	0.37	0.45	0.66	0.69	0.05	0.74
Sample	1999.3 – 2010.12					1999.3 – 2006.12	

Panel B: U.K. (1999.11-2010.12)

$y_{n,t}^{TIPS}$	(1)	(2)	(3)	(4)	(5)	(6)
Off-the-Run Spr.		0.56 (1.15)	0.73 (1.41)	1.29 (1.09)		5.21** (0.99)
LIBOR-GC Spr.			-0.06 (0.22)	-0.09 (0.19)		-1.41** (0.26)
Transaction Vol.				-1.24** (0.16)		-1.05** (0.13)
Survey Inflation	-0.55** (0.09)	-0.56** (0.10)	-0.55** (0.10)	-0.12 (0.09)	-0.62* (0.29)	-0.20 (0.18)
p-value	0.00	0.00	0.00	0.00	0.03	0.00
R^2	0.36	0.37	0.37	0.62	0.15	0.65
Sample	1999.11 – 2010.12				1999.11 – 2006.12	

Table A.VII: Return Predictability Liquidity with Nonlinear Liquidity.

Return-predictability regressions as in Table A.IX. We adjust for nonlinear liquidity as estimated in Table A.IV, column (1) in Panel A and column (3) in Panel B for U.S. and U.K., respectively. Newey-West standard errors with three lags appear in parentheses. The p-value of the F-test for no predictability is shown. We also show one-sided bootstrap p-values from 2000 replications. We use block bootstrap with block length 24 months. Bootstrap accounts for the fact that the liquidity premium is estimated.

Panel A: U.S. (1999.6-2010.12)

		(1) $xr_{n,t+1}^{TIPS-L}$	(2) $xr_{n,t+1}^{TIPS-L}$	(3) $xr_{n,t+1}^{b+L}$	(4) $xr_{n,t+1}^{b+L}$	(5) $r_{n,t+1}^L$	(6) $r_{n,t+1}^L$
$(y_{n,t}^{TIPS} - L_{n,t}) - y_{1,t}^{TIPS}$		3.05	2.64		-1.68		-0.29
	Newey-West SE	(1.24)	(1.43)		(1.22)		(0.53)
	Bootstrap p-value	12.6%	17.4%		12.8%		28.2%
$(b_{n,t} + L_{n,t}) - b_{1,t}$			0.05	4.42	5.11		-0.47
	Newey-West SE		(2.83)	(1.62)	(1.53)		(1.87)
	Bootstrap p-value		19.8%	0.1%	0.0%		38.4%
$L_{n,t}$			4.89		-3.88	15.93	16.38
	Newey-West SE		(9.20)		(5.67)	(3.96)	(4.18)
	Bootstrap p-value		26.1%		21.1%	0.0%	0.0%
$Const.$		-0.00	-0.01	-0.00	0.01	-0.01	-0.01
	Newey-West SE	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
	Bootstrap p-value	73.3%	11.5%	25.6%	7.8%	20.9%	26.4%
p-value		0.02	0.11	0.01	0.01	0.00	0.00
R^2		0.06	0.07	0.08	0.12	0.22	0.23
Sample		1999.6 – 2010.12					

Panel B: U.K. (2000.2-2010.12)

		(1) $xr_{n,t+1}^{TIPS-L}$	(2) $xr_{n,t+1}^{TIPS-L}$	(3) $xr_{n,t+1}^{b+L}$	(4) $xr_{n,t+1}^{b+L}$	(5) $r_{n,t+1}^L$	(6) $r_{n,t+1}^L$
$(y_{n,t}^{TIPS} - L_{n,t}) - y_{1,t}^{TIPS}$		3.42	2.68		-1.72		0.39
	Newey-West SE	(2.20)	(2.77)		(3.10)		(2.26)
	Bootstrap p-value	5.2%	4.6%		5.3%		11.6%
$(b_{n,t} + L_{n,t}) - b_{1,t}$			-2.50	3.72	6.03		2.41
	Newey-West SE		(3.74)	(4.16)	(4.60)		(2.91)
	Bootstrap p-value		23.5%	0.5%	0.8%		19.8%
$L_{n,t}$			-24.17		15.99	21.15	23.20
	Newey-West SE		(9.51)		(11.20)	(6.85)	(7.94)
	Bootstrap p-value		7.0%		13.0%	0.0%	0.0%
$Const.$		0.00	0.03	-0.01	-0.03	-0.02	-0.02
	Newey-West SE	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	Bootstrap p-value	31.8%	4.7%	1.7%	3.9%	2.4%	2.1%
p-value		0.12	0.00	0.37	0.19	0.00	0.00
R^2		0.03	0.12	0.02	0.08	0.14	0.16
Sample		2000.2 – 2010.12					

Table A.VIII: Return Predictability Liquidity with Tradeable Excess Returns.

We run liquidity-adjusted return-predictive regressions as in Table A.IX. We consider liquidity-adjusted log nominal bond returns on TIPS over nominal returns on the nominal T-bill rate $r_{n,t}^{TIPS-L} - r_t^{Tbill}$ as a tradeable version of liquidity-adjusted log excess returns of TIPS. We also consider log nominal bond returns on nominal bonds over liquidity-adjusted log nominal bond returns on TIPS $r_{n,t}^{nom} - r_{n,t}^{TIPS-L}$ as a tradeable version of liquidity-adjusted breakeven returns. Newey-West standard errors with three lags appear in parentheses. The p-value of the F-test for no predictability is shown. We also show one-sided bootstrap p-values from 2000 replications. We use block bootstrap with block length 24 months. Bootstrap accounts for the fact that the liquidity premium is estimated.

Panel A: U.S. (1999.6-2010.12)

	$(r_{n,t}^{TIPS-L} - r_t^{Tbill})$		$(r_{n,t}^{nom} - r_{n,t}^{TIPS-L})$	
$(y_{n,t}^{TIPS} - L_{n,t}) - y_{1,t}^{TIPS}$	2.27	2.42	-1.42	
Newey-West SE	(1.50)	(1.69)	(1.66)	
Bootstrap p-value	31.2%	24.3%	33.2%	
$(b_{n,t} + L_{n,t}) - b_{1,t}$		-0.57	4.93	5.55
Newey-West SE		(2.50)	(2.09)	(2.20)
Bootstrap p-value		14.5%	0.6%	0.2%
$L_{n,t}$	5.19	4.91	-7.81	-4.78
Newey-West SE	(8.75)	(9.36)	(5.74)	(7.58)
Bootstrap p-value	21.5%	27.5%	9.8%	20.0%
p-value	0.11	0.20	0.05	0.08
R^2	0.06	0.06	0.09	0.10
Sample	1999.6 – 2010.12			

Panel B: U.K. (2000.2-2010.12)

	$(r_{n,t}^{TIPS-L} - r_t^{Tbill})$		$(r_{n,t}^{nom} - r_{n,t}^{TIPS-L})$	
$(y_{n,t}^{TIPS} - L_{n,t}) - y_{1,t}^{TIPS}$	3.90	4.92	-4.16	
Newey-West SE	(2.53)	(2.71)	(3.19)	
Bootstrap p-value	7.8%	10.4%	13.8%	
$(b_{n,t} + L_{n,t}) - b_{1,t}$		-2.39	3.88	6.49
Newey-West SE		(2.90)	(3.75)	(4.22)
Bootstrap p-value		14.5%	37.9%	26.0%
$L_{n,t}$	-17.96	-18.00	15.43	11.74
Newey-West SE	(12.40)	(12.38)	(14.32)	(15.50)
Bootstrap p-value	62.0%	38.8%	48.3%	50.0%
p-value	0.00	0.00	0.39	0.06
R^2	0.10	0.11	0.05	0.08
Sample	2000.2 – 2010.12			

Table A.IX: Return Predictability of Unadjusted Excess Returns.

We regress 3-month overlapping excess log bond returns of TIPS and of nominal bonds onto the TIPS term spread, the nominal term spread, the liquidity-adjusted TIPS term spread, the liquidity-adjusted breakeven term spread and the liquidity premium on TIPS $L_{n,t}$. $L_{n,t}$ is estimated as the negative of the variation explained by liquidity variables in Table II(4). Newey-West standard errors with three lags in parentheses. The p-value of the F-test for no predictability is shown. We also show one-sided bootstrap p-values from 2000 replications. We use block bootstrap with block length 24 months. Bootstrap accounts for the fact that the liquidity premium is estimated.

Panel A: U.S. (1999.6-2010.12)

		(1) $xr_{n,t+1}^{TIPS}$	(2) $xr_{n,t+1}^{TIPS}$	(3) $xr_{n,t+1}^{\$}$	(4) $xr_{n,t+1}^{\$}$
$y_{n,t}^{TIPS} - y_{1,t}^{TIPS}$		4.36			
	Newey-West SE	(1.29)			
	Bootstrap p-value	1.9%			
$y_{n,t}^{\$} - y_{1,t}^{\$}$				2.40	
	Newey-West SE			(1.42)	
	Bootstrap p-value			21.3%	
$(y_{n,t}^{TIPS} - L_{n,t}) - y_{1,t}^{TIPS}$			2.54		1.00
	Newey-West SE		(1.71)		(2.38)
	Bootstrap p-value		21.5%		30.8%
$(b_{n,t} + L_{n,t}) - b_{1,t}$			-1.09		4.98
	Newey-West SE		(2.80)		(3.32)
	Bootstrap p-value		10.3%		39.3%
$L_{n,t}$			17.91		0.12
	Newey-West SE		(8.98)		(9.24)
	Bootstrap p-value		9.2%		48.6%
$Const.$		-0.01	-0.03	-0.00	-0.00
	Newey-West SE	(0.01)	(0.01)	(0.01)	(0.01)
	Bootstrap p-value	94.9%	1.9%	46.5%	31.6%
p-value		0.00	0.01	0.09	0.33
R^2		0.12	0.16	0.04	0.05
Std-Expected Exc. Ret.		2.64	3.07	1.75	2.01
Sample		1999.6 – 2010.12			

Table A.IX (continued)

Panel B: U.K. (2000.2-2010.12)

		(1) $xr_{n,t+1}^{TIPS}$	(2) $xr_{n,t+1}^{TIPS}$	(3) $xr_{n,t+1}^{\$}$	(4) $xr_{n,t+1}^{\$}$
$y_{n,t}^{TIPS} - y_{1,t}^{TIPS}$		3.10			
	Newey-West SE	(1.71)			
	Bootstrap p-value	19.5%			
$y_{n,t}^{\$} - y_{1,t}^{\$}$				2.42	
	Newey-West SE			(1.58)	
	Bootstrap p-value			2.8%	
$(y_{n,t}^{TIPS} - L_{n,t}) - y_{1,t}^{TIPS}$			3.09		0.76
	Newey-West SE		(1.86)		(2.30)
	Bootstrap p-value		18.0%		41.6%
$(b_{n,t} + L_{n,t}) - b_{1,t}$			-0.14		4.10
	Newey-West SE		(2.46)		(4.37)
	Bootstrap p-value		40.2%		3.1%
$L_{n,t}$			-2.49		-6.26
	Newey-West SE		(10.15)		(10.13)
	Bootstrap p-value		16.3%		26.7%
$Const.$		0.00	0.01	-0.00	0.00
	Newey-West SE	(0.01)	(0.01)	(0.01)	(0.01)
	Bootstrap p-value	52.6%	37.2%	37.3%	48.1%
p-value		0.07	0.03	0.13	0.47
R^2		0.03	0.04	0.04	0.05
Std-Expected Exc. Ret.		1.56	1.69	2.01	2.23
Sample			2000.2 – 2010.12		

Table A.X: Sub-Period Betas.

We regress liquidity-adjusted and non liquidity-adjusted excess log government bond returns onto excess log stock returns. All variables are described in Table VI. Newey-West standard errors are computed with three lags. * and ** denote significance at the 5% and 1% level for $\hat{\alpha}$ and $\hat{\beta}$, respectively.

Panel A: U.S.		1999.6-2010.12		1999.6-2006.12		2002.1-2010.12			
		$\hat{\beta}$	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\alpha}$		
Excess Log Return	Nominal	-0.19**	4.21*	-0.23*	3.66	-0.19**	4.87*		
Excess Log Return	TIPS	0.01	4.66*	-0.16*	4.36**	0.03	4.89*		
Excess Log Return	BEI	-0.21*	-0.45	-0.07	-0.69	-0.22*	-0.01		
Liq.-Adj. Exc. Log Ret.	BEI	-0.08	0.52	-0.05	0.72	-0.09	0.65		
Liq.-Adj. Exc. Log Ret.	TIPS	-0.11	3.68*	-0.18**	2.94*	-0.11	4.23*		
Log Return Liquidity		0.12**	0.98	0.02	1.41**	0.13**	0.66		
Panel B: UK		1985.7-2010.12		1985.7-2006.12		1985.7-1998.12		1999.1-2010.12	
		$\hat{\beta}$	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\alpha}$
Excess Log Return	Nominal	0.15	3.16	0.19	3.45	0.31	4.26	-0.07	0.86
Excess Log Return	TIPS	0.14**	1.63	0.13*	1.58	0.16*	0.53	0.13	2.77
Excess Log Return	BEI	0.01	1.53	0.06	1.87	0.15	3.73	-0.20*	-1.91
		2000.2-2010.12		2000.2-2006.12		2002.1-2010.12			
		$\hat{\beta}$	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\alpha}$		
Excess Log Return	Nominal	-0.08	0.42	-0.16	0.32	-0.08	1.50		
Excess Log Return	TIPS	0.11	2.58	0.02	2.75	0.11	3.34		
Excess Log Return	BEI	-0.19*	-2.16	-0.19**	-2.43	-0.19	-1.84		
Liq.-Adj. Exc. Log Ret.	BEI	-0.22*	-0.58	-0.22*	-0.32	-0.21	-0.28		
Liq.-Adj. Exc. Log Ret.	TIPS	0.14	1.00	0.06*	0.64*	0.13	1.79		
Log Return Liquidity		-0.03	1.58	-0.03	2.11	-0.02	1.56		

Table A.XI: Four Factor Regressions.

US liquidity-adjusted and non liquidity-adjusted excess log government bond returns onto excess log stock returns xr_{t+1}^{equity} , the SMB factor, the HML factor, and innovations in the Pastor-Stambaugh liquidity factor. Annualized (%). Newey-West standard errors with three lags in brackets. * and ** denote significance at the 5% and 1% level.

Panel A: 1999.6-2010.12	$xr_{n,t+1}^{\$}$	$xr_{n,t+1}^{TIPS}$	$xr_{n,t+1}^b$	$xr_{n,t+1}^{TIPS-L}$	$xr_{n,t+1}^{b+L}$	$r_{n,t+1}^L$
xr_{t+1}^{equity}	-0.13* (0.06)	0.08 (0.11)	-0.21* (0.09)	-0.05 (0.07)	-0.09 (0.05)	0.13** (0.04)
HML	0.02 (0.06)	-0.03 (0.07)	0.05 (0.06)	-0.04 (0.07)	0.06 (0.06)	0.01 (0.02)
SMB	-0.16* (0.06)	-0.11 (0.06)	-0.05 (0.05)	-0.13* (0.05)	-0.03 (0.05)	0.03 (0.02)
Pastor-Stambaugh	-0.07* (0.03)	-0.08* (0.03)	0.01 (0.03)	-0.07* (0.03)	-0.00 (0.03)	-0.02 (0.01)
const.	5.00* (1.99)	5.23** (1.81)	-0.22 (1.60)	4.59** (1.47)	0.42 (1.30)	0.64 (0.67)

Table A.XII: Dickey-Fuller Unit Root Tests.

We report Dickey-Fuller test for the null-hypothesis of a unit root with twelve lags. $Supply_t$ denotes the amount of inflation-indexed bonds outstanding relative to all nominal and inflation-indexed bonds outstanding. $\Delta Supply_t$ denotes the relative issuance of inflation-indexed bonds relative to all nominal and inflation-indexed bonds issuance. $\Delta Supply_t - \Delta Supply_{t-12}$ is the change in relative issuance over the past 12 months. * and ** denote significance at the 5% and 1% level respectively.

Panel A: U.S.

	$Supply_t$	$\Delta Supply_t$	$\Delta Supply_t - \Delta Supply_{t-12}$
	-2.02	-2.12	-3.25*
Sample	1999.1 – 2010.12	1999.2 – 2010.12	2000.2 – 2010.12

Panel B: UK

	$Supply_t$	$\Delta Supply_t$	$\Delta Supply_t - \Delta Supply_{t-12}$
	-1.96	-4.75**	-2.65
Sample	1986.1 – 2010.12	1986.1 – 2010.12	1987.1 – 2010.12

Table A.XIII: Supply Autoregression.

We regress relative issuance $\Delta Supply_t$, as described in Table 5 onto its own twelve lags. We also regress the 12-month change in relative issuance onto its own twelve lags. We report the sum of the twelve autoregressive coefficients.

	Panel A: U.S.	Panel B: UK
	$\Delta Supply_t$	
	$-\Delta Supply_{t-12}$	$\Delta Supply_t$
Sum of Coeff.	0.44	0.23
const.	-0.25	0.00
	(0.21)	(0.00)
R^2	0.29	0.04
Sample	2000.2 – 2010.12	1986.1 – 2010.12

Table A.XIV: Sample Correlations of Excess Returns and Spreads.

Monthly data of quarterly overlapping returns and inflation 1999.6-2010.12. Annualized (%). All data are described in Table A.IX.

Panel A. U.S. (1999.6 – 2010.12)

Correlations Excess Returns				
	$xr_{n,t+1}^{TIPS-L}$	$xr_{n,t+1}^{b+L}$	$r_{n,t+1}^L$	
$xr_{n,t+1}^{TIPS-L}$	1	-0.06	-0.03	
$xr_{n,t+1}^{b+L}$	.	1	-0.18	
$r_{n,t+1}^L$	.	.	1	
Correlations Spreads				
	$(y_{n,t}^{TIPS} - L_{n,t}) - y_{1,t}^{TIPS}$	$(b_{n,t} + L_{n,t}) - b_{1,t}$	$L_{n,t}$	
$(y_{n,t}^{TIPS} - L_{n,t}) - y_{1,t}^{TIPS}$	1	0.30	0.49	
$(b_{n,t} + L_{n,t}) - b_{1,t}$	.	1	0.02	
$L_{n,t}$	.	.	1	

Panel B. U.K. (2000.2 – 2010.12)

Correlations Excess Returns				
	$xr_{n,t+1}^{TIPS-L}$	$xr_{n,t+1}^{b+L}$	$r_{n,t+1}^L$	
$xr_{n,t+1}^{TIPS-L}$	1	-0.55	-0.63	
$xr_{n,t+1}^{b+L}$	.	1	0.65	
$r_{n,t+1}^L$	.	.	1	
Correlations Spreads				
	$(y_{n,t}^{TIPS} - L_{n,t}) - y_{1,t}^{TIPS}$	$(b_{n,t} + L_{n,t}) - b_{1,t}$	$L_{n,t}$	
$(y_{n,t}^{TIPS} - L_{n,t}) - y_{1,t}^{TIPS}$	1	0.53	-0.28	
$(b_{n,t} + L_{n,t}) - b_{1,t}$	.	1	-0.15	
$L_{n,t}$	.	.	1	

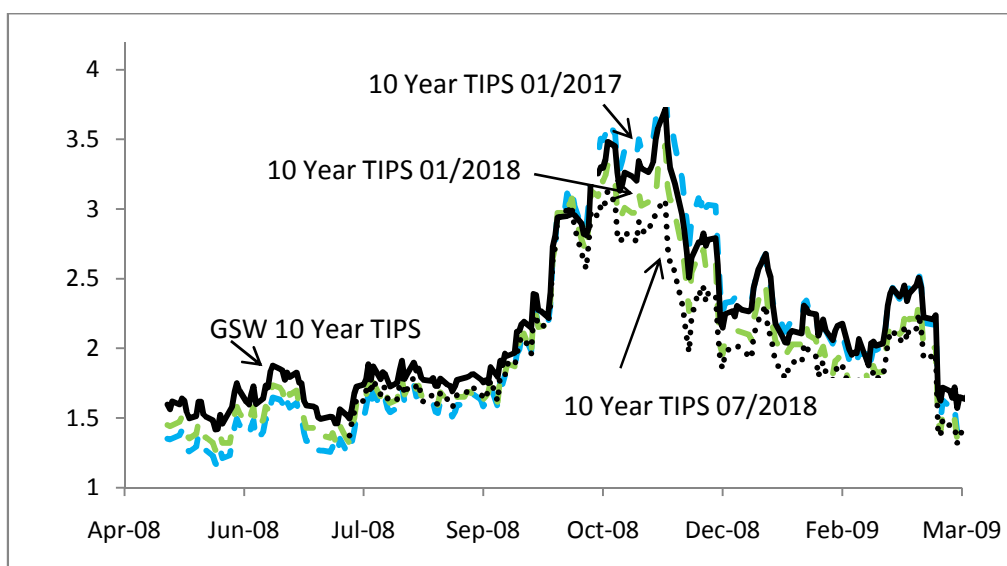


Figure A.1: Recently Issued and Less Recently Issued 10 Year TIPS.

GSW 10 Year TIPS yields from Gurkaynak, Sack and Wright (2010); 10 Year TIPS maturing in 07/2018 (reference CPI 215.7), 01/2018 (reference CPI 209.5) and 01/2017 (reference CPI 201.7) from Bloomberg.

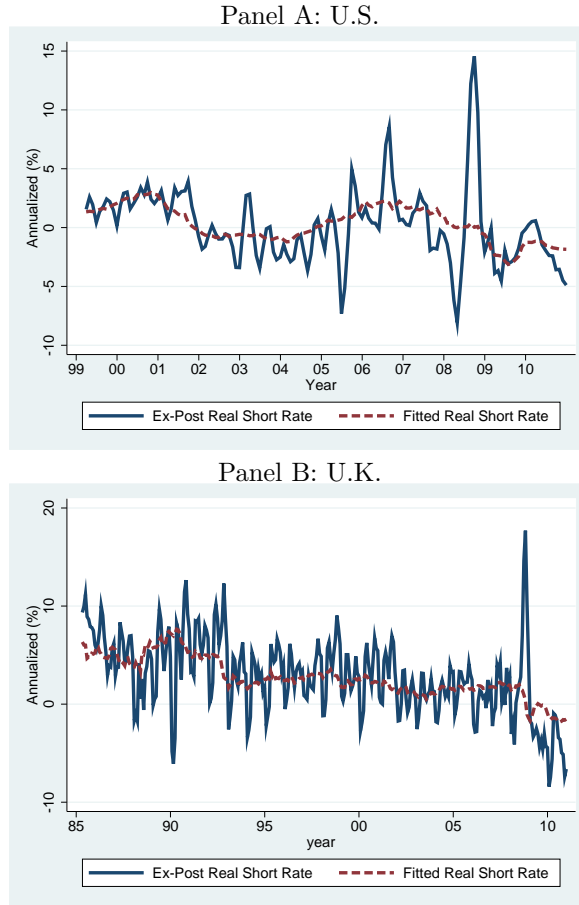


Figure A.2: U.S. and U.K. Ex-Post and Fitted Real Short-Term Rates

Ex-post real return on a nominal three month T-bill. The fitted real short rate obtains by regressing overlapping quarterly realized real return on nominal three month T-bill onto the nominal three month T-bill, three month lagged realized real return on three month T-bill and inflation over the past year, see Table A.I.

An Empirical Decomposition of Risk and Liquidity in Nominal and Inflation-Indexed Government Bonds

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ABSTRACT

This paper decomposes inflation-indexed and nominal government bond excess return predictability into liquidity, real interest rate risk and inflation risk. We estimate a systematic liquidity premium in Treasury Inflation Protected Securities (TIPS) yields relative to nominal yields. The liquidity premium is around 30 bps during normal times but larger during the early years of TIPS and during the financial crisis 2008-2009. We find that time-varying liquidity premia in TIPS and time-varying inflation risk premia in nominal bonds generate return predictability. We find no evidence that shocks to relative issuance generate bond return predictability in the US or UK.

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