Economic Policy Uncertainty and Bond Risk Premia

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Abstract

We study the forecasting power of economic uncertainty in government policies for future bond returns. Using the policy uncertainty measure developed by Baker, Bloom, and Davis, 2016, we investigate the relation between economic policy uncertainty (EPU) and expected bond returns. The impact of EPU is shown to be large for lower maturities in shorter investment horizons. Estimating affine term structure model incorporating EPU, we show that term premia estimates from a model with the additional pricing factor show higher fluctuations and move more closely to the variations in observed yields. Implied term premia show strong countercyclical movements, better explaining higher risk compensation under bad economic conditions as theories expect.

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1 Introduction

Fundamental drivers of excess returns on financial assets have recently become a question of interest in macro-financial studies. Since Fama and Bliss, 1987 and Campbell and Shiller, 1991 addressed the empirical failure of the expectation hypothesis, literature has made much progress suggesting that the market price of risk varies over time and information in the current bond yields, for example, the slope of the term structure, have predictive ability for future bond returns. In line with these findings, Cochrane and Piazzesi, 2005 have proposed that a single linear combination of the forward spreads contains remarkable information predicting excess returns on Treasury bonds. This strand of studies in financial economics, however, did not pay much attention to revealing macroeconomic fundamentals driving the factors' forecasting ability, that could provide invaluable knowledge for policymakers and financial market participants.

Filling this gap, recent studies have attempted to find macroeconomic forces that predict future returns and the information content beyond the one contained in the current prices of financial assets. For example, Cooper and Priestley, 2009 related excess holding period returns with variations in real economic conditions. Specifically, they have shown that the output gap, a variable representing business cycle fluctuations, serves as a strong predictor of stock and excess bond returns, conducting both in-sample and out-of-sample forecasting exercises. Literature has followed connecting excess returns with a broader set of macroeconomic variables. Ludvigson and Ng, 2009's work tests the predictive power of several factors summarising information in a large set of macroeconomic and financial variables, related studies include Joslin, Priebsch, and Singleton, 2014, Cieslak and Povala, 2015, and Coroneo, Giannone, and Modugno, 2016. Among the first eight principal components of the dataset, the factors closely related to "real activity" and "inflation" were shown to have strong predictive power for excess bond returns in US Treasury. They also found that affine term structure models incorporating the macro factors produces a distinct countercyclical yield risk premium, which is consistent with the findings in the previous studies such as Campbell and Cochrane, 1999 and Wachter, 2006.[1]

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[1] The predictability of excess bond returns is not necessarily connected with economic gains for investors (Thornton and Valente 2012). However, recent studies such as Gargano, Pettenuzzo, and Timmermann, 2017 have found that a model adding the macro factor of Ludvigson and Ng, 2009 to two financial return forecasting factors - forward spreads (Fama and Bliss 1987) and the term structure of forward rates (Cochrane and Piazzesi

Economic uncertainty has recently gained much attention as one of the factors containing return predictability in several theoretical and empirical studies (see, Bollerslev, Tauchen, and Zhou 2009; Wright 2011; Wright and Zhou 2009; D'Amico and Orphanides 2014; Kaminska and Roberts-Sklar 2015; Huang et al. 2015; Brogaard and Detzel 2015; Malkhozov et al. 2016; Grishchenko, Song, and Zhou 2017). Wright, 2011, for example, has shown that uncertainty, measured by the dispersion of professionals' inflation forecasts, serves as an important driver of risk premia in nominal yields. The variance risk premium, as a measure of volatility in asset prices, has also been shown to be a strong predictor of returns both in stock (Bollerslev, Tauchen, and Zhou 2009) and in fixed income markets (Grishchenko, Song, and Zhou 2017). Providing theoretical underpinning, Pástor and Veronesi, 2013 have established a general equilibrium model, in which the government's protective role over the market is affected by economic uncertainty, thus uncertain policy demands additional premia, especially when the economic conditions are weak. In their model, policy heterogeneity in poor economic condition makes the uncertainty over policy choice more important generating higher volatility and risk premia in stock returns.

In this paper, we explore the empirical evidence linking economic uncertainty in government policies and bond returns. We use a measure of Economic Policy Uncertainty (EPU), which is recently developed by Baker, Bloom, and Davis, 2016. The index measuring the level of uncertainty in economic policy has been shown to be related closely to various macroeconomic and financial variables. For example, Baker, Bloom, and Davis, 2016 show that the EPU is associated with price volatility in the stock market and can forecast macroeconomic aggregates such as investment, output, and employment. Aastveit, Natvik, and Sola, 2013 find that the influence of monetary policy shocks becomes weaker when EPU is high. Karnizova and J. C. Li, 2014 and Benati, 2013 assess the ability of the EPU index to predict future recessions. The macroeconomic effects of EPU through the bank lending channel have been studied by Bordo, Duca, and Koch, 2016, confirming that policy uncertainty has a significant adverse impact on bank credit growth.

The advantages of using EPU as a potential predictor of bond returns are threefold. First,

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2005) - generates higher out-of-sample forecast accuracy.

the uncertainty index can be computed as a near real-time measure, so it is free from publication delay and data revision. This advantage is not vulnerable to the issue of using macroeconomic data (or macroeconomic factors built on them) in return forecasting exercises. The use of synthetic variables such as the output gap is problematic as they are unobservable and need to be estimated. Orphanides and Van Norden, 2002 have shown that the estimate of the output gap in real time is not reliable particularly due to the unreliability of end-of-sample estimates of the output trend. The finding implies that policy recommendations based on real time measure of output gap can be substantially differ from those obtained with ex-post revised data (Orphanides 2001). Indeed, Ghysels, Horan, and Moench, 2014 document that data revisions in macroeconomic variables account for considerable amount of their in-sample and out-of-sample predictive power for bond returns. Specifically, they report that predictability using real-time macroeconomic data is considerably weaker. Adding information in survey forecasts, which is orthogonal to the real-time macro variables, is shown to help predict bond returns. The issue is also relevant in the studies using information from the professional surveys. For example, in a study measuring macroeconomic uncertainty using the forecast errors of consensus survey, Jo and Sekkel, 2017 found substantially different size of jumps in estimated uncertainty dependent on the selection of data vintage. Additional empirical evidence has shown that the forecasting performance of econometric models is largely dependant on the inclusion of different data vintages (see, for example, Diebold and Rudebusch 1991; Faust, Rogers, and Wright 2003).

Second, as the index is constructed based on the count of policy-related news,[2] it is continuously collectable at different frequencies which enable us to test the high-frequency relationship between economic uncertainty and asset returns. By and large, empirical studies todate evaluating the impact of policy on asset pricing models have mostly employed event studies around infrequent policy changes such as elections (see, for example, Bernhard and Leblang 2006; Białkowski, Gottschalk, and Wisniewski 2008; Boutchkova et al. 2012).

Third, we believe that the approach of measuring uncertainty based on news counts, unlike several alternative measures using asset prices in specific markets (for example, stock market

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[2] EPU is constructed based on the frequency of articles in 10 leading U.S newspapers. To be counted as an uncertainty event, each article should contain three combinations of words related to "Economy", "Uncertainty" and "Policy". We provide details of construction in data section.

volatility) or survey of small number of professionals (such as dispersion or economic forecasts), enables us to assess the level of uncertainty to which a wider range of economic agencies is exposed. In fact, evaluating economic uncertainty based on a broader information set, such as news publications and internet searches, is growing in popularity in financial studies (for example, Rogers, Sun, and Husted 2016; Caporale, F. Spagnolo, and N. Spagnolo 2016; Da, Engelberg, and Gao 2011, 2015).

To examine the effect of fluctuating economic policy uncertainty on risk premia, our exercise tests the forecasting ability of EPU on excess bond returns of different maturities across various holding periods other than examining only a single holding period such as a year. This approach is in line with the recent studies finding return forecasting factors in short investment horizons. For instance, Mueller, Vedolin, and Yen, 2012 show that market variance risk premium, as a proxy of economic uncertainty, has strong predictive power for the one-month horizon, but the relations disappear when testing with longer investment horizons. Gargano, Pettenuzzo, and Timmermann, 2017 suggest that studying the return forecasting-ability only for longer holding periods may inhibit efforts to identify short-lived dynamics in bond returns.

The growing attention in the high-frequency fluctuations of the risk premia is in line with studies such as Liu et al., 2016 and Crump, Eusepi, and Moench, 2017. More specifically, studies by Fricke and Menkhoff, 2015, Lee, 2016, and Grishchenko, Song, and Zhou, 2017 test the forecasting ability of various econometric specifications for monthly returns. Common predictive regressions in the literature (for example, Cochrane and Piazzesi 2005; Ludvigson and Ng 2009, among many others) have estimated linear models with annual excess bond returns as dependent variables in regression equations using overlapping monthly observations. Bauer and Hamilton, 2017 address the point that estimation using bond returns, which are longer than the sampling interval, reduces the reliability of the regression results. To examine the possible issues in previous studies, they re-estimate the models published in six previous studies using their newly proposed test. Their exercise has shown considerable weakening of the empirical results, suggesting the literature does not support robust evidence against the spanning hypothesis.

Recent studies in the macro-finance literature explicitly incorporate macroeconomic variables or factors representing economic activities and inflation measures (Ang and Piazzesi 2003;

Diebold and C. Li 2006, among many others), linking the dynamics of the term structure of interest rates to the fundamental macroeconomic determinants. The approaches in most macro-finance models, however, are based on the assumption that macroeconomic factors are entirely spanned by the current yield curve. This spanning hypothesis is contradicted by a large number of empirical studies testing for the predictive ability of macro variables for future excess returns (see, for example, Ludvigson and Ng 2009; Cieslak and Povala 2015).

In line with this criticism, Duffee, 2011 uncovers the presence of a hidden factor which is not related to the cross sectional representation of the yield curve. Specifically, this factor is hidden from the information captured by the current yield curve, since its influence on the expectations of the future short-rate is cancelled out by the changes in term premia. The existence of hidden factor implies that a conventional model accommodating only the factors describing the cross section of yields could be misspecified. Joslin, Priebsch, and Singleton, 2014 also stress the existence of hidden factors estimating a term structure model. Unlike the approach of Duffee, 2011 who apply filtering to discover hidden factors, the authors include macroeconomic variables, representing output growth and expected inflation and find that they are not entirely spanned by contemporaneous yields. Chernov and Mueller, 2012 specify a term structure model that accommodates survey-based inflation expectations in addition to two macro variables (inflation and output) in both real and nominal yields. The authors argue that introducing survey-based forecasts of inflation helps to uncover the existence of hidden factor that has no effect on the nominal yields but clearly influence inflation expectations.

Motivated by the findings in return forecasting exercises, we incorporate EPU in a canonical affine term structure model as a candidate for hidden factors (Duffee 2011; Joslin, Singleton, and Zhu 2011), unspanned by the current yield curve. Specifically, we estimate an affine term structure model with Cochrane and Piazzesi, 2005's return forecasting factor and EPU in addition to the first three principal components representing the level, slope, and curvature of the yield curve.

Our empirical findings can be summarised as follows. Testing the impact of EPU on monthly US Treasury returns, we find that a one standard deviation increase in the EPU predicts a positive future excess return from 0.48% (1-year maturity, annualised) to 1.97% (5-year maturity) in 1-month holding period. The finding is in line with Brogaard and Detzel, 2015's empirical work based on the US stock index that the increase in EPU predicts positive expected excess returns. The size of effects on stock returns is larger than our results using Treasury bond returns, but the predictability for stock returns is more concentrated on 2 to 3-month investment horizons. We find that inclusion of EPU in addition to the factors extracted from current yield curve increases adjusted R^2, implying EPU contains information predicting future returns, that is not spanned by the information in contemporaneous term structure. The size and significance of such effects have shown to be larger in near investment horizons in bonds with lower maturities, showing no statistically significant influence on 12-month investment horizon with all maturities considered. We interpret the result that EPU is more closely related to bond price volatility in higher frequency, implying that the influence of economic policy uncertainty almost disappears in investment horizons longer than six months.

To ensure that the strong predictability of EPU is an independent factors from those used in the literature, we add well-known return forecasting factors in the same exercises. Estimation results confirm that including the return forecasting factors from Cochrane and Piazzesi, 2005 and Cieslak and Povala, 2015 does not affect the predictive power of EPU. The factor proposed from Cochrane and Piazzesi, 2005 used in this analysis, and the factor developed by Cieslak and Povala, 2015 are spanning the yield curve which best predicts excess bond returns and therefore it is expected that they will be related with the principal components (see Table 2 for the correlations between them). However, these return forecasting factors are statistically significant in predicting excess returns, even after controlling the first three principal components of the yield curves. So although related to the principal components, they do not behave as their perfect linear representation, thus allowing for the provision of additional independent information in the forecasting equation. Controlling for other measures of macroeconomic and financial uncertainty from Jurado, Ludvigson, and Ng, 2015 and Ludvigson, Ma, and Ng, 2017 does not change the results, suggesting that EPU captures variations in economic uncertainty which are related but distinct from alternative uncertainty measures. Our estimated expected returns using Adrian, Crump, and Moench, 2013's three-step linear regression method explain a considerable amount of the fluctuations in observed returns. EPU has negligible influence on the current yield curves, but significantly forecasts positive excess returns, implying that investors demand additional reward holding Treasury bond when the uncertainty in economic policy is rising. Comparing the estimated term premia with those from a model using only the factors summarising the information in contemporaneous yield curve, we find that adding the two factors generates more volatile and countercyclical term premia estimates, explaining a larger share of the variations in observed yield dynamics.

The rest of the paper is organised as follows: Section 2 discusses the affine term structure models methodology and the estimation procedure. Section 3 presents the description of the data and the sources. Section 4 provides the initial empirical findings regarding the relevance of EPU and other return forecasting factors for the predictability of bond returns at different maturities and different holding periods. Section 5 presents and discusses the results based on the methodology in Section 2. Finally, Section 6 concludes.

2 Term Structure Estimation

Canonical affine term structure models in finance treat yields as functions of a small number of latent (unobserved) factors such as level, slope, and curvature of the yield curve (for example, Dai and Singleton 2000; Duffee 2002). As the short rate and the price of risk are assumed to follow affine functions of state variables, then by imposing a no-arbitrage condition between yields on assets of various maturities, yields become affine functions of the state variables themselves.

2.1 Affine No-Arbitrage Model

The standard no-arbitrage affine term structure model (ATSM) assumes K risk pricing factors X_t following a first order VAR such as

$$X_{t+1} = \mu + \Phi X_t + v_{t+1}, \tag{1}$$

where the shocks conditionally follow the Gaussian distribution with variance-covariance matrix Σ, i.e. $v_{t+1} \sim N(0, \Sigma)$. The assumption of no-arbitrage implies that there exists a pricing kernel

M_t that satisfies the pricing condition such as

$$P_t^{(n)} = E_t[M_{t+1} P_{t+1}^{(n-1)}], \tag{2}$$

where $P_t^{(n)}$ is the price of a bond with n-maturity at time t. The pricing kernel is assumed to be exponentially affine (Duffee, 2002) as

$$M_{t+1} = exp(-r_t - \frac{1}{2}\lambda_t'\lambda_t - \lambda_t'\Sigma^{-\frac{1}{2}} v_{t+1}). \tag{3}$$

The short-term interest rate $r_t = -ln(P_t^{(1)})$ and the market prices of risk are assumed to be affine functions of the pricing factors:

$$r_t = \delta_0 + \delta_1' X_t, \tag{4}$$

$$\lambda_t = \Sigma^{-\frac{1}{2}}(\lambda_0 + \lambda_1 X_t). \tag{5}$$

where δ_0 is a scalar and δ_1 is an $(k \times 1)$ vector of coefficients.

The dynamics of pricing factors (1), short rate (4), and the pricing kernel (3) imply that the price of an n-period bond can be summarised as

$$P_t^{(n)} = exp(A_n + B_n' X_t), \tag{6}$$

where the factor loadings A_n and B_n follow the recursions:

$$A_{n+1} = -\delta_0 + A_n + B_n'(\mu - \Sigma\lambda_0) + \frac{1}{2} B_n'\Sigma\Sigma' B_n, \tag{7}$$

$$B_{n+1} = (\Phi - \Sigma\lambda_1)' B_n - \delta_1. \tag{8}$$

and yields of n-period zero coupon bonds are an affine function of the pricing vector:

$$y_t^{(n)} = -\frac{\log P_t^{(n)}}{n} = a_n + b_n' X_t, \tag{9}$$

where $a_n = -A_n/n$, and $b_n = -B_n/n$.

2.2 Excess Returns in Affine No-Arbitrage Model

To estimate the parameters of this structure, we follow a three-step linear regression approach of Adrian, Crump, and Moench, 2013 (hereafter ACM) who use excess holding period returns to estimate the model. The one-period holding return of a bond maturing in n-period is expressed as

$$rx_{t+1}^{(n)} = lnP_{t+1}^{(n-1)} - lnP_t^{(n)} - r_t. \tag{10}$$

Using equations (3) and (10) in Equation (2) yields

$$1 = E_t[exp(rx_{t+1}^{(n)} - \frac{1}{2}\lambda_t'\lambda_t - \lambda_t'\Sigma^{-\frac{1}{2}}v_{t+1})]. \tag{11}$$

Assuming that $rx_{t+1}^{(n)}$ and v_{t+1} follow a multivariate normal distribution, ACM show

$$E_t[rx_{t+1}^{(n)}] = Cov[rx_{t+1}^{(n)}, v_{t+1}'\Sigma^{-\frac{1}{2}}\lambda_t] - \frac{1}{2}Var_t[rx_{t+1}^{(n)}]. \tag{12}$$

Defining

$$\beta_t^{(n)\prime} = Cov[rx_{t+1}^{(n)}, v_{t+1}']\Sigma^{-1}, \tag{13}$$

and using Equation (5), we can rewrite Equation (12) such that

$$E_t[rx_{t+1}^{(n)}] = \beta_t^{(n)\prime}[\lambda_0 + \lambda_1 X_t] - \frac{1}{2}Var_t[rx_{t+1}^{(n)}]. \tag{14}$$

We then decompose the unexpected excess return into a component coming from shocks in the pricing factors (v_{t+1}) and a remaining term that is conditionally orthogonal. Then using (13), the unexpected excess return can be written as

$$rx_{t+1}^{(n)} - E_t[rx_{t+1}^{(n)}] = \beta_t^{(n)\prime}v_{t+1} + e_{t+1}^{(n)}, \tag{15}$$

where the pricing error $e_{t+1}^{(n)}$ is assumed to be conditionally independent and identically distributed (i.i.d) with variance σ^2.

Assuming $\beta_t = \beta$ for all t, the return generating process is:

$$rx_{t+1}^{(n)} = \beta^{(n)\prime}(\lambda_0 + \lambda_1 X_t) - \frac{1}{2}(\beta^{(n)\prime}\Sigma\beta^{(n)} + \sigma^2) + \beta^{(n)\prime}v_{t+1} + e_{t+1}^{(n)}. \tag{16}$$

This specification enables the holding period return to be decomposed into; expected return from previous pricing factors and a part coming from their innovations. Stacking the system across maturities and time period gives

$$rx = \boldsymbol{\beta}'(\lambda_0\iota_T' + \lambda_1 X_-) - \frac{1}{2}(B^* vec(\Sigma) + \sigma^2\iota_N)\iota_T' + \boldsymbol{\beta}'V + E, \tag{17}$$

where rx denotes an $N \times T$ matrix of excess returns, $\boldsymbol{\beta} = [\beta^{(1)}\, \beta^{(2)}\, \ldots\, \beta^{(N)}]$ is a $K \times N$ matrix of factor loadings, ι_T and ι_N are $T \times 1$ and $N \times 1$ vectors of ones, $X_t = [X_0\, X_1\, \ldots\, X_{T-1}]$ is $K \times T$ matrix of lagged pricing factors. We define $B^* = [vec(\beta^{(1)}\beta^{(1)\prime})\, \ldots\, vec(\beta^{(N)}\beta^{(N)\prime})]$ $(N \times K^2)$, V is factor innovations $(K \times T)$, and E is return pricing errors $(N \times T)$.

2.3 Estimation Methodology

The estimation follows the procedure proposed by ACM using excess returns and observed yield factors. First, we estimate Equation (1) using the vector of pricing factors, X_t. This step enables us to obtain the estimate of the transition matrix and obtain estimates of innovations $\hat{v}_t$. Stacking the estimated factor innovations $\hat{v}_t$ in matrix $\hat{V}$, we obtain an estimate of the state variable variance-covariance matrix $\hat{\Sigma} = \hat{V}\hat{V}'/T$.

Factorising Equation (17) in terms of X and $\hat{V}$ results in

$$rx = \boldsymbol{a}\iota_T + \boldsymbol{c}X_- + \boldsymbol{\beta}'\hat{V} + E. \tag{18}$$

According to this equation, we regress the monthly excess holding period returns on a constant, pricing factors, and estimated innovations. Least squares regression estimation provides estimates of $\boldsymbol{a}$, $\boldsymbol{\beta}$, and $\boldsymbol{c}$ ($\hat{\boldsymbol{a}}$, $\hat{\boldsymbol{\beta}}$, and $\hat{\boldsymbol{c}}$). The estimate of the pricing error covariance matrix is then calculated as $\hat{\sigma}^2 = tr(\hat{E}\hat{E}')/NT$ and B^* is constructed using $\hat{\boldsymbol{\beta}}$.

Finally, the estimates of parameters in the price of risk equation ($\hat{\lambda}_0$ and $\hat{\lambda}_1$) can be obtained using the estimates of the parameters from the previous steps. Arranging Equation (17), we know that $\boldsymbol{a} = \boldsymbol{\beta}'\lambda_0 - (1/2)(B^* vec(\hat{\Sigma}) + \hat{\sigma}^2 \iota_N)$ and $\boldsymbol{c} = \boldsymbol{\beta}'\lambda_1$. Using the relations, the risk parameters are estimated as

$$\hat{\lambda}_0 = (\hat{\boldsymbol{\beta}}\hat{\boldsymbol{\beta}}')^{-1}\hat{\boldsymbol{\beta}}(\hat{\boldsymbol{a}} + \frac{1}{2}(\hat{B}^* vec(\hat{\Sigma}) + \hat{\sigma}^2 \iota_N)), \tag{19}$$

$$\hat{\lambda}_1 = (\hat{\boldsymbol{\beta}}\hat{\boldsymbol{\beta}}')^{-1}\hat{\boldsymbol{\beta}}\hat{\boldsymbol{c}}. \tag{20}$$

The short-term interest rate (Equation (4)) is measured with error η_t:

$$r_t = \delta_0 + \delta_1' X_t + \eta_t. \tag{21}$$

We use least squares estimation to obtain estimates $\hat{\delta_0}$ and $\hat{\delta_1}$.

From Equation (6), log bond prices follow an affine process depending on the vector of pricing factors X_t:

$$lnP_t^{(n)} = A_n + B_n' X_t. \tag{22}$$

Substituting Equation (22) into Equation (10) and matching the terms with the process of Equation (16) give the following linear restrictions which can be solved recursively:

$$A_n = A_{n-1} + B_{n-1}'(\mu - \lambda_0) + \frac{1}{2}(B_{n-1}'\Sigma B_{n-1} + \sigma^2) - \delta_0, \tag{23}$$

$$B_n' = B_{n-1}'(\Phi - \lambda_1) - \delta_1', \tag{24}$$

$$A_0 = 0, \quad B_0 = 0, \quad \text{and} \tag{25}$$

$$\beta^{(n)} = B_n'. \tag{26}$$

3 Data

3.1 Economic Policy Uncertainty

The main variable measuring economic uncertainty in our study is the economic policy uncertainty series developed by Baker, Bloom, and Davis, 2016 for the United States. This index is constructed by counting the frequency of articles in 10 leading U.S. newspapers containing combinations of terms in three categories: (i) "economic" or "economy"; (ii) "uncertain" or "uncertainty"; and (iii) "Congress," "deficit," "Federal Reserve," "legislation," "regulation," or "White House." The series are available from 1985 on a monthly basis, and extended monthly historical index covers from 1900 for the United united states. The latter index is built with expanded article selecting criteria and with different coverage of the newspaper archives. This model-free constructing methodology based on newspaper archives, with the aid of search engine technology, enables it to be extended to most countries and facilitates to build specific sub-categories measures.[3]

Figure 1 plots monthly EPU ranging from 1985 to 2015 for the US. It spikes apparently around major political and economic events such as the 9/11 terrorist attack in 2001 and the Lehman Brothers collapse in 2008. The index may cover a restrictive area of uncertainty in that it only counts "economic" uncertainty related to "government policy", but we expect it will have a broad impact on financial markets considering the significant role of government in the overall economy.[4] In the empirical exercise, Baker, Bloom, and Davis, 2016 show that increases in EPU are followed by decreases in overall economic activities like investment, output, and employment. When using firm-level data, it is found that policy sensitive economic sectors (for example, industry with higher exposure to government purchase) respond more drastically to EPU changes.

3.2 Bond Market Variables

We use daily observations of nominal zero-coupon bond yields from the dataset built by Gürkaynak, Sack, and Wright, 2007.[5] The interest rate series are constructed using the methodology of Nelson-Siegel-Svensson (Nelson and Siegel 1987; Svensson 1994) and the estimated parameters of daily yield curves are also provided. Based on the model, we back out the daily yields for all

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[3] The series of economic policy uncertainty for 11 countries are being updated on a monthly basis at `http://www.policyuncertainty.com`. Daily series for the US and the UK are also available since 1985 and 2001, respectively. For more detailed explanation of the index, see Baker, Bloom, and Davis, 2016.

[4] Baker, Bloom, and Davis, 2016 also provide a broader measure of economic uncertainty, dropping 'policy' criteria among the three words combinations. The correlation coefficient of the two series between 1985:01 and 2015:12 is 0.88.

[5] The data-set is updated periodically and accessible at the Federal Reserve Board Website (`https://www.federalreserve.gov/pubs/feds/2006/200628/200628abs.html`).

the maturities between 3 and 120 months. For the one month risk-free rate, we use the Treasury Bill rate from Ibbotson and Associates.[6] Figure 2 plots end-of-month bond yields at selective maturities ranging from 12 to 120-month.

We denote $p_t^{(n)}$ the log price of an n-month zero-coupon bond at time t. Then, the log return from buying an n-month bond at time t and selling it as a $(n-h)$-month bond at time $t+h$ becomes

$$r_{t+h}^{(n)} = p_{t+h}^{(n-h)} - p_t^{(n)}, \tag{27}$$

where h is the holding periods in months. We can express excess log returns as

$$rx_{t+h}^{(n)} = r_{t+h}^{(n)} - y_t^{(h)}, \tag{28}$$

where $y_t^{(h)}$ is the h-period zero-coupon rate at time t. We then calculate excess bond returns from 1 to 12-month investment horizons. Figure 3 illustrates monthly excess returns for the 1, 3, 5, and 10-year maturities. Table 1 reports summary statistics for annualised monthly excess returns. The means and standard deviations of the monthly returns increase as maturity increases and as the holding period decreases. Our return forecasting exercises using EPU and other return forecasting factors are based on the sample beginning January 1985, when the main EPU index starts, and ends in December 2015.

3.3 Other Variables

We consider two well established return forecasting factors in the literature (Cochrane and Piazzesi 2005, 2008; Cieslak and Povala 2015) as control variables in the return forecasting exercise. Cochrane and Piazzesi(CP)'s factors for each holding period is constructed by regressing excess returns across maturities on the one-year yield and forward rates:

$$rx_{t+12}^{(n)} = \gamma_0^{(n)} + \gamma^{(n)} F_t + \eta_{t+12}^{(n)}, \tag{29}$$

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[6] The rate is accessible at Kenneth French's website (`http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/index.html`).

where F_t is the vector of ten one-year forward rates. As in Cochrane and Piazzesi, 2008, we calculate the CP factor to be the first principal component of the expected excess returns.

The Cieslak and Povala's factor is built by decomposing the yields into the expectation hypothesis components and the term related to risk premia. Specifically, the return forecasting factor is the fitted value from regressing the average of excess bond returns on the maturity-specific yield cycles:

$$\overline{rx}_{t+h} = \delta_0 + \delta_1 \bar{c}_t + \delta_2 c_t^{(1)} + u_{t+h}, \tag{30}$$

where $c_t^{(i)}$ is i maturity-specific yield cycle, obtained by projecting i-year maturity yields on trend inflation measured by a discounted moving average of core inflation. $\bar{c}_t$ is the average of the cycle for 2 to 20-year maturity. We call the resulting forecasting factor as $Cycle$.

We also include general macroeconomic and financial uncertainty proxies used in recent studies, in order to confirm whether EPU keep its forecasting power controlling for the other uncertainty measure. Macroeconomic uncertainty ($MacroU$, hereafter) of Jurado, Ludvigson, and Ng, 2015 is built on the dispersion of forecast errors based on a statistical model using a large number of macroeconomic and financial variables. The financial uncertainty measure ($FinU$) is introduced by Ludvigson, Ma, and Ng, 2017 using the similar methodology of Jurado et al. (2015) with an extensive financial dataset. Analysing the possible contemporaneous effects between the two types of uncertainty and economic activity, Ludvigson, Ma, and Ng, 2017 suggest that financial uncertainty primarily works as exogenous shocks affecting business cycles fluctuations, while uncertainty about real economic activity is close to the endogenous consequence of adverse macroeconomic shocks.

Table 2 presents the correlation coefficients between three yield factors, the return forecasters, and two additional uncertainty measures for the sample period between 1985:01 and 2015:12. The correlation structure shows EPU and other statistical uncertainty measures are positively related (around 0.3 with $MacroU$ and 0.4 with $FinU$). EPU has negative correlation with Cieslak and Povala's $Cycle$ factor, and has no significant correlation with CP factor.

4 Policy Uncertainty and Bond Returns

4.1 Return Predictability of Economic Policy Uncertainty

We first examine the forecasting ability of EPU for future Treasury excess return for different maturities across various holding periods. To test whether EPU contains information that is not captured by the current bond prices, we add it to a prediction equation of excess bond returns for different maturities and different holding period to the yield factors representing the information in the current yield curve. Specifically, we estimate

$$rx_{t+h}^{(n)} = \beta_0^{(n)} + \beta_1^{(n)} PC_t + \beta_2^{(n)} EPU_t + \varepsilon_{t+h}^{(n)}, \tag{31}$$

where $PC_t = (PC1_t \; PC2_t \; PC3_t)'$ and EPU_t is economic policy uncertainty at time t.[7] Joslin, Priebsch, and Singleton, 2014 and Bauer and Hamilton, 2017's return forecasting exercises include the first three principal components (PCs) of the yield curve - level, slope, and curvature - which explain most of all the cross-sectional variations in the yield curve (Litterman and Scheinkman litterman1991common). All the dependant variables in the regression are standardised to have mean 0 and a standard deviation of 1 to facilitate the interpretation of the coefficients. The Newey and West, 1987 t-statistics with the optimal lag length determined following Newey and West, 1994 are reported in parentheses.

The regression results are presented in Table 3. As shown in previous studies such as Bauer and Hamilton (2017), $PC1$ (level) and $PC2$ (slope) significantly predicts excess bond returns consistently across most maturities and holding periods. We find that the addition of EPU predicts the existence of positive excess returns. Adding EPU in addition to the first three principal components of yields increases the adjusted R^2, implying that EPU contains predictive information for future bond returns that is not spanned by contemporaneous yields. We calculate that a one standard deviation increase in the EPU predicts a significant positive future excess return from 0.48% (1-year maturity, annualised) to 1.97% (5-year maturity) when the holding period is a month.

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[7] The value of EPU for January 2000 is used for forecasting the one-month log excess returns buying n-month bond on 31st January 2000 and selling it as a $(n-1)$-month bond on 29th February 2000.

The size and significance of these effects are larger in near investment horizons, having no statistically significant influence in 12-month investment horizons. Our interpretation of this results is that EPU is more closely related to bond price current/immediate volatility affecting investment decisions with short horizons. The finding is in line with Brogaard and Detzel, 2015's empirical work using stock returns that the increase in EPU raises expected excess returns. The statistical significance of the effects on stock returns is larger than our results using Treasury bond returns, but the predictability for stock return is more concentrated on 2 to 3 month holding periods.

To further establish the validity of EPU as an independent forecasting factor, we add it as a predictor to the augmented model estimated by ACM which adds two additional PCs ($PC4$ and $PC5$) extracted from the observed term structure. The test for the significance of EPU in the augmented model will help establish whether the EPU is simply a substitute of the two additional components or it makes an independent contribution. Table 4 reports that $PC5$ affects bond returns negatively. However, the size of coefficients and their statistical significance of EPU do not diminish, confirming that the predictability of EPU is independent of those from current term structure of interest rates.

4.2 Predictability Controlling Other Return Forecasters

To test whether EPU forecasts the future bond return in the presence of additional forecasting factors, we add the factors of Cochrane and Piazzesi (2005, 2008) and Cieslak and Povala, 2015 in Equation (31) as follows:

$$rx_{t+h}^{(n)} = \beta_0^{(n)} + \beta_1^{(n)} PC_t + \beta_2^{(n)} EPU_t + \beta_3^{(n)} X_t + \varepsilon_{t+h}^{(n)}, \tag{32}$$

where X_t includes the CP and $Cycle$ factors introduced in subsection 3.3.

Columns (1) and (2) of Table 5 and Table 6 report the regression coefficients for excess bond returns with 1 and 3-month holding periods, respectively. Both CP and $Cycle$ factors predict with positive one-month holding period returns across all the maturities ranging from 1 to 10 years. Controlling for CP and $Cycle$ factor, it is shown that EPU consistently holds significant predictive power for excess returns of 1 to 3-year maturity at the 1% significance level. Its statistical significance deteriorates as the maturity increases, keeping its significance just below 10% level for 10-year maturity. As reported in Table 6, regressions for excess returns with longer holding periods show limited predictability of EPU, displaying no significant relations for 3-month holding excess returns over 5-year maturities. However, as reported in Table 7, we can confirm that the predictive power of EPU factor holds for all the maturities with 1-month holding period and for 1 and 2-year maturity with 3-month holding period, even controlling for all the return forecasting factors considered.

We test the validity of the model incorporating CP and EPU to the augmented $5PC$ model by using a simple model specification test proposed by Davidson and MacKinnon (1981, 1993).[8] Specifically, we compare two non-nested models, both of which have five return forecasting factors, but the first model ($M1$) uses the first five PCs of interest rates, whilst the other model ($M2$) has factors comprising the first three PCs, CP, and EPU. Table 8 presents the J-test results comparing the two models forecasting excess bond returns for 1-month holding period. Panel A presents the fitted values from $M1$ ($\widehat{rx}_{M1}{}_{t+1}^{(n)}$) do not significantly forecast returns when added in $M2$. As shown in Panel B, the fitted values from $M2$ ($\widehat{rx}_{M2}{}_{t+1}^{(n)}$) enter significantly in the regressions for all the maturities rendering strong support for the model using CP and EPU as bond return predictors.

Having established the statistical improvement over the five PC factor model, we now proceed to test whether the newly established variables proxying economic and financial uncertainty are substitutes for the presence of EPU as a forecasting driver. Specifically, we consider the same regressions (Equation (31)) adding two uncertainty measures as:

$$rx_{t+h}^{(n)} = \beta_0^{(n)} + \beta_1^{(n)} PC_t + \beta_2^{(n)} EPU_t + \beta_3^{(n)} U_t + \varepsilon_{t+h}^{(n)}, \tag{33}$$

where U_t are two statistical uncertainty measures ($MacorU$ and $FinU$) discussed in subsection 3.3. Columns (3) of Table 5 and Table 6 reports $MacroU$ and $FinU$ positively affect one-month

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[8] Davidson and MacKinnon (1981, 1993')s J-test examines the validity of two non-nested models. The basic idea of the test is that the fitted values from $M1$ ($M2$) have no explanatory power when they added to $M2$ ($M1$), if the other model is the correct one.

excess return, but the significance of the predictive power is somewhat limited. Meanwhile, EPU consistently holds significant coefficients for the returns of short maturity bonds when controlling the two uncertainty measures. From an unreported exercise, we find that both $MacroU$ and $FinU$ predict significant positive excess bond returns in the absence of EPU as a factor in the regression. As reported, the two alternative uncertainty measures lose their predictive power in the regression with the EPU factor. The coefficients on $MacroU$, however, become significant when the holding period increases. This result and the strong comovement of EPU with $FinU$ imply that the EPU measure is likely to be linked to the type of uncertainty that affects financial markets.

From this section, we conclude that the significance profile of EPU as a predictor of excess returns remains approximately constant independently of the conditioning set. EPU is a strong predictor for 1-month holding period for up to medium maturity bonds, subsequently its significance across maturities is restricted to short-term bonds as the holding horizon increases. The addition of alternative uncertainty proxies and the well established forecasting factors such as CP and $Cycle$ does not change this profile, establishing EPU's independent contribution as a forecasting factor for short-term forecasting horizon.

5 Economic Policy Uncertainty in ATSM

The finding from previous excess return forecasting exercise implies that using only principal components from the yield curve may omit significant information contained in macroeconomic proxies for uncertainty such as EPU. In this section we test for the contribution of EPU in the pricing kernel (Equation (3)) under alternative conditioning factor structure.

By and large traditional models of accounting for the pricing kernel are functions of the observed yield curve, via the constructed PCs. The objective of this section is to examine whether the substitution of some of the PCs by variables outside the yield curve can be used for both description of the pricing kernel and the term premium in particular.

Yield on n-month bond $y_t^{(n)}$ satisfies the following identity:

$$y_t^{(n)} = \frac{1}{n}\sum_{\tau=0}^{n-1} E_t[y_{t+\tau}^{(1)}] + tp_t^{(n)}, \tag{34}$$

where, $y_t^{(1)}$ is risk-free nominal short rate and $tp_t^{(n)}$ is the nominal term premium on n-month bond. The average expected risk-free short rate over the maturity is the expectation component of the n-month bond which correspond to the yield following the expectation hypothesis. The second term representing the risk premium can be expressed using the expected excess holding return $rx_{t+1}^{(n)}$ as

$$tp_t^{(n)} = \frac{1}{n}\sum_{\tau=0}^{n-1} E_t[rx_{t+\tau+1}^{(n-\tau)}]. \tag{35}$$

Accurate estimates of this quantity require that the conditioning information set reflects all relevant information, not restricting it to the existing term structure. Following the expectation hypothesis, we calculate the yield by setting the parameters of the price of risk (λ_0 and λ_1). Then the term premia implied by the model can be obtained by differencing the fitted yields and the expected terms for each maturity bond.

To summarise, an affine model of the term structure aims at providing efficient estimates of the price of risk. If the price of risk is indeed zero, the stochastic discount factor depends on the instantaneous interest rate alone. In the presence of positive price of risk, the conditioning factors provide such estimates. It is therefore important that the set of the conditioning factors contains all the relevant information affecting both components constituting the observed yields; the expectations and the term premia.

The calculation of the price of risk is based upon forecasts of the factors rather than information contained in the observed yield curves (see Equations (19) and (20)). Fitting models accounting for the pricing kernel based exclusively on PCs does not take into account that it is the forecast of the factors that determines the price of risk rather than the existing extracted principal components. To take this into account, we introduce affine models, based on 5 factors consisting of the traditional yield factors along with CP and EPU. The last two factors are not extracted from the observed yield curves and the forecasts will determine the price of the risk and the term premia.

By including additional factors such as the EPU, we test for their distinct contribution to the dynamics of both the term premium and the formation of expectations. The empirical evidence to date in accounting for the yields suggests that the 5-factor PC model is superior to the traditional 3-factor PC model with the addition to CP factor. Our findings in forecasting bond returns from the Section 4, in conjunction with Equation (35), imply that there is a distinct case for substituting some of the principal components by variables generated outside the yield curve. To explain the fluctuations in yields, we need to calculate both expectations and term premia. Estimating term premia requires predicting future returns which can be better forecasted by the additional factors such as CP and EPU.

To account for the yields in accordance with the evidence presented in Section 4 we need principal components and some forecasting variables. If we were to restrict the overall number of factors to five then we consider two affine models, one using three PCs and CP and EPU, and one with 5 factors used by ACM. We call the former five factor specification as the "Yield-Plus" model, since the factors from the yield curve are augmented by the additional data containing yield-independent information. Our pricing factor vector is $X_t = [PC1_t \ PC2_t \ PC3_t \ CP_t \ EPU_t]'$, where CP_t is the Cochrane and Piazzesi (2005)'s return forecasting factor and EPU is the economic policy uncertainty index of Baker et al. (2016).[9]

The sample period for model estimation begins in January 1962 from when Gürkaynak, Sack, and Wright, 2007's zero-coupon yield series and ends in December 2013. ACM include the forth and fifth principal components of the yield curve which have significant role in explaining expected excess returns, although they do not explain much about the contemporaneous yield curve. Due to the short span of the main EPU index, we choose the historical news-based policy index of Baker et al. (2016) which is available on a monthly basis.[10] As introduced in

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[9] Principal components of the yield curve are extracted from the yields with maturities $n = 3, 6, \ldots, 120$ months. To back out interest rates with various maturities, the parameters for Nelson-Siegel-Sevenson (1994) yield curves, also provided by Gürkaynak, Sack, and Wright, 2007, are used. We choose end-of-month values for monthly frequency estimation.

[10] To build longer span EPU index, Baker, Bloom, and Davis, 2016 use digital archives of six newspapers and apply expanded word combinations also related to policy-related economic uncertainty. The historical EPU series covers the period 1900:01 and 2014:10 and moves closely together with the main monthly EPU covering after

Section 3, Cochrane and Piazzesi (2005, 2008) build the return forecasting factor using annual excess holding period returns as the dependent variable. Our corresponding factor is the first principal component of expected returns obtained by regressing the 1-month holding period returns ($rx_{t+1}^{(n)}$) on ten one-year forward rates. Estimation using monthly excess returns is required because the regression Equation (18) holds explicitly for non-overlapping monthly returns.

Figure 4 shows the observed (solid lines) and estimated yields (dotted lines) for 12, 60, and 120-month Treasury notes, indicating that the two series for each maturity are almost indistinguishable. In estimating Equation (18), the cross-equation constraints (Equations (24) and (25)) are not imposed. In deriving the predicted values of yield curve, the constraints on factor loading are used. These are derived after we obtain the estimates of all the parameters from the excess returns regressions. The dashed lines in Figure 4 plot the term premia estimates of the model and the dashed lines in Figure 5 show that the expected component of excess returns explains a considerable amount of the variations in observed series, capturing the highly volatile movements in excess returns.

As shown in the lower panel of Figure 6, CP (dash-dotted line) and EPU (thicker dashed line) factors forecast positive excess returns, in line with the estimation results in the previous section. The loadings on the first three principal components, illustrated in the upper panel, confirm the factors' role of the level, slope, and curvature of the yield curve accounting for the observed term structure. In the case of expected excess returns we find that the influence of three PCs is minimal, reinforcing the importance of CP and EPU as the factors predicting excess returns. The loading on the CP factor for excess returns increases with maturity, whilst the influence of EPU peaks between 60 and 80 months. The additional premium required for early to mid-maturities bonds, following increases in EPU, is attributed to the marked rise of uncertainty regarding the yields of these maturities and can be accounted by the following two reasons. First, as reported in studies relating uncertainty with macroeconomic outcomes (for example, Bloom 2009 and Baker, Bloom, and Davis 2016), economic uncertainty is largely related to the evolution of the medium term business cycle, and it is subsequently associated with the pricing of bonds at corresponding maturities. Second, supported by the evidence provided

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1985:01. The correlation coefficient between the two series for the overlapping period is 0.98.

by Christiansen and Lund, 2005, the effect of higher volatility in the short-term rate due to economic uncertainty on bond risk premia is more concentrated on the short to medium-term maturities.

To assess the significance of the factors' effects on excess returns, in Figure 7, we report 90% confidence intervals (dashed lines) for the factor loadings ($\beta'\lambda_1$), computed using a bootstrap procedure introduced by Malik and Meldrum, 2016 with 10,000 replications. Specifically, we generate bootstrap samples by using the estimated parameters from the initial estimation and randomly selected estimated residuals for v_t, E, and η_t in Equations (1), (18), and (21). We re-estimate the model using the bootstrapped sample and obtain confidence intervals by computing the percentiles of the bootstrapped estimates. The result shows that CP factor is significant for all the maturities, whilst EPU factor is significant up to around 7 years, which is consistent with our findings in the return forecasting exercises that the predictive ability of EPU are more pronounced in short- and medium-term maturities. From this result, we can infer that the effect of monetary easing to counter the adverse impact of the economic shocks can be offset partly by the influence from the changing term premia. This implies that during times of high economic uncertainty, monetary authorities have to act aggressively and try to mitigate the uncertainty in policies to stabilise the economy.

To compare the approach with a model incorporating only the factors summarising yield curve, we estimate a model with the first five principal components, which we call "Yield-Only" model. Litterman and Scheinkman, 1991 show that almost all the variations of the yield curve can be explained by three factors, whilst Cochrane and Piazzesi (2005, 2008) and Duffee, 2011 find that including additional factors, which are not important for explaining variations of current yield, can be essential for explaining expected returns.

Figure 8 shows the observed (solid lines) and estimated yields (dotted lines) for 12, 60, and 120-month Treasury notes, indicating that estimated yields are almost identical to the actual yields. The observed and fitted excess holding returns are illustrated in Figure 9 showing that the fitted returns (dotted lines) follows the actual returns (solid lines) closely.

As discussed in ACM, the bottom panel of Figure 10 shows that the second (dashed line), fourth (dash-dotted line), and fifth (thicker dashed line) principal components play important roles explaining excess returns, whilst the weights on yields associated with the fourth and fifth factors are negligible. 90% confidence intervals (dashed lines) for the factor loadings, computed using the same bootstrap procedure with 10,000 replications, are reported in Figure 11. The influence of $PC2$ and $PC4$ is stronger than the other PCs and is shown to have significance for most maturities, whilst $PC1$ and $PC5$ are significant only in some maturities. Comparing the effects of the yield factors on excess returns with those of CP and EPU factors (shown in Figure 7) suggests that the predictive content of CP factor is possibly related with the second, fourth, and fifth principal components. The correlation coefficients between CP and $PC2$, $PC4$, and $PC5$ are 0.53, 0.42, and 0.21, respectively. Meanwhile, the effect of EPU factor seems to be less related with those from principal components, as correlations with the three PCs are 0.36, 0.24, and 0.07, respectively.

Figure 12 compares the expected excess return using the two models: the Yield-Only ($5PC$) and the Yield-Plus model ($3PC$, CP, and EPU). The left panel presents the observed excess returns with maturities of 12, 60, and 120 months and the right panel plots expected parts of excess returns predicted by the two models. The expected returns implied by Yield-Plus model fluctuate more closely with the actual excess returns, confirming the two factors predictive power established in the previous section. From Table 9, the average of calculated pricing errors do not exceed 11 basis points with equivalent standard deviations for short maturities. These pricing errors become vanishingly small along with standard deviations, as maturities increase. In terms of returns, in all cases the mean error is less than 4 basis points with standard deviation between 6 and 42 basis points.

As we do not observe major differences in statistical fits, we expect more realistic estimate of term premia from the first model as it includes in the specification forecasts of variables independent of the observed yields. Although the second model may provide better statistical fit for the observed yields, it does not account for the forecasting errors of the hidden factors that determine term premia. From the results above we conclude that, given the very small magnitude of pricing errors in all cases, the advantage of calculating the price of risk by using estimates of hidden factors outweighs the very small losses of statistical fit. We then calculate the term premia from the two models, one using information only from the term structure and the alternative which includes only the 3 first PCs with the CP and EPU as hidden factors.

The left column of Figure 13 plots the expected yields and term premia with observed yields for maturity 12, 60, and 120, implied by Yield-Plus model which include three PCs, EPU, and CP. The right column plots those of Yields-Only model. The dashed lines indicate expected yields, while the solid lines below show the variations in term premia. It is natural that lower-maturity yields move more closely with the expected term, and the share of implied term premia in observed yields increases along with maturity. The two components estimated by the two models show broadly similar movements.

Figure 14 compares the term premia estimates from the two models. From the left column of the figure, we can see that the term premia estimates by Yield-Plus approach (solid lines) have higher volatility, contributing more to the variations in observed yields. This finding over the important role of the term premia in explaining the actual yields dynamics is consistent with the results in recent studies (see, for example, Bernanke, Reinhart, and Sack 2004; Dewachter, Iania, and Lyrio 2014; Crump, Eusepi, and Moench 2017), which attribute more prominent role of the term premia accounting for variation in yield curve dynamics.

Theoretical models with utility maximising agents predict that investors demand higher risk premium under bad economic condition (see, for example, Campbell and Cochrane 1999; Bansal and Yaron 2004; Wachter 2006; Bansal and Shaliastovich 2013). For example, in the model of Wachter, 2006, short-term real rate is negatively correlated with surplus consumption (current consumption compared to its recent trend), as agents wish to borrow more in order to smooth consumption when current consumption is temporally reduced by negative economic shocks. This intertemporal consumption smoothing due to habit persistence makes agents demand additional compensation to hold bonds, implying that term premia should exhibit countercyclical movements as reported in much empirical literature (Harvey 1989; Cochrane and Piazzesi 2005, among others). The relation between consumption shocks and short-term rates is dependent upon the relative size of effects between agents' desire for consumption smoothing and precautionary saving. Wachter, 2006's calibration result supports the dominance of the smoothing effect, consistently with the countercyclical pattern of term premia in the empirical studies.

We examine the cyclical variations of our estimated term premia whether they satisfy the theoretical prediction. Figure 15 compare the 12-month moving averages of estimated term premia with 60-month maturity and industrial production (IP_t) growth. Both of the term premia increase as IP_t growth deteriorates and decrease as growth rises, suggesting both model produce countercyclical term premia. Furthermore, the negative correlation between tp_t and IP_t growth is stronger for the *Yield–Plus* model (-0.15) compared to the correlation from the *Yield–Only* model (-0.11). We also confirm that the countercylical relation between IP_t and TP_t and the stronger negative correlations for *Yield-Plus* model hold for other maturities and in estimations using sub-sample periods. Alternative measures of economic activity such as ADS real-time Business Conditions Index (Aruoba, Diebold, and Scotti 2009) also validate the strong relation. As shown in the third plot of Figure 15, we find strong negative relation between the gap of the two term premia estimates (*Yield–Plus* $-$ *Yield–Only*) and IP_t, with correlation of -0.33, suggesting that the difference between the two term premia is closely related to the cyclical fluctuations in economic activity.

6 Conclusion

We provide strong empirical evidence of the predictive ability of uncertainty in government policies (EPU) for future bond returns. EPU has been shown to contain information predicting future returns that is not spanned by the factors in the contemporaneous term structure. The size and significance of the effects is especially large for short maturity bonds in near investment horizons.

We have shown that, incorporating EPU as an additional pricing factor in affine term structure models does not explain variations in current yields much, but it affects the term premia by influencing the price of risk. Model predicted term premia exhibit fluctuations that follow closely the variations in observed yields. These term premia estimates show stronger counter-cyclical movements than those estimates using a model with only yield curve factors. This provides an account for the requirement of increasing risk compensation under adverse economic conditions as theories expect, independently of the shape and position of the yield curve.

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Table 1: Treasury Bond Excess Returns

	1y	**2y**	**3y**	**5y**	**7y**	**10y**
	1-month holding period					
Mean	0.994	1.798	2.529	3.783	4.779	5.916
Median	0.489	1.368	2.239	4.417	4.629	6.502
Max	12.099	25.451	38.683	65.813	96.327	148.694
Min	−7.901	−18.740	−27.804	−48.865	−76.969	−117.932
Std. Dev.	2.789	6.605	10.549	18.037	24.979	34.844
Skewness	0.705	0.193	0.020	−0.046	0.031	0.146
Kurtosis	4.969	3.756	3.380	3.373	3.771	4.512
AC(1)	0.174	0.167	0.144	0.101	0.066	0.031
AC(5)	0.011	−0.022	−0.049	−0.072	−0.076	−0.075
	3-month holding period					
Mean	0.673	1.501	2.255	3.553	4.596	5.800
Median	0.266	0.888	1.474	2.445	3.359	4.513
Max	6.694	14.486	20.600	33.300	45.319	70.066
Min	−3.148	−9.664	−16.109	−27.289	−36.663	−48.338
Std. Dev.	1.569	3.984	6.373	10.661	14.375	19.433
Skewness	0.837	0.456	0.329	0.217	0.191	0.245
Kurtosis	4.008	3.445	3.184	2.945	3.030	3.468
AC(1)	0.759	0.740	0.724	0.701	0.681	0.661
AC(5)	0.149	0.026	−0.036	−0.073	−0.063	−0.038
	6-month holding period					
Mean	0.439	1.263	2.014	3.311	4.354	5.553
Median	0.238	0.941	1.598	2.645	3.859	4.870
Max	2.837	8.182	14.242	25.546	38.511	59.128
Min	−1.141	−4.603	−8.866	−17.136	−24.822	−35.416
Std. Dev.	0.808	2.544	4.222	7.224	9.849	13.442
Skewness	0.679	0.340	0.238	0.173	0.154	0.196
Kurtosis	2.877	2.748	2.822	2.926	3.106	3.558
AC(1)	0.888	0.871	0.856	0.839	0.828	0.817
AC(5)	0.381	0.266	0.186	0.115	0.100	0.103
	12-month holding period					
Mean		0.824	1.575	3.777	3.938	5.154
Median		0.634	1.322	3.930	4.193	5.605
Max		4.194	8.663	24.918	26.361	39.212
Min		−2.522	−4.972	−11.248	−11.807	−16.410
Std. Dev.		1.311	2.513	6.067	6.355	8.848
Skewness		0.230	0.126	0.165	0.176	0.307
Kurtosis		2.558	2.760	3.374	3.424	3.859
AC(1)		0.948	0.938	0.914	0.912	0.902
AC(5)		0.651	0.601	0.498	0.493	0.463

Notes: This table reports summary statistics for annualised Treasury bond excess returns (in percentage) with four different holding period (1, 3, 6, 12 months). Each panel includes bond excess returns for 1 to 10-year bond maturities. Excess returns are constructed using daily Treasury yield curve constructed by Gurkaynak et al. (2007) and Treasury bill rate from Ibbotson and Associates. The sample period covers from 1985:01 to 2015:12.

Table 2: Correlation Coefficients of Predictor Variables

	$PC1$	$PC2$	$PC3$	EPU	CP	$Cycle$	$MacroU$	$FinU$
$PC1$	1.000							
	-							
$PC2$	0.002	1.000						
	(0.036)	-						
$PC3$	-0.007	0.003	1.000					
	(-0.125)	(0.053)	-					
EPU	-0.361	-0.256	0.332	1.000				
	(-7.432)	(-5.093)	(6.753)	-				
CP	0.304	-0.563	0.183	0.038	1.000			
	(6.120)	(-13.088)	(3.567)	(0.721)	-			
$Cycle$	0.477	-0.522	-0.264	-0.219	0.441	1.000		
	(10.439)	(-11.762)	(-5.263)	(-4.318)	(9.442)	-		
$MacroU$	-0.236	-0.035	0.295	0.316	0.194	-0.089	1.000	
	(-4.659)	(-0.679)	(5.932)	(6.390)	(3.800)	(-1.718)	-	
$FinU$	-0.090	-0.119	0.253	0.411	0.171	0.069	0.641	1.000
	(-1.726)	(-2.303)	(5.021)	(8.673)	(3.334)	(1.330)	(16.043)	-

Notes: This table reports the correlation coefficients for the three yield factors ($PC1$, $PC2$, and $PC3$), economic policy uncertainty of Baker et al. (2016), EPU, Cocrane and Piazzesi (2005) factor, CP, the cycle factor from Cieslak and Povala (2015), $Cycle$, macroeconomic and financial uncertainty measures by Ludvigson et al. (2017), $MacroU$ and $FinU$, respectively. The sample period covers from 1985:01 to 2015:12.

Table 3: EPU Return Predictability

	1y		2y		3y		5y		7y		10y	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
	1-month holding period											
$PC1$	0.582	0.754	0.883	1.252	1.122	1.644	1.526	2.234	1.867	2.634	2.362	3.124
	(3.854)	(5.168)	(2.582)	(3.627)	(2.028)	(2.789)	(1.549)	(2.176)	(1.326)	(1.924)	(1.163)	(1.620)
$PC2$	-0.327	-0.204	-0.858	-0.595	-1.407	-1.034	-2.489	-1.983	-3.485	-2.937	-4.765	-4.220
	(-2.212)	(-1.361)	(-2.371)	(-1.600)	(-2.392)	(-1.700)	(-2.532)	(-1.995)	(-2.696)	(-2.401)	(-2.819)	(-2.767)
$PC3$	0.126	-0.033	0.069	-0.271	0.051	-0.431	0.341	-0.312	0.991	0.283	2.120	1.415
	(0.679)	(-0.179)	(0.167)	(-0.650)	(0.077)	(-0.652)	(0.295)	(-0.266)	(0.588)	(0.163)	(0.859)	(0.566)
EPU		0.479		1.026		1.452		1.971		2.135		2.124
		(3.429)		(2.835)		(2.349)		(1.909)		(1.624)		(1.176)
R^2	0.051	0.069	0.027	0.041	0.021	0.032	0.019	0.024	0.019	0.021	0.019	0.019
	3-month holding period											
$PC1$	0.494	0.608	0.855	1.049	1.137	1.353	1.600	1.804	1.990	2.135	2.541	2.544
	(3.436)	(5.041)	(2.481)	(3.081)	(2.180)	(2.612)	(1.806)	(2.046)	(1.543)	(1.670)	(1.318)	(1.539)
$PC2$	-0.295	-0.214	-0.807	-0.668	-1.352	-1.197	-2.449	-2.303	-3.468	-3.364	-4.779	-4.776
	(-2.012)	(-1.467)	(-2.154)	(-1.700)	(-2.318)	(-1.910)	(-2.679)	(-2.313)	(-3.002)	(-2.668)	(-3.318)	(-2.960)
$PC3$	0.022	-0.083	-0.179	-0.359	-0.418	-0.619	-0.658	-0.846	-0.545	-0.680	-0.104	-0.108
	(0.169)	(-0.577)	(-0.577)	(-1.185)	(-0.892)	(-1.370)	(-0.900)	(-1.192)	(-0.561)	(-0.730)	(-0.078)	(-0.078)
EPU		0.317		0.540		0.605		0.567		0.406		0.010
		(3.151)		(1.637)		(1.064)		(0.592)		(0.332)		(0.008)
R^2	0.126	0.153	0.082	0.092	0.074	0.078	0.072	0.071	0.071	0.069	0.070	0.067
	6-month holding period											
$PC1$	0.307	0.355	0.645	0.743	0.881	0.972	1.264	1.267	1.599	1.461	2.088	1.699
	(2.391)	(2.882)	(1.742)	(1.943)	(1.635)	(1.664)	(1.513)	(1.396)	(1.364)	(1.181)	(1.185)	(0.951)
$PC2$	-0.152	-0.116	-0.586	-0.513	-1.101	-1.031	-2.193	-2.192	-3.249	-3.353	-4.648	-4.941
	(-1.175)	(-0.936)	(-1.402)	(-1.310)	(-1.673)	(-1.600)	(-2.245)	(-2.246)	(-2.759)	(-2.820)	(-3.179)	(-3.452)
$PC3$	0.015	-0.033	-0.140	-0.239	-0.377	-0.469	-0.728	-0.730	-0.835	-0.696	-0.784	-0.391
	(0.183)	(-0.456)	(-0.431)	(-0.989)	(-0.756)	(-1.186)	(-1.080)	(-1.205)	(-1.050)	(-0.911)	(-0.792)	(-0.411)
EPU		0.139		0.283		0.266		0.006		-0.398		-1.126
		(2.191)		(1.195)		(0.662)		(0.011)		(-0.582)		(-1.316)
R^2	0.169	0.188	0.113	0.119	0.113	0.114	0.127	0.125	0.137	0.136	0.141	0.144
	12-month holding period											
$PC1$			0.411	0.485	0.633	0.743	1.138	1.155	1.175	1.176	1.514	1.361
			(2.394)	(2.370)	(2.140)	(2.121)	(1.631)	(1.514)	(1.602)	(1.473)	(1.303)	(0.787)
$PC2$			-0.222	-0.166	-0.580	-0.495	-2.325	-2.312	-2.492	-2.492	-3.924	-4.043
			(-0.787)	(-0.567)	(-1.113)	(-0.950)	(-2.270)	(-2.240)	(-2.357)	(-2.331)	(-3.568)	(-2.405)
$PC3$			0.063	-0.014	0.047	-0.068	-0.016	-0.033	-0.016	-0.017	-0.040	0.121
			(0.334)	(-0.079)	(0.130)	(-0.197)	(-0.022)	(-0.043)	(-0.022)	(-0.021)	(-0.043)	(0.112)
EPU				0.216		0.322		0.050		0.002		-0.452
				(1.513)		(1.202)		(0.090)		(0.003)		(-0.569)
R^2			0.114	0.131	0.106	0.115	0.176	0.173	0.182	0.179	0.221	0.221

Notes: This table reports the coefficient estimates in a regression of the annualised bond excess returns on six n-month maturity bond ranging 12 to 120-month, with a holding period of 1 month. EPU is economic policy uncertainty index of Baker et al. (2016). PCs are the first three principal components of Treasury yields representing the level, slope, and curvature of yield curve. All the dependant variables in the regression are standardised to have a mean of 0 and a standard deviation of 1. The values in parentheses are the Newey and West (1987) t-statistics with the optimal length determined based on Newey and West (1994). The sample period covers from 1985:01 to 2015:12.

Table 4: *EPU* Return Predictability

	1y		2y		3y		5y		7y		10y	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
	1-month holding period											
$PC1$	0.580	0.772	0.878	1.298	0.887	1.721	1.508	2.371	1.844	2.807	2.338	3.299
	(3.971)	(5.816)	(2.638)	(3.893)	(1.434)	(2.853)	(1.513)	(2.220)	(1.330)	(2.000)	(1.243)	(1.692)
$PC2$	-0.326	-0.188	-0.856	-0.555	0.571	-0.966	-2.482	-1.863	-3.475	-2.785	-4.754	-4.066
	(-2.282)	(-1.332)	(-2.555)	(-1.593)	(0.752)	(-1.632)	(-2.577)	(-1.899)	(-2.753)	(-2.300)	(-3.088)	(-2.698)
$PC3$	0.123	-0.056	0.061	-0.328	-1.020	-0.528	0.315	-0.485	0.957	0.064	2.084	1.192
	(0.648)	(-0.299)	(0.149)	(-0.797)	(-1.598)	(-0.814)	(0.285)	(-0.427)	(0.582)	(0.039)	(0.857)	(0.494)
$PC4$	0.163	0.199	0.611	0.690	1.683	1.184	1.674	1.836	1.779	1.960	1.316	1.497
	(0.988)	(1.308)	(1.803)	(2.138)	(2.919)	(2.324)	(1.924)	(2.115)	(1.556)	(1.718)	(0.848)	(0.935)
$PC5$	-0.328	-0.368	-0.670	-0.756	2.743	-1.246	-2.292	-2.470	-3.240	-3.439	-3.727	-3.925
	(-2.235)	(-2.799)	(-1.875)	(-2.157)	(4.257)	(-2.197)	(-2.524)	(-2.670)	(-2.668)	(-2.821)	(-2.389)	(-2.515)
EPU		0.537		1.172		1.697		2.408		2.685		2.681
		(3.899)		(3.218)		(2.675)		(2.245)		(1.988)		(1.465)
R^2	0.064	0.087	0.041	0.060	0.038	0.053	0.038	0.048	0.035	0.041	0.026	0.028
	3-month holding period											
$PC1$	0.489	0.618	0.842	1.075	1.115	1.394	1.562	1.869	1.942	2.212	2.493	2.615
	(3.357)	(4.714)	(2.393)	(3.317)	(1.962)	(2.647)	(1.908)	(2.391)	(1.692)	(1.953)	(1.477)	(1.533)
$PC2$	-0.293	-0.200	-0.802	-0.634	-1.344	-1.143	-2.435	-2.213	-3.451	-3.256	-4.761	-4.673
	(-2.008)	(-1.372)	(-2.171)	(-1.690)	(-2.366)	(-1.994)	(-2.747)	(-2.452)	(-2.994)	(-2.762)	(-3.072)	(-2.981)
$PC3$	0.015	-0.106	-0.198	-0.416	-0.448	-0.710	-0.711	-0.999	-0.611	-0.865	-0.171	-0.286
	(0.106)	(-0.728)	(-0.574)	(-1.133)	(-0.840)	(-1.217)	(-0.818)	(-1.150)	(-0.540)	(-0.776)	(-0.116)	(-0.203)
$PC4$	0.224	0.249	0.616	0.661	0.944	0.997	1.320	1.379	1.322	1.374	0.850	0.874
	(1.351)	(1.534)	(1.710)	(1.839)	(1.787)	(1.897)	(1.635)	(1.765)	(1.315)	(1.375)	(0.620)	(0.636)
$PC5$	-0.170	-0.198	-0.402	-0.451	-0.715	-0.774	-1.444	-1.510	-2.021	-2.078	-2.318	-2.344
	(-1.552)	(-2.080)	(-1.386)	(-1.690)	(-1.522)	(-1.728)	(-1.858)	(-1.966)	(-2.124)	(-2.186)	(-1.975)	(-1.973)
EPU		0.362		0.652		0.783		0.860		0.758		0.343
		(3.660)		(2.316)		(1.651)		(1.107)		(0.761)		(0.272)
R^2	0.154	0.189	0.111	0.127	0.103	0.111	0.100	0.102	0.094	0.094	0.081	0.079
	6-month holding period											
$PC1$	0.301	0.358	0.625	0.754	0.846	0.991	1.203	1.294	1.520	1.493	2.003	1.728
	(2.564)	(3.349)	(1.848)	(2.267)	(1.155)	(1.791)	(1.222)	(1.315)	(1.096)	(1.070)	(0.996)	(0.852)
$PC2$	-0.150	-0.106	-0.580	-0.481	-1.090	-0.979	-2.175	-2.105	-3.225	-3.246	-4.622	-4.834
	(-1.167)	(-0.881)	(-1.398)	(-1.175)	(-1.972)	(-1.429)	(-1.858)	(-1.814)	(-2.116)	(-2.137)	(-2.404)	(-2.490)
$PC3$	0.007	-0.053	-0.167	-0.302	-0.423	-0.574	-0.810	-0.906	-0.941	-0.913	-0.898	-0.611
	(0.065)	(-0.465)	(-0.442)	(-0.768)	(-0.630)	(-0.903)	(-0.863)	(-0.908)	(-0.813)	(-0.747)	(-0.659)	(-0.426)
$PC4$	0.177	0.190	0.605	0.634	0.927	0.960	1.306	1.327	1.385	1.379	1.127	1.066
	(1.526)	(1.753)	(1.789)	(1.948)	(1.496)	(1.979)	(1.843)	(1.874)	(1.581)	(1.558)	(0.996)	(0.919)
$PC5$	-0.057	-0.073	-0.190	-0.225	-0.405	-0.444	-0.917	-0.941	-1.353	-1.346	-1.674	-1.600
	(-0.875)	(-1.207)	(-0.807)	(-0.993)	(-0.929)	(-1.146)	(-1.391)	(-1.447)	(-1.582)	(-1.573)	(-1.521)	(-1.450)
EPU		0.169		0.380		0.425		0.268		-0.080		-0.809
		(2.600)		(1.567)		(1.031)		(0.400)		(-0.092)		(-0.724)
R^2	0.217	0.245	0.170	0.183	0.165	0.170	0.171	0.169	0.170	0.168	0.159	0.159
	12-month holding period											
$PC1$			0.377	0.468	0.567	0.712	1.001	1.096	1.036	1.116	1.378	1.306
			(1.580)	(2.079)	(1.899)	(1.675)	(0.983)	(1.037)	(0.963)	(0.999)	(0.828)	(0.771)
$PC2$			-0.213	-0.138	-0.561	-0.442	-2.287	-2.210	-2.454	-2.388	-3.887	-3.945
			(-0.682)	(-0.451)	(-1.183)	(-0.784)	(-1.961)	(-1.891)	(-2.036)	(-1.981)	(-2.656)	(-2.597)
$PC3$			0.016	-0.090	-0.044	-0.212	-0.202	-0.312	-0.206	-0.299	-0.226	-0.143
			(0.066)	(-0.451)	(-0.117)	(-0.529)	(-0.236)	(-0.364)	(-0.235)	(-0.339)	(-0.221)	(-0.131)
$PC4$			0.384	0.410	0.683	0.724	1.049	1.076	1.037	1.060	0.744	0.724
			(2.077)	(2.439)	(2.346)	(2.604)	(1.979)	(2.044)	(1.897)	(1.946)	(1.011)	(0.995)
$PC5$			-0.104	-0.134	-0.250	-0.297	-0.851	-0.881	-0.894	-0.919	-1.132	-1.109
			(-0.643)	(-0.898)	(-0.894)	(-1.095)	(-1.645)	(-1.706)	(-1.698)	(-1.734)	(-1.801)	(-1.745)
EPU				0.281		0.446		0.292		0.247		-0.220
				(2.321)		(1.871)		(0.572)		(0.466)		(-0.306)
R^2			0.196	0.226	0.179	0.198	0.216	0.215	0.219	0.218	0.238	0.236

Notes: This table reports the coefficient estimates in a regression of the annualised bond excess returns on six n-month maturity bond ranging 12 to 120-month, with a holding period of 1 month. *EPU* is economic policy uncertainty index of Baker et al. (2016). *PC*s are the first five principal components of Treasury yields. All the dependant variables in the regression are standardised to have a mean of 0 and a standard deviation of 1. The values in parentheses are the Newey and West (1987) t-statistics with the optimal length determined based on Newey and West (1994). The sample period covers from 1985:01 to 2015:12.

Table 5: *EPU* Return Predictability with Additional Factors (1-month holding period)

	1y			2y			3y			5y			7y			10y		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
$PC1$	0.558	0.565	0.792	0.789	0.729	1.325	0.887	0.781	1.743	0.874	0.687	2.359	0.784	0.430	2.754	0.859	0.036	3.215
	(3.510)	(2.694)	(4.628)	(2.136)	(1.491)	(3.455)	(1.434)	(0.997)	(3.263)	(0.788)	(0.501)	(2.459)	(0.505)	(0.226)	(2.037)	(0.423)	(0.013)	(1.537)
$PC2$	0.213	0.043	-0.203	0.386	0.085	-0.593	0.571	0.089	-1.031	0.899	0.028	-1.980	0.986	-0.071	-2.935	0.585	-0.203	-4.224
	(1.155)	(0.215)	(-1.241)	(0.823)	(0.174)	(-1.496)	(0.752)	(0.115)	(-1.831)	(0.721)	(0.022)	(-2.266)	(0.602)	(-0.041)	(-2.723)	(0.288)	(-0.086)	(-2.894)
$PC3$	-0.186	0.062	-0.117	-0.630	-0.008	-0.439	-1.020	0.003	-0.664	-1.369	0.465	-0.606	-1.156	1.392	0.017	-0.347	2.969	1.274
	(-1.090)	(0.332)	(-0.684)	(-1.585)	(-0.018)	(-1.148)	(-1.598)	(0.005)	(-1.090)	(-1.245)	(0.375)	(-0.555)	(-0.754)	(0.780)	(0.010)	(-0.160)	(1.160)	(0.516)
EPU	0.539	0.539	0.370	1.167	1.193	0.802	1.683	1.727	1.136	2.384	2.464	1.575	2.697	2.837	1.787	2.813	3.108	1.993
	(3.966)	(3.681)	(2.486)	(3.414)	(2.998)	(2.026)	(2.919)	(2.551)	(1.695)	(2.399)	(2.154)	(1.370)	(2.051)	(1.844)	(1.148)	(1.650)	(1.386)	(1.013)
CP	0.712			1.676			2.743			4.925			6.705			8.210		
	(4.786)			(4.447)			(4.257)			(4.094)			(3.800)			(3.375)		
$Cycle$		0.467			1.290			2.130			3.815			5.437			7.619	
		(1.982)			(2.153)			(2.212)			(2.315)			(2.438)			(2.352)	
$MacroU$			0.308			0.600			0.821			1.036			0.966			0.631
			(1.539)			(1.111)			(1.036)			(0.804)			(0.563)			(0.291)
$FinU$			0.147			0.314			0.454			0.565			0.474			0.075
			(0.749)			(0.606)			(0.575)			(0.439)			(0.283)			(0.034)
R^2	0.103	0.078	0.081	0.075	0.053	0.048	0.067	0.045	0.036	0.063	0.039	0.024	0.059	0.036	0.018	0.047	0.034	0.014

Notes: This table reports the coefficient estimates in a regression of the annualised bond excess returns on six n-month maturity bond ranging 12 to 120-month, with a holding period of 1 month. PCs are the first three principal components of Treasury yields representing the level, slope, and curvature of yield curve. EPU is economic policy uncertainty index of Baker et al. (2016). CP and $Cycle$ are the return forecastig factors from Cochrane and Piazzesi (2005) and Cieslak and Povala (2014), respectively. $MacroU$ is the macroeconomic uncertainty of Jurado et al. (2015) and $FinU$ is the financial uncertainty measure introduced by Ludvigson et al. (2017). All the dependant variables in the regression are standardised to have mean 0 and a standard deviation of 1. The values in parentheses are the Newey and West (1987) t-statistics with the optimal length determined based on Newey and West (1994). The sample period covers from 1985:01 to 2015:12.

Table 6: *EPU* Return Predictability with Additional Factors (3-month holding period)

	1y			2y			3y			5y			7y			10y		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
$PC1$	0.398	0.453	0.643	0.489	0.613	1.124	0.449	0.652	1.457	0.245	0.588	1.939	0.085	0.439	2.275	0.214	0.252	2.667
	(2.861)	(2.151)	(5.330)	(1.329)	(1.123)	(3.764)	(0.727)	(0.737)	(3.015)	(0.244)	(0.457)	(2.273)	(0.063)	(0.243)	(1.833)	(0.113)	(0.099)	(1.447)
$PC2$	0.176	-0.011	-0.219	0.376	-0.095	-0.678	0.489	-0.275	-1.210	0.602	-0.705	-2.319	0.457	-1.135	-3.381	-0.433	-1.763	-4.795
	(0.891)	(-0.044)	(-1.436)	(0.722)	(-0.153)	(-1.746)	(0.617)	(-0.285)	(-2.070)	(0.479)	(-0.501)	(-2.523)	(0.276)	(-0.600)	(-2.795)	(-0.194)	(-0.702)	(-2.946)
$PC3$	-0.046	-0.001	-0.158	-0.258	-0.127	-0.532	-0.456	-0.247	-0.873	-0.566	-0.201	-1.191	-0.311	0.220	-1.024	0.311	1.108	-0.351
	(-0.322)	(-0.008)	(-1.115)	(-0.743)	(-0.329)	(-1.760)	(-0.912)	(-0.418)	(-1.845)	(-0.711)	(-0.234)	(-1.539)	(-0.298)	(0.200)	(-1.001)	(0.228)	(0.789)	(-0.258)
EPU	0.350	0.367	0.234	0.629	0.681	0.333	0.748	0.831	0.287	0.814	0.960	0.126	0.730	0.953	-0.024	0.379	0.750	-0.243
	(3.924)	(3.449)	(1.947)	(2.554)	(2.184)	(0.969)	(1.741)	(1.542)	(0.507)	(1.142)	(0.984)	(0.131)	(0.786)	(0.728)	(-0.019)	(0.317)	(0.451)	(-0.153)
CP	0.551			1.475			2.382			4.105			5.398			6.135		
	(3.525)			(3.467)			(3.534)			(3.760)			(3.635)			(2.914)		
$Cycle$		0.386			1.091			1.757			3.044			4.246			5.738	
		(1.327)			(1.488)			(1.538)			(1.826)			(1.848)			(1.869)	
$MacroU$			0.319			0.703			1.003			1.338			1.356			1.077
			(1.599)			(1.470)			(1.351)			(1.158)			(0.916)			(0.552)
$FinU$			0.084			0.244			0.400			0.577			0.543			0.216
			(0.416)			(0.506)			(0.524)			(0.474)			(0.343)			(0.104)
R^2	0.194	0.173	0.186	0.138	0.118	0.120	0.124	0.104	0.100	0.121	0.100	0.085	0.117	0.100	0.074	0.100	0.098	0.065

Notes: This table reports the coefficient estimates in a regression of the annualised bond excess returns on six n-month maturity bond ranging 12 to 120-month, with a holding period of 3 months. PCs are the first three principal components of Treasury yields representing the level, slope, and curvature of yield curve. EPU is economic policy uncertainty index of Baker et al. (2016). CP and $Cycle$ are the return forecastig factors from Cochrane and Piazzesi (2005) and Cieslak and Povala (2014), respectively. $MacroU$ is the macroeconomic uncertainty of Jurado et al. (2015) and $FinU$ is the financial uncertainty measure introduced by Ludvigson et al. (2017). All the dependant variables in the regression are standardised to have mean 0 and a standard deviation of 1. The values in parentheses are the Newey and West (1987) t-statistics with the optimal length determined based on Newey and West (1994). The sample period covers from 1985:01 to 2015:12.

Table 7: EPU Return Predictability with Additional Factors

	1y	2y	3y	5y	7y	10y
	1-month holding period					
$PC1$	0.461	0.432	0.227	-0.505	-1.406	-2.508
	(2.155)	(0.738)	(0.239)	(-0.305)	(-0.568)	(-0.830)
$PC2$	0.337	0.832	1.385	2.580	3.649	4.709
	(1.407)	(1.306)	(1.364)	(1.517)	(1.522)	(1.565)
$PC3$	-0.141	-0.445	-0.666	-0.598	0.106	1.654
	(-0.819)	(-1.168)	(-1.132)	(-0.588)	(0.071)	(0.754)
EPU	0.510	1.184	1.786	2.803	3.580	4.488
	(3.266)	(2.824)	(2.449)	(2.238)	(2.094)	(1.975)
CP	0.626	1.515	2.549	4.782	6.717	8.485
	(4.257)	(3.860)	(3.804)	(3.737)	(3.442)	(2.954)
$Cycle$	0.329	1.020	1.750	3.335	5.026	7.526
	(1.385)	(1.723)	(1.847)	(2.019)	(2.222)	(2.603)
$MacroU$	0.122	0.148	0.060	-0.392	-1.046	-1.925
	(0.639)	(0.281)	(0.070)	(-0.277)	(-0.531)	(-0.813)
$FinU$	0.110	0.188	0.237	0.151	-0.162	-0.913
	(0.542)	(0.365)	(0.292)	(0.114)	(-0.095)	(-0.419)
R^2	0.107	0.079	0.071	0.069	0.066	0.057
	3-month holding period					
$PC1$	0.430	0.560	0.547	0.302	-0.088	-0.564
	(1.957)	(1.253)	(0.731)	(0.186)	(-0.039)	(-0.177)
$PC2$	0.125	0.213	0.220	0.231	0.257	0.075
	(0.431)	(0.366)	(0.232)	(0.129)	(0.107)	(0.023)
$PC3$	-0.145	-0.453	-0.737	-0.925	-0.586	0.420
	(-0.998)	(-1.355)	(-1.427)	(-1.192)	(-0.603)	(0.326)
EPU	0.328	0.588	0.700	0.873	1.060	1.255
	(2.462)	(1.663)	(1.164)	(0.750)	(0.697)	(0.663)
CP	0.325	0.740	1.162	2.021	2.757	3.277
	(1.924)	(1.868)	(1.748)	(1.896)	(1.880)	(1.528)
$Cycle$	0.282	0.852	1.399	2.570	3.825	5.607
	(0.995)	(1.355)	(1.411)	(1.539)	(1.715)	(1.911)
$MacroU$	0.202	0.444	0.610	0.699	0.521	0.115
	(1.102)	(0.903)	(0.776)	(0.563)	(0.313)	(0.050)
$FinU$	0.052	0.133	0.210	0.207	-0.026	-0.642
	(0.260)	(0.284)	(0.290)	(0.163)	(-0.016)	(-0.302)
R^2	0.217	0.151	0.132	0.121	0.116	0.106

Notes: This table reports the coefficient estimates in a regression of the annualised bond excess returns on six n-month maturity bond ranging 12 to 120-month, with a holding period of 1 and 3 months. PCs are the first three principal components of Treasury yields representing the level, slope, and curvature of yield curve. EPU is economic policy uncertainty index of Baker et al. (2016). CP and $Cycle$ are the return forecastig factors from Cochrane and Piazzesi (2005) and Cieslak and Povala (2014), respectively. $MacroU$ is the macroeconomic uncertainty of Jurado et al. (2015) and $FinU$ is the financial uncertainty measure introduced by Ludvigson et al. (2017). All the dependant variables in the regression are standardised to have mean 0 and a standard deviation of 1. The values in parentheses are the Newey and West (1987) t-statistics with the optimal length determined based on Newey and West (1994). The sample period covers from 1985:01 to 2015:12.

Table 8: J-test for Model Specification

	1y	2y	3y	5y	7y	10y
	Panel A. Test for M1					
$PC1$	0.453	0.547	0.411	-0.188	-0.228	1.296
	(1.432)	(0.729)	(0.339)	(-0.092)	(-0.085)	(0.371)
$PC2$	0.243	0.456	0.710	1.209	1.282	0.457
	(1.063)	(0.798)	(0.781)	(0.826)	(0.678)	(0.192)
$PC3$	-0.201	-0.666	-1.089	-1.524	-1.303	-0.283
	(-1.102)	(-1.555)	(-1.588)	(-1.322)	(-0.837)	(-0.130)
CP	0.634	1.496	2.391	4.139	5.957	8.533
	(3.200)	(3.171)	(2.995)	(2.612)	(2.417)	(2.332)
EPU	0.543	1.178	1.704	2.432	2.743	2.793
	(3.956)	(3.458)	(2.960)	(2.422)	(2.077)	(1.500)
$\widehat{rx}_{M1}$	0.224	0.517	1.016	2.268	2.159	-0.933
	(0.427)	(0.442)	(0.537)	(0.671)	(0.448)	(-0.142)
R^2	0.101	0.072	0.065	0.062	0.056	0.045
	Panel B. Test for M2					
$PC1$	0.023	-0.369	-0.765	-1.416	-1.887	-2.289
	(0.129)	(-0.754)	(-0.995)	(-1.056)	(-0.972)	(-0.834)
$PC2$	-0.013	-0.156	-0.348	-0.840	-1.380	-2.156
	(-0.090)	(-0.400)	(-0.568)	(-0.824)	(-1.000)	(-1.201)
$PC3$	0.004	-0.203	-0.361	-0.304	0.167	1.104
	(0.026)	(-0.543)	(-0.614)	(-0.300)	(0.116)	(0.533)
$PC4$	0.020	0.290	0.585	0.920	0.818	0.124
	(0.130)	(0.870)	(1.155)	(1.102)	(0.719)	(0.080)
$PC5$	-0.050	-0.046	-0.181	-0.829	-1.374	-1.412
	(-0.360)	(-0.125)	(-0.305)	(-0.844)	(-1.059)	(-0.833)
$\widehat{rx}_{M2}$	0.961	2.149	3.238	5.042	6.432	7.978
	(5.780)	(3.945)	(3.559)	(3.070)	(2.691)	(2.409)
R^2	0.101	0.074	0.067	0.062	0.055	0.042

Notes: This table reports model specification results based on the J-test proposed by Davidson and Mackinnon (1981, 1993). We compare two non-nested models described as

$$M1: \; rx_{t+1}^{(n)} = \gamma_0^{(n)} + \gamma_1^{(n)} PC_t^{1,\dots,5} + \varepsilon_{t+1}^{(n)} \quad and$$

$$M2: \; rx_{t+1}^{(n)} = \beta_0^{(n)} + \beta_1^{(n)} PC_t^{1,2,3} + \beta_2^{(n)} CP_t + \beta_3^{(n)} EPU_t + \eta_{t+1}^{(n)},$$

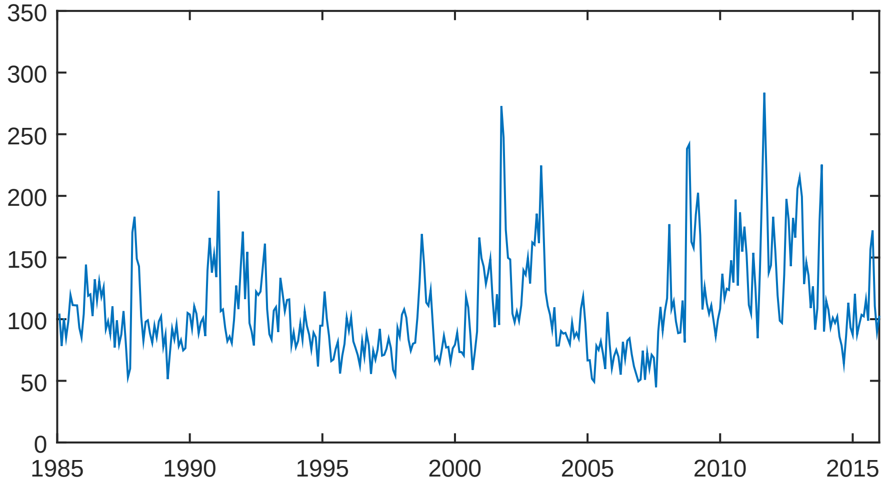
where model 1 ($M1$) uses the first five PCs of interest rates, whilst model 2 ($M2$) has the first three PCs, CP, and EPU as bond return forecasting factos. CP is the return forecastig factor from Cochrane and Piazzesi (2005) and EPU is economic policy uncertainty index of Baker et al. (2016). J-test adds the fitted value from one model ($\widehat{rx}_{M1}{}_{t+1}^{(n)}$ and $\widehat{rx}_{M2}{}_{t+1}^{(n)}$) into the other one and examines the significance of the additional regressor using the t-test. All the dependant variables in the initial regressions are standardised to have mean 0 and a standard deviation of 1. The values in parentheses are the Newey and West (1987) t-statistics with the optimal length determined based on Newey and West (1994). The sample period covers from 1985:01 to 2015:12.

Table 9: Pricing Errors

	12m	24m	36m	60m	84m	120m
	Panel A. Yield Pricing Error (Yield-Plus Model)					
	12m	24m	36m	60m	84m	120m
Mean	0.092	0.111	0.080	-0.020	-0.069	-0.005
Std. Dev.	0.121	0.091	0.040	0.084	0.096	0.067
Skewness	0.261	1.191	0.781	-0.471	-0.496	0.284
Kurtosis	6.124	6.065	5.235	4.572	3.581	5.729
AC(1)	0.826	0.945	0.780	0.938	0.980	0.806
AC(6)	0.669	0.801	0.589	0.817	0.908	0.570
	Panel B. Yield Pricing Error (Yield-Only Model)					
Mean	0.110	0.053	0.031	0.016	0.007	-0.002
Std. Dev.	0.094	0.031	0.017	0.007	0.012	0.019
Skewness	0.776	-0.095	-0.040	-0.555	-0.941	-0.279
Kurtosis	4.182	3.282	4.932	3.432	6.775	3.392
AC(1)	0.953	0.967	0.825	0.811	0.793	0.788
AC(6)	0.787	0.877	0.628	0.580	0.591	0.566
	Panel C. Return Pricing Error (Yield-Plus Model)					
Mean	0.006	0.009	-0.005	-0.020	-0.011	0.040
Std. Dev.	0.094	0.081	0.095	0.158	0.143	0.416
Skewness	0.245	0.892	-0.576	-0.854	-1.090	0.864
Kurtosis	8.632	11.820	7.930	10.161	17.955	9.931
AC(1)	-0.067	-0.096	-0.169	0.023	0.188	-0.187
AC(6)	0.144	0.003	0.112	0.046	-0.003	0.035
	Panel D. Return Pricing Error (Yield-Only Model)					
Mean	0.002	-0.001	-0.001	-0.001	-0.002	-0.001
Std. Dev.	0.061	0.058	0.064	0.063	0.082	0.133
Skewness	-0.498	-0.733	-0.501	-0.598	-0.545	-0.017
Kurtosis	9.929	9.314	7.689	8.225	10.728	9.476
AC(1)	-0.035	0.086	0.064	0.135	-0.036	-0.144
AC(6)	0.074	0.010	0.002	0.056	0.044	0.028

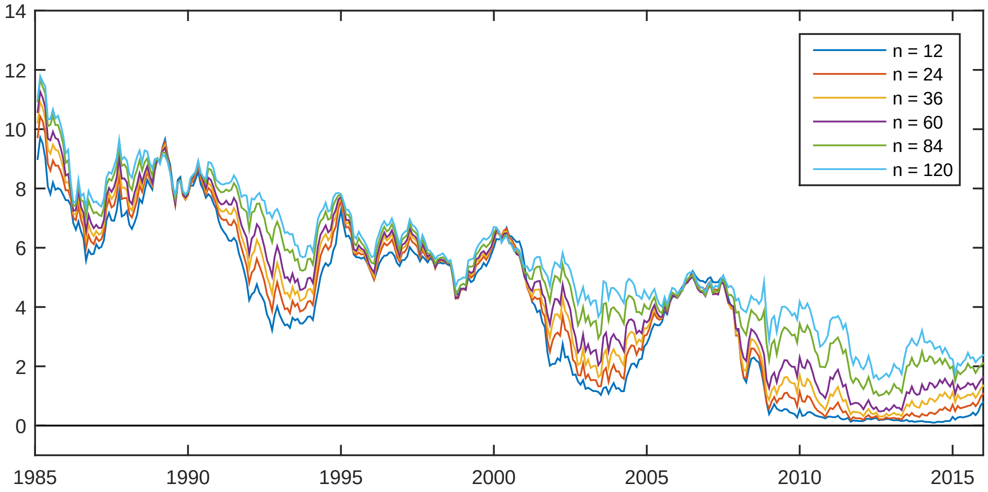
Notes: This table reports the pricing errors from the term structure estimation following Yield-Plus and Yield-Only approaches. The pricing factors for the former include the first three principal components of Treasury yields, Cochrane and Piazzesi (2005)'s return forecasting factor, and the economic policy uncertainty index by Baker et al. (2016), whilst those for the latter include the first five principal components of Treasury yields. Panel A and B show the yield pricing error $\hat{u}^{(n)}$ and Panel C and D show the return pricing error $\hat{e}^{(n)}$.

Figure 1: Economic Policy Uncertainty



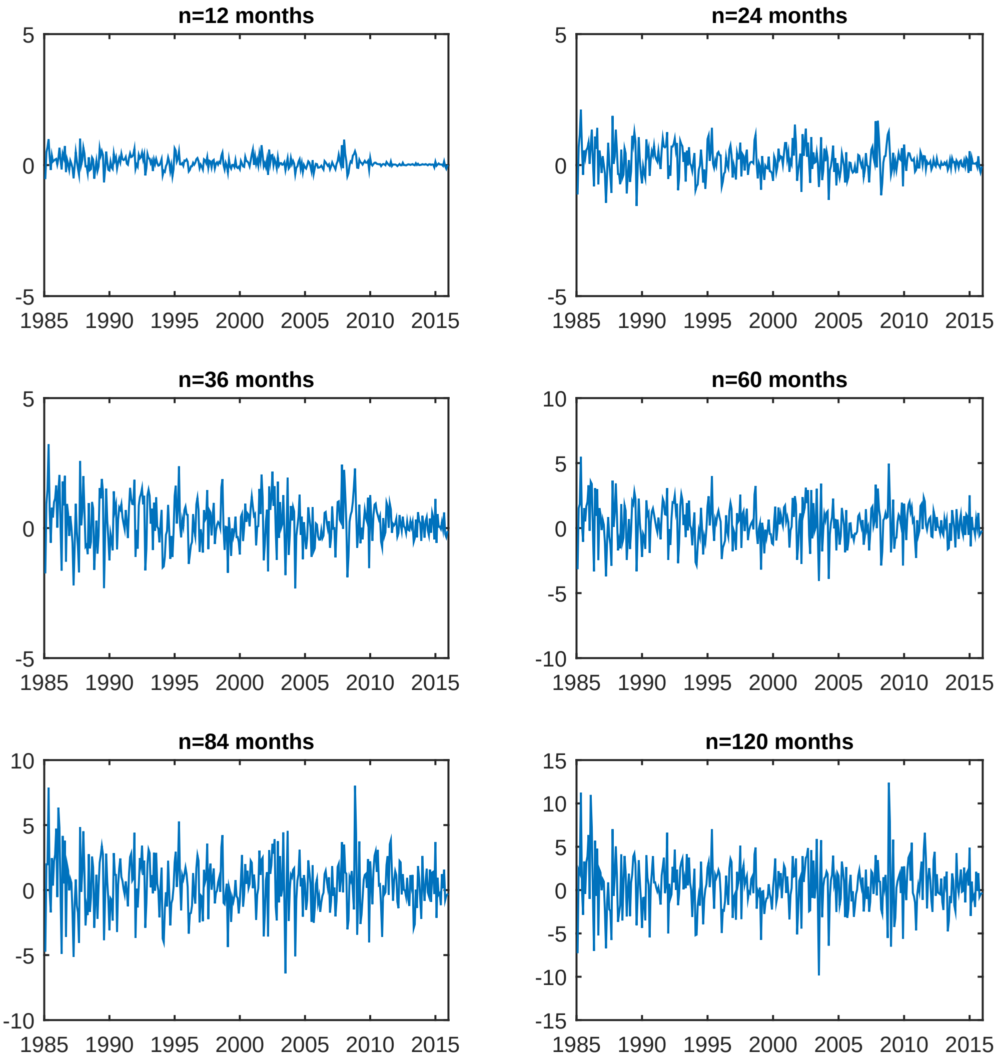
Notes: This figure plots monthly Economic Policy Uncertainty index constructed by Baker et al. (2016). The sample period covers from 1985:01 to 2015:12 and the series is normalised to have a mean of 100.

Figure 2: Treasury Bond Yields



Notes: This figure plots time series of Treasury bond yields (in percentage) for selective maturities (n) ranging from 12 months to 120 months. Sample period is from 1985:01 to 2015:12.

Figure 3: Treasury Bond Excess Returns (1-month holding period)

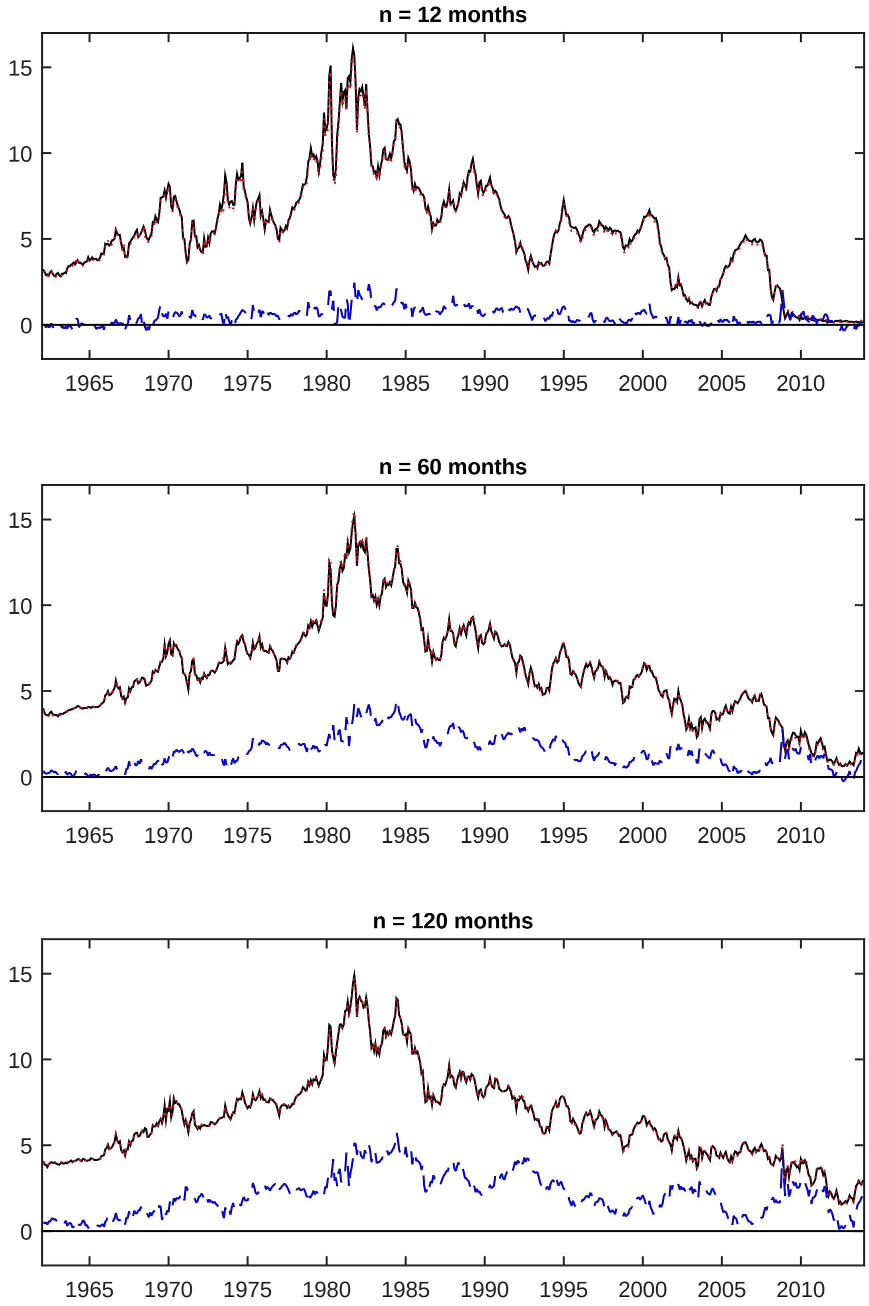


Notes: This figure plots time series of bond monthly bond excess returns (in percentage) for selective maturities (n) ranging from 12 months to 120 months. Monthly bond excess returns are constructed from Treasuries with maturity (n):

$$rx_{t+1}^{(n)} = r_{t+1}^{(n)} - y_t^{(1)},$$

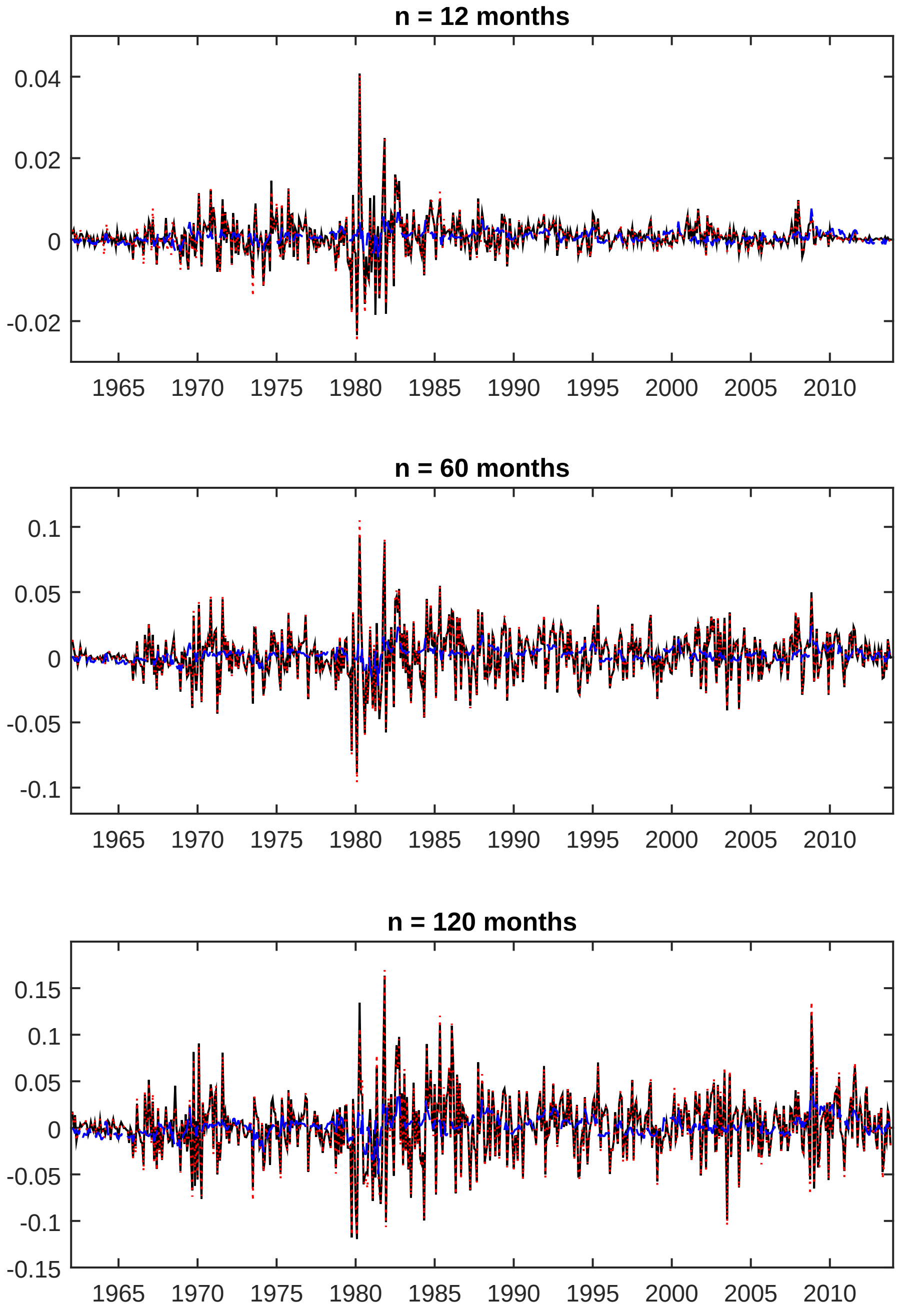
where $r_{t+1}^{(n)}$ is the log return holding n-month bond ($r_{t+1}^{(n)} = p_{t+1}^{(n-1)} - p_t^{(n)}$). Sample period is from 1985:01 to 2015:12.

Figure 4: Fitted Yields and Term Premia (Yield-Plus model)



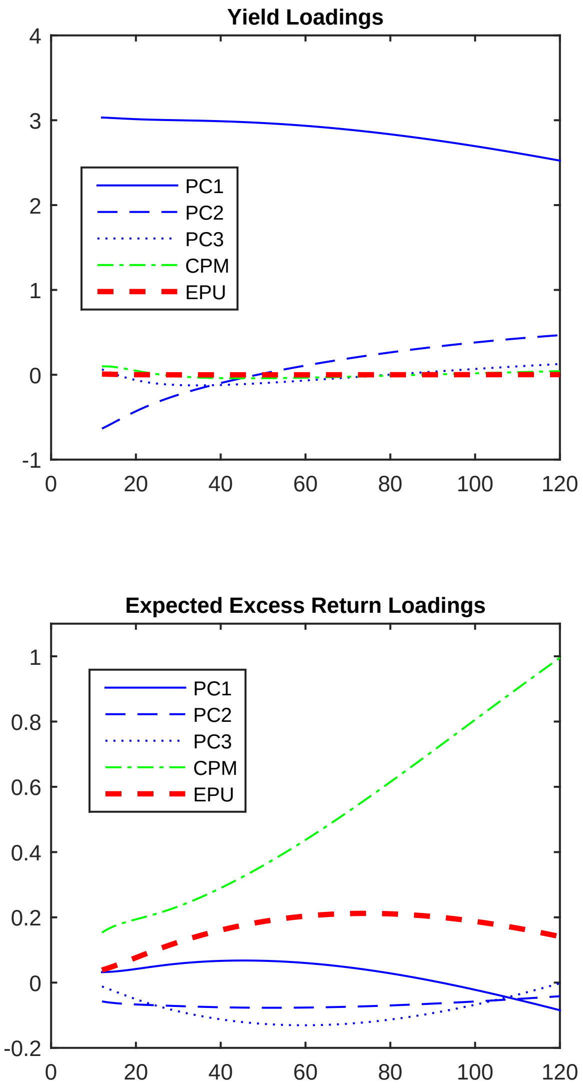
Notes: This figure plots the actual and fitted yields and term premia estimates for 12, 60, and 120 months maturities. The observed yields are plotted with solid line and dotted line show fitted yields. The model implied term premia for corresponding maturities are plotted by dashed lines.

Figure 5: Observed and Model-Implied Excess Returns (Yield-Plus model)



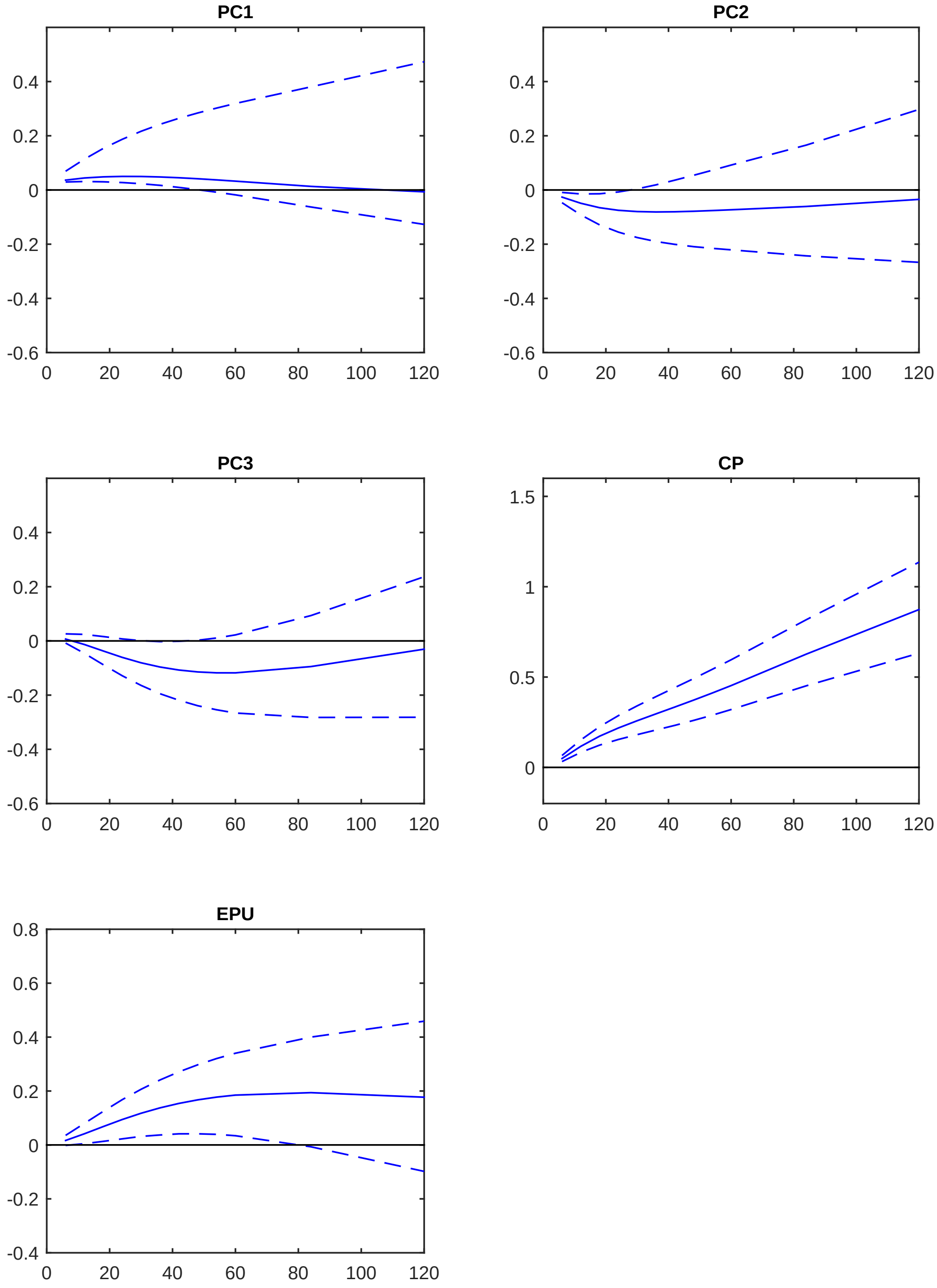
Notes: This figure plots the actual and fitted yields and term premia estimates for 12, 60, and 120 months maturities. The observed yields are plotted with solid line and dotted line show fitted yields. The model implied term premia for corresponding maturities are plotted by dashed lines.

Figure 6: Factor Loadings (Yield-Plus model)



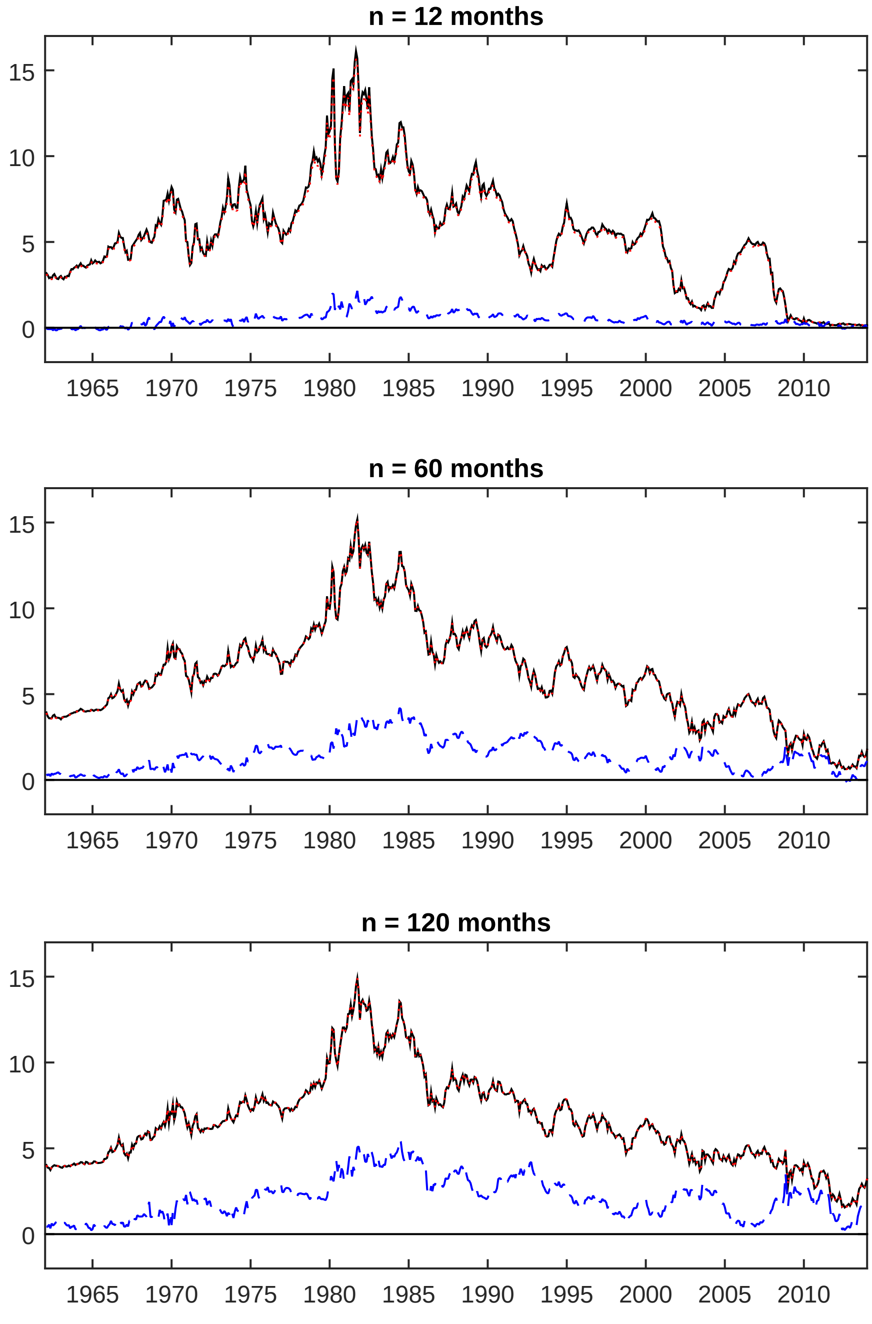
Notes: This figure plots the model implied loadings for yields and excess returns. The upper panel shows the loadings ($b_n = -\frac{1}{n}B_n$) for yields across 12 to 120-month maturities. The lower panel plots the loadings ($B_n'\lambda_1$) for expected one month holding period excess returns for the same maturities. Factors are the first three principal components of Treasury yields, Cochrane and Piazzesi (2005)'s return forecasting factor, and Economic Policy Uncertainty of Baker et al. (2016). Sample period is from 1962:01 to 2013:12.

Figure 7: Factor Loadings with Confidence Intervals (Yield-Plus model)



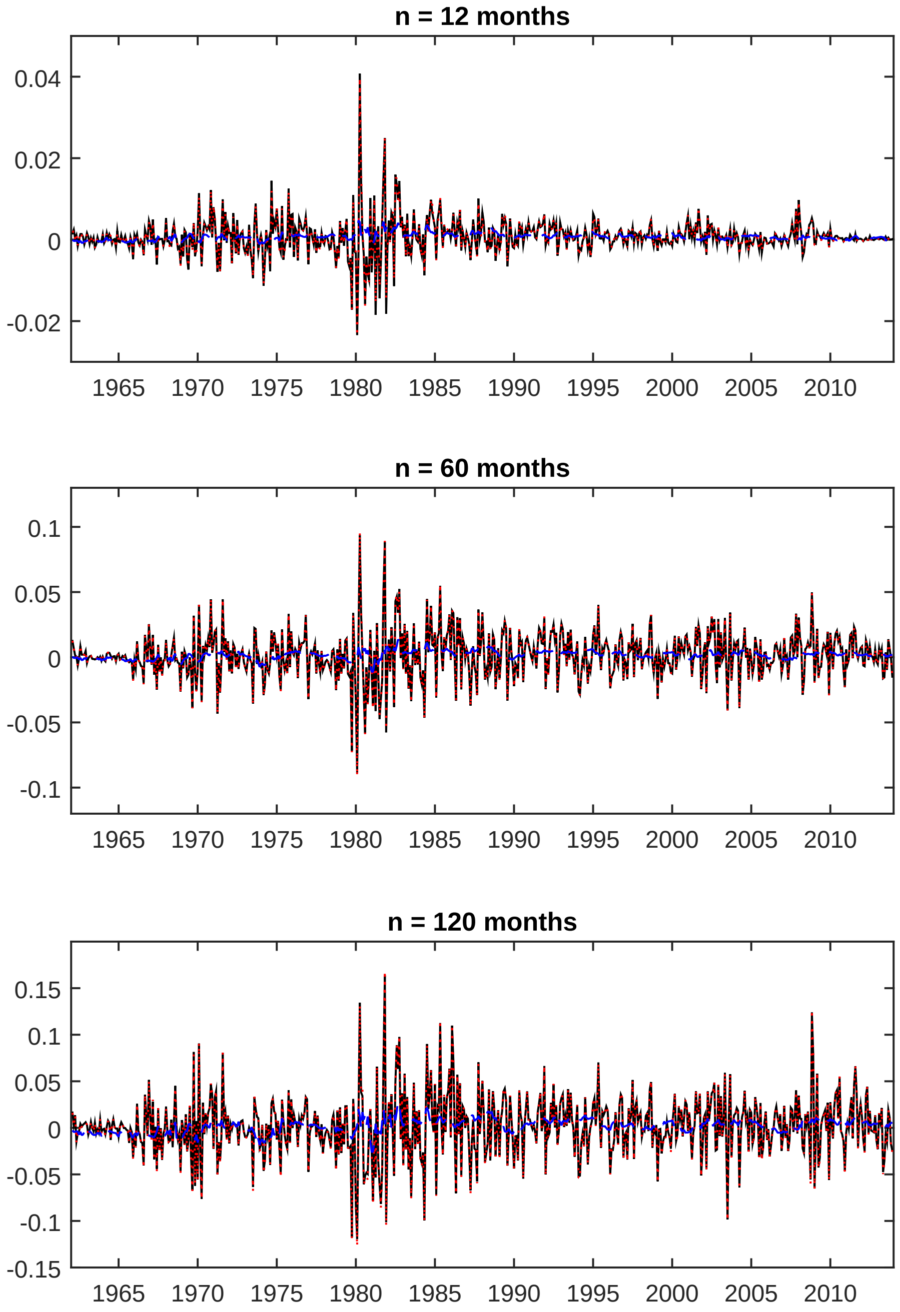
Notes: This figure plots the model implied loadings for excess returns with 90% confidence intervals for the factor loadings. Conficence intervals are calculated using a bootstrap procedure introduce by Malik and Meldrum (2016) with 10,000 replications. Factors are the first three principal components of Treasury yields, Cochrane and Piazzesi (2005)'s return forecasting factor, and Economic Policy Uncertainty of Baker et al. (2016). Sample period is from 1962:01 to 2013:12.

Figure 8: Fitted Yields and Term Premia (Yield-Only model)



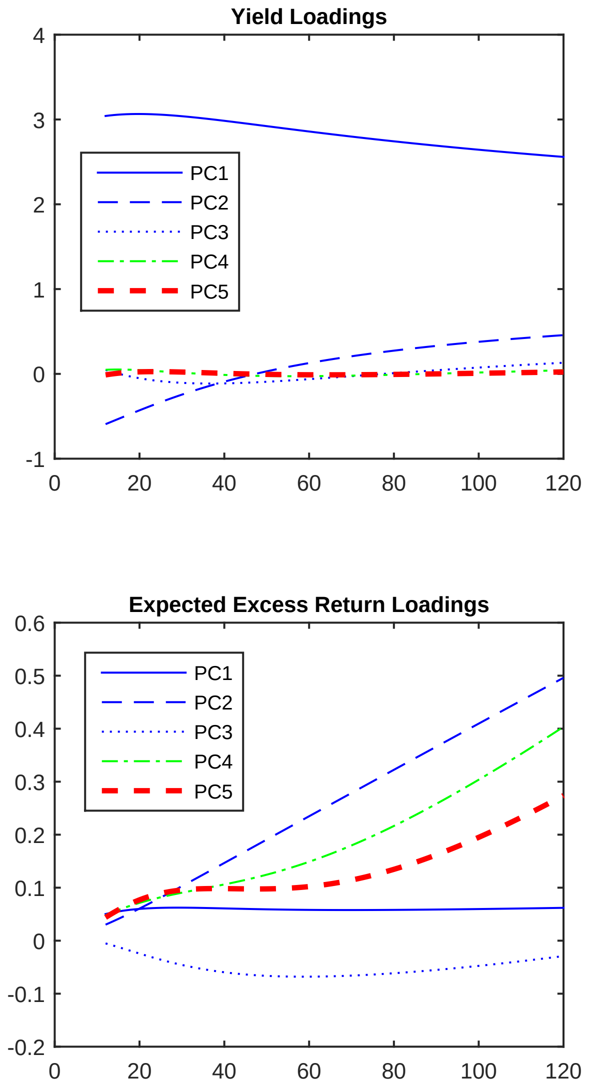
Notes: This figure plots the actual and fitted excess returns for 12, 60, and 120 months maturities. The observed monthly excess returns are plotted with solid line and dotted line show model implied returns. The expected components of excess returns for corresponding maturities are plotted by dashed lines.

Figure 9: Observed and model-implied excess returns (Yield-Only model)



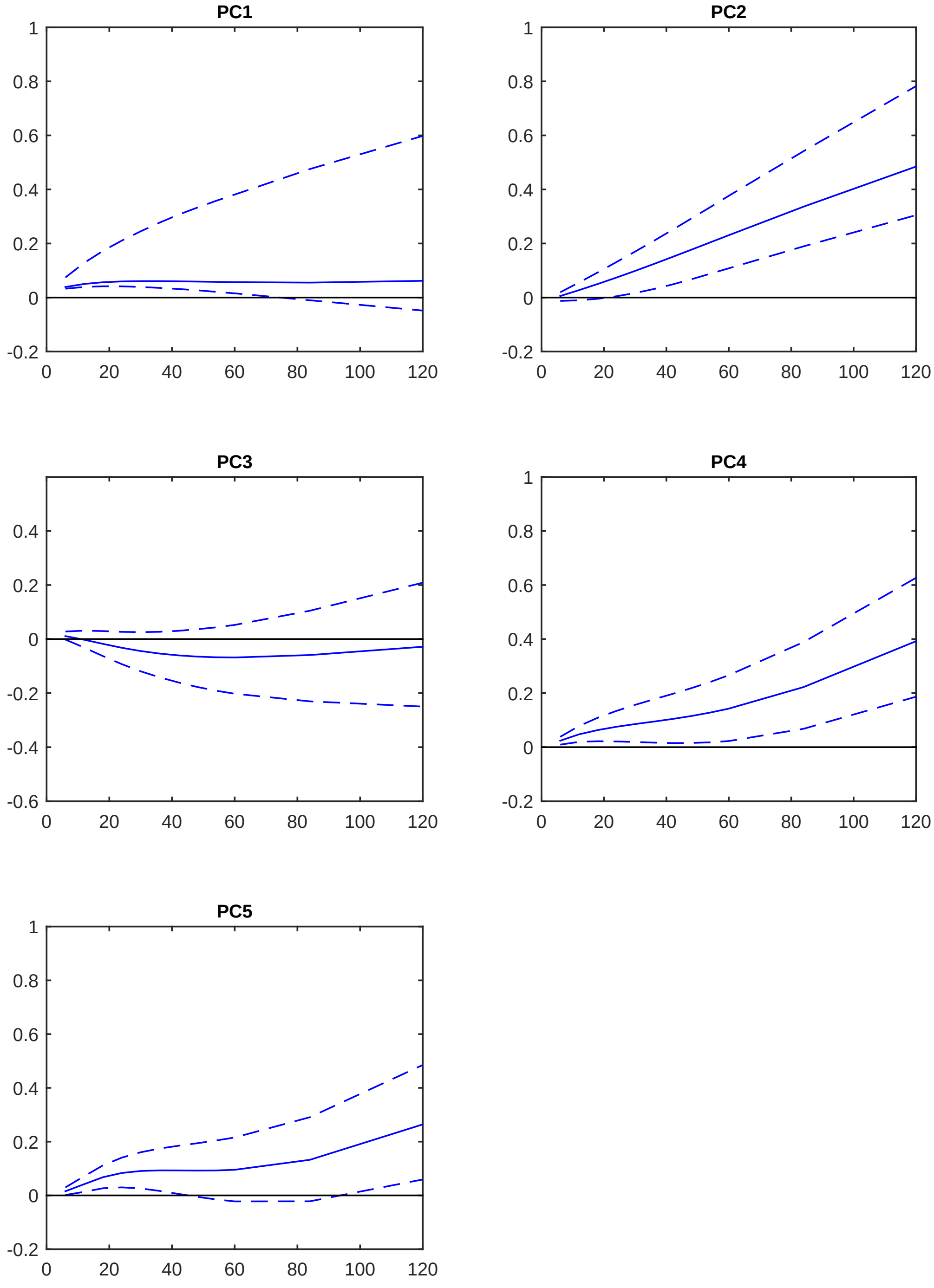
Notes: This figure plots the actual and fitted excess returns for 12, 60, and 120 months maturities. The observed monthly excess returns are plotted with solid line and dotted line show model implied returns. The expected components of excess returns for corresponding maturities are plotted by dashed lines.

Figure 10: Factor Loadings (Yield-Only model)



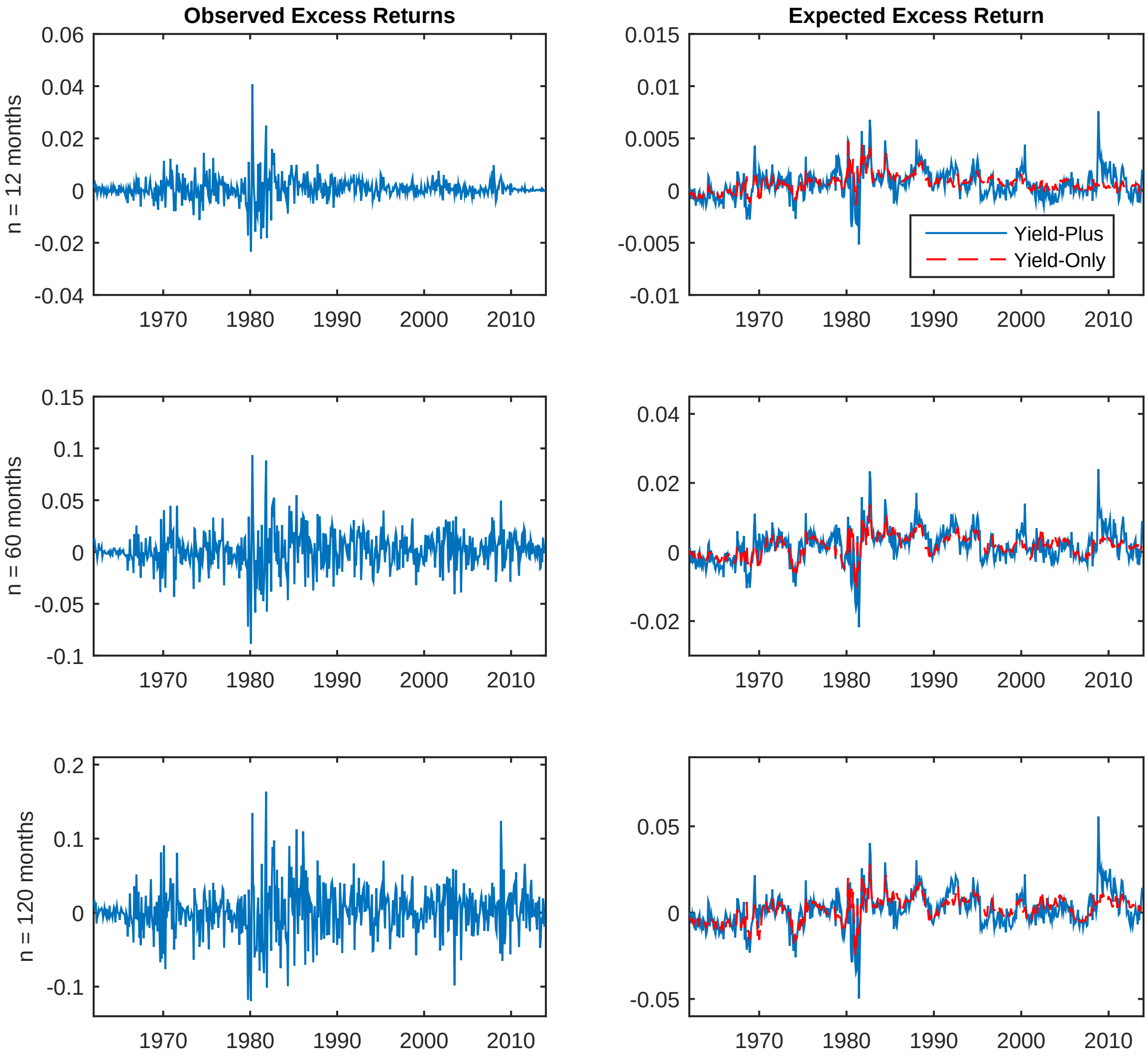
Notes: This figure plots the model implied loadings for yields and excess returns. The upper panel shows the loadings ($b_n = -\frac{1}{n}B_n$) for yields across 12 to 120-month maturities. The lower panel plots the loadings ($B_n'\lambda_1$) for expected one month holding period excess returns for the same maturities. Factors are the first five principal components of Treasury yields. Sample period is from 1962:01 to 2013:12.

Figure 11: Factor Loadings with Confidence Intervals (Yield-Only model)



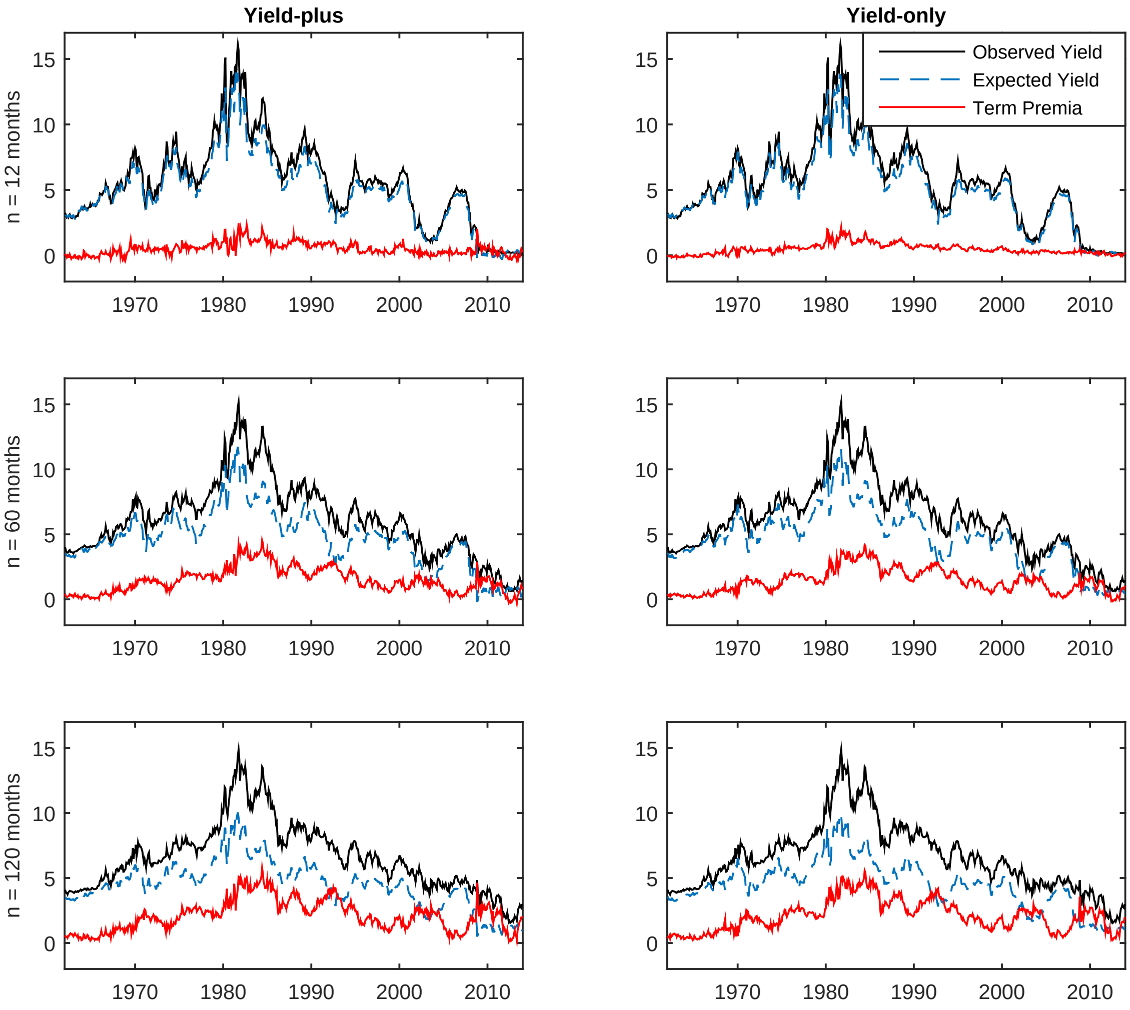
Notes: This figure plots the model implied loadings for excess returns with 90% confidence intervals for the factor loadings. Conficence intervals are calculated using a bootstrap procedure introduce by Malik and Meldrum (2016) with 10,000 replications. Factors are the first five principal components of Treasury yields Sample period is from 1962:01 to 2013:12.

Figure 12: Observed and Expected Returns



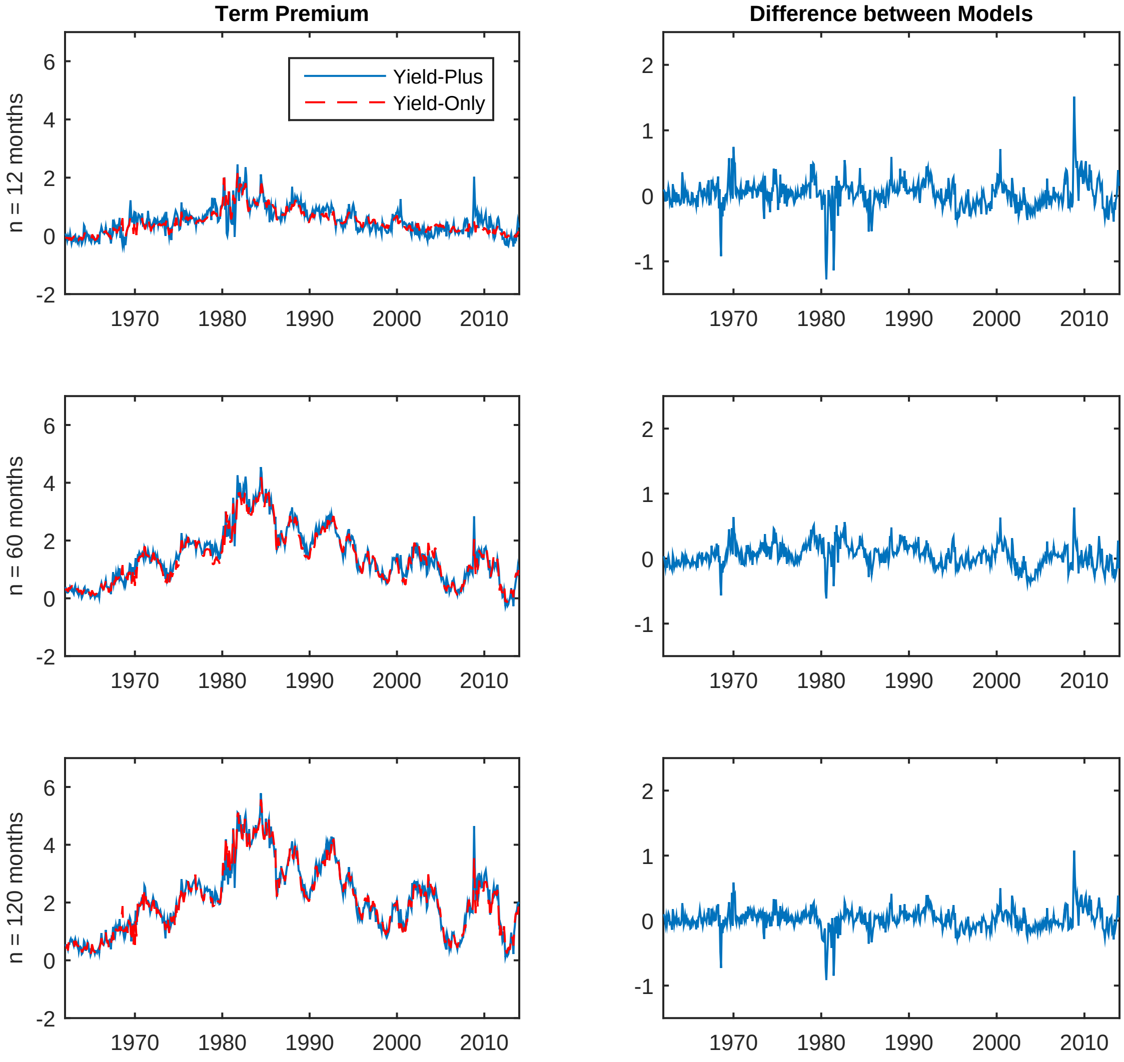
Notes: This figure plots excess holding period returns for 12, 60, and 120-month maturities. The left column shows observed excess returns and the right column shows model implied expected excess returns. The solid lines plot the expected excess return estimated using Yield-Plus model with the factors comprising the first three principal components of Treasury yields, Cochrane and Piazzesi (2005)'s monthly return forecasting factors, and the index of Economic Policy Uncertainty constructed by Baker et al. (2016). The dashed lines plot the expected returns estimated using Yield-Only model with the factors of the first five principal components of Treasury yields. Sample period is from 1962:01 to 2013:12.

Figure 13: Expected Yields and Term Premia



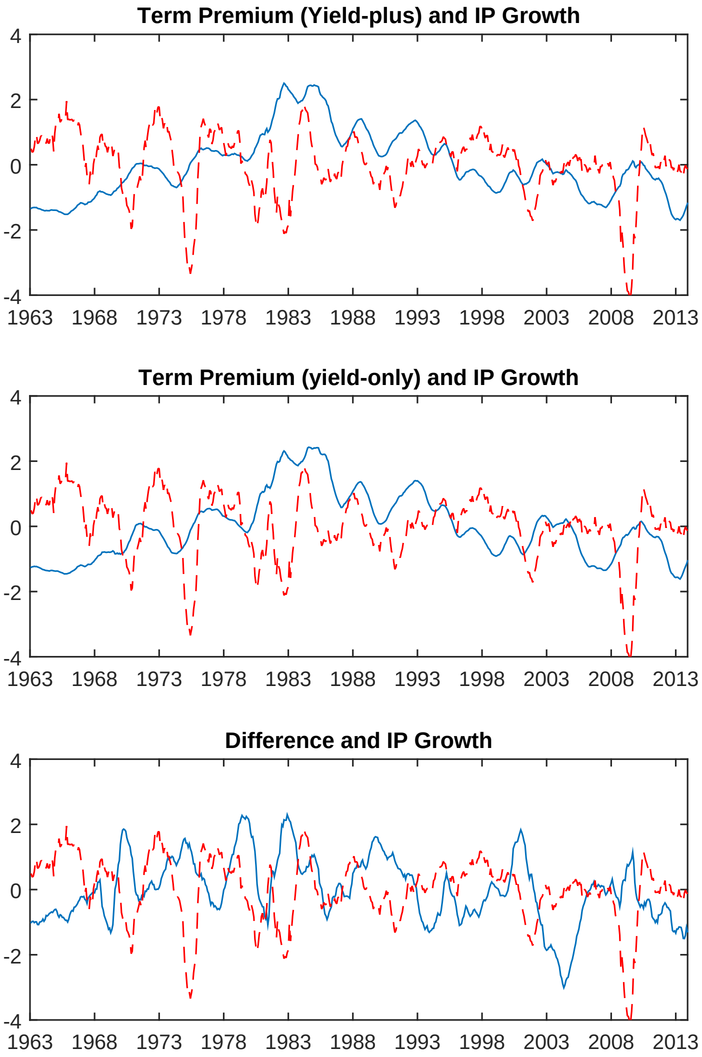
Notes: This figure plots observed yields (solid lines), model implied expected yields (dashed lines) and term premia (solid lines below) for 12, 60, and 120-month maturities. The two components of yields in the left column are estimated using Yield-Plus model and those of in the right column are estimated using Yield-Only model model. Yield-Plus model uses the factors comprising the first three principal components of Treasury yields, Cochrane and Piazzesi (2005)'s monthly return forecasting factors, and the index of Economic Policy Uncertainty constructed by Baker et al. (2016). The Yield-Only model uses the factors of the first five principal components of Treasury yields. Sample period is from 1962:01 to 2013:12.

Figure 14: Term Premia Estimates



Notes: This figure plots model implied term premia for 12, 60, and 120-month maturities. In the left column, the solid line plots the term premia estimated using yield-Plus model and the dashed line plots the term premia estimated using Yield-Only model model. Yield-Plus model uses the factors comprising the first three principal components of Treasury yields, Cochrane and Piazzesi (2005)'s monthly return forecasting factors, and the index of Economic Policy Uncertainty constructed by Baker et al. (2016). The Yield-Only model uses the factors of the first five principal components of Treasury yields. The right column plots the difference of the estimated term premia between the two models. Sample period is from 1962:01 to 2013:12.

Figure 15: Term Premia and Industrial Production Growth



Notes: This figure plots compare two term premia estimates for 60-month maturity from Yield-Plus and Yield-Only models with industrial production growth. The solid line of the figure in the third row illustrates the difference of model implied term premia (Yield-Plus−Yield-Only). The dashed lines are monthly industrial production growth. All the series are the 12-month moving averages of the corresponding data and are standardised for easier comparison.