ERASMUS UNIVERSITY ROTTERDAM

Erasmus School of Economics

Bachelor Thesis International Bachelor Economics and Business Economics (IBEB)

The development of term premia over time.

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1. Introduction

In 1987 Eugene F. Fama and Robert R. Bliss presented *The Information in Long-Maturity Forward Rates*. In this study, they made some novel findings on the relationship between the forward spread, which is the difference between the forward rate and the interest rate on a bond, and the 1- to 5-year expected returns for U.S. Treasury, measured as the excess of the expected return on top of the interest rate on a 1-year bond. Fama & Bliss (1987) concluded that there is an existence of a term-premium during the 1964-85 period and its variation can be attributed to business cycles. The result of the of these term premia can be found in Table 11 (See Appendix A).

Thirty-two years has passed since the publication of the Fama-Bliss regression and it would be expected that investors and firms would take advantage of this available term premium by arbitraging it away. Imakubo & Nakajima (2015) decomposed bond yields into: [1] expected real rates, [2] real term premia, [3] expected inflation rates and [4] inflation risk premia and found that U.S. yields are driven mainly by the term premia and the expected real rates. They state that the real term premium contains the real-term interest-rate risk, investors' preference for safer assets and other factors such as Central Banks' policy.

Fama and Bliss found that there is a term premium consistently and that the premium varies over time (Table 11, Appendix A). In fact, it varies with the forward rates, which is suggestive of some predictable mean reversion that the market is not arbitraging away. This Bachelor Thesis will look to replicate this Fama-Bliss regression by validating it with a more current extensive dataset. This thesis will extend the original used data (1964-85) to data from 1964 through 2018. Furthermore, data from the Euro area will also be tested to see if this regression produces a significant term premium for 1- to 5-year maturity AAA-rated euro area central government bonds and if this premium is comparable to the term premium for U.S. treasury bonds. This leads to the following research question:

To what extent has the term premium in treasury bonds changed compared to the period of 1964-85 and does the European Union show similar premia?

This research question will try to identify if there is a term premium in U.S. treasury bonds and AAA-rated euro area central government bonds and evaluate how the term premium has developed throughout both periods. Finally, it will look to determine if there might be better ways to estimate the term premium in bonds.

This thesis is of scientific relevance for different reasons. First, it contributes to existing literature as it tries to validate the findings by Fama and Bliss (1987). Next, this research can serve as a confirmation that the Fama & Bliss methodology is still applicable in current times while remaining accurate and reliable. Furthermore, this thesis tries to make a comparison between two periods of history and look for similarities or differences within term premia.

The remainder of this paper is structured as follows; the next chapter gives an overview on the literature of term structure of interest rate. Then, other theories will be introduced on the term premium and its development. Chapter three describes the data used for this research, consisting of the yield and forward rate data. The fourth chapter contains the empirical results, and the fifth chapter looks to answer the research question, presenting the limitations of the methodology and ideas for future research.

2. Literature review

2.1 Term structure of interest rates

There is an extensive amount of research on the term structure of interest rates on government bonds. This thesis will focus on two influential theories, that are both addressed by Fama & Bliss, the Expectations Theory (ET) and the Liquidity Preference Hypothesis (LPH).

Though the Expectations Theory theorizes that short-term interest rates can be inferred from long-term interest rates, the theory has different versions: pure, normal and weak. The Pure Expectations Hypothesis by Lutz (1940) gives an explanation on the association between maturity and the yield for bonds and states that there should be no excess return of long over short maturity bonds. It assumes that yields at higher maturities correspond exactly to future realized rates and are compounded from the yields on shorter maturities, thus there is no existence of a term premium. In other words, buying a twenty-year bond should be equal to buying two ten-year bonds in succession. Besides the Pure Expectations Hypothesis, there is also a Normal Expectations Theory, which incorporates risk and expects the term premium to be a non-zero constant. This term premium is constant over time. The Weak Expectations Hypothesis states that the term premium is non-constant but time-varying. Kim & Orphanides (2007) state that the weak version has a term premium that is a time-varying compensation for varying perceptions of uncertainty about inflation, real activity and monetary policy and could vary with the business cycle, as investors might be more risk-averse in recessions than in booms.

Hicks' Liquidity Preference Hypothesis (1946) states that expected returns on bonds should increase with maturity and thus it is also expected that the term premium is strictly increasing over time to maturity. The risk premium is the result of lesser liquidity of long maturity interest rate contracts, as well as the higher risk of default the more we delay the date of repayment. However, Ornelas & de Almeida (2015) state that it is difficult to isolate this term premium due to both the term premium and the market expectations for short-term interest rates are embedded in the yield of a bond.

Despite the abundance of available literature, Fama & Bliss (1987) conclude that their results from the 1964-85 period are inconsistent with both the expectations theory as well as the liquidity preference theory. They conclude that expected term premia seems to be related to the business cycle during the 1964-85 period. Expected term premia tend to be positive during good times while negative during bad times.

2.2 Term premia

Kim and Wright (2005) use a three-factor arbitrage-free term structure model of Kim and Orphanides (2004) to decompose yields on treasury bonds from July 1990 to July 2005. This model assumes that there are no arbitrage opportunities in the market and that the yield curve can be explained by the following three factors; expected future short-term interest rates, term premia and surveys of financial market participants. Theoretically, these factors can be interpreted as proxies for macroeconomic variables and for different characteristics of the yield curve, such as the slope. Furthermore, Kim and Wright (2005) also extend the model by adding inflation data to split term premia and expected future short rates into inflation and real components. Both the nominal and real model observe a decrease in longer-term yields as a result of a decline in term premium. Kim and Wright (2005) rationalize this decline by stating that investors are demanding smaller excess returns due to higher demand of longer-maturity securities relative to their supply. They trace this increased demand mainly due to:

(1) Less uncertainty involved in inflation expectations and a decrease in volatility.
(2) A larger proportion of Treasury securities bought by foreign official institutions.
(3) Corporate pension fund reform leading to portfolio shifts towards long-duration bonds.

Cohen et al (2018), look to compare term premia on ten-year US treasury bonds and ten-year euro area government bond yield by using three term structure models. These are the Kim and Wright (2005) factor model, the Hördahl and Tristani (2014) model and a model proposed in Adrian et al (2013). The Hördahl and Tristani model includes data on real and nominal yields while adding inflation, output gap and survey data on future inflation rates and future short-term interest rates. Adrian et al. model uses principal components of bond yields, which includes using time series data to generate other set of series. The three different methods all generate different term premia levels for US treasuries and can differ by as much as 200 basis points in some years. Despite this, all three models follow the same trend and correlate between each other with factors ranging from 77% to 92%. Cohen et al. state that the decline in term premia since the Great Financial Crisis is due to two main factors. First, there was reduced uncertainty in the projected short rates path because of better guidance and communication by the Federal Reserve (FED). Secondly, this decrease in term premia coincided with an increase in holdings of Treasuries by both the Federal Reserve and foreign officials, which can be attributed to a flight to safe assets.

In a recent report, Wells Fargo (2019) confirmed this theory by stating that the decrease in term premium is a direct result of the Quantitative Easing (QE) program, making the current yield curve more dynamic. Despite economic conditions, their report concludes that without the purchase of treasury securities by the Federal Reserve, we would be seeing a much higher yield on treasury bonds.

Like US Treasury yield, term premia for the euro area also differ depending on the model used but agree on the general trend. The euro area shows a larger decline in term premia compared to the US data and was heavily impacted by asset purchases by the domestic official sector.

Cohen et al. (2018) also conclude that term premia between the United States and the euro area tends to be highly correlated. Historically, this correlation has been above 0.5 and up to 0.93 at times. Despite this, the real rates and the expected inflation between the two areas have shown little correlation.

3. Data

This research uses a dataset of 1-, 2-, 3-, 4- and 5-year maturity for U.S. treasury bonds and AAA-rated euro area central government bonds. Data on the Yield for U.S. treasury bonds of 1- to 5-year are derived from the U.S. Government Bond File of the Center for Research in Security Prices (CRSP) of the University of Chicago and covers a period of 1964-2018. Data on the Yield for AAA-rated euro area central government bonds are collected from the Eurostat database and covers a period from 2006 to 2018. The frequency for all data is monthly. Summary statistics for both datasets can be found in table 1, for each maturity the amount of observations, mean, standard deviation, minimum and maximum is presented.

Table 1: Summary Statistics for U.S treasury bonds from 1964-2018

Maturity (years)	Observations	Mean	Standard deviation	Minimum	Maximum
1	660	5.153	3.322	.095	15.812
2	660	5.365	3.268	.205	15.639
3	660	5.552	3.183	.290	15.557
4	660	5.718	3.106	.428	15.824
5	660	5.833	3.027	.597	15.001

To test if the term premium observed by Fama & Bliss (1987) over the period 1964-85 is no longer present in the period 1985-2018 for U.S. treasury bonds and/or if it has remained the same over both periods, it is required that the dataset of 1964-2018 be divided in sub-sample 1 and sub-sample 2. Sub-sample 1 uses the same dataset as the original Fama-Bliss regression with data from 1964-85, while sub-sample 2 uses data from 1986-2018. Summary statistics for both sub-samples can be found in table 2&3.

Table 2: Summary Statistics for U.S treasury bonds from 1964-1985

Maturity (years)	Observations	Mean	Standard deviation	Minimum	Maximum
1	276	7.467	2.791	3.756	15.812
2	276	7.603	2.768	3.664	15.639
3	276	7.710	2.719	3.868	15.557
4	276	7.788	2.711	3.943	15.824
5	276	7.831	2.695	3.977	15.001

Table 3: Summary Statistics for U.S treasury bonds from 1986-2018

Maturity (years)	Observations	Mean	Standard deviation	Minimum	Maximum
1	384	3.491	2.601	.095	9.621
2	384	3.756	2.582	.205	9.518
3	384	4.001	2.522	.290	9.456
4	384	4.230	2.451	.428	9.341
5	384	4.397	2.369	.597	9.287

The third hypothesis involves a comparison of 1- to 5-year maturity AAA-rated euro area central government bonds and the U.S. treasury bonds to see if they show same term premia over the period 2006-2018. Summary statistics for both dataset within the period of 2006-2018 can be found in table 4&5.

Table 4: Summary Statistics for AAA-rated euro central government bonds from 2006-2018

Maturity (years)	Observations	Mean	Standard deviation	Minimum	Maximum
1	156	.849	1.630	-.84	4.43
2	156	.995	1.637	-.82	4.55
3	156	1.165	1.626	-.75	4.55
4	156	1.350	1.608	-.61	4.54
5	156	1.536	1.588	-.54	4.54

Table 5: Summary Statistics for U.S Treasury Bonds from 2006-2018

Maturity (years)	Observations	Mean	Standard deviation	Minimum	Maximum
1	156	1.322	1.591	.095	5.206
2	156	1.485	1.454	.205	5.079
3	156	1.711	1.348	.290	5.050
4	156	1.965	1.256	.428	5.017
5	156	2.189	1.175	.597	5.026

To give a visual representation on the data of U.S treasury bonds, Figure 1 illustrates a time series for 1- through 5-year yield on U.S Treasury Bonds. The time-series plot shows the time plot between the yield on different maturities (y-axis) in the observed month (x-axis). A reference line is added to denote the split between the two sub-samples, with the first (1964-1985) part being the original Fama-Bliss (1987) research and the second (1985-2018) part being the extended data to validate their research.

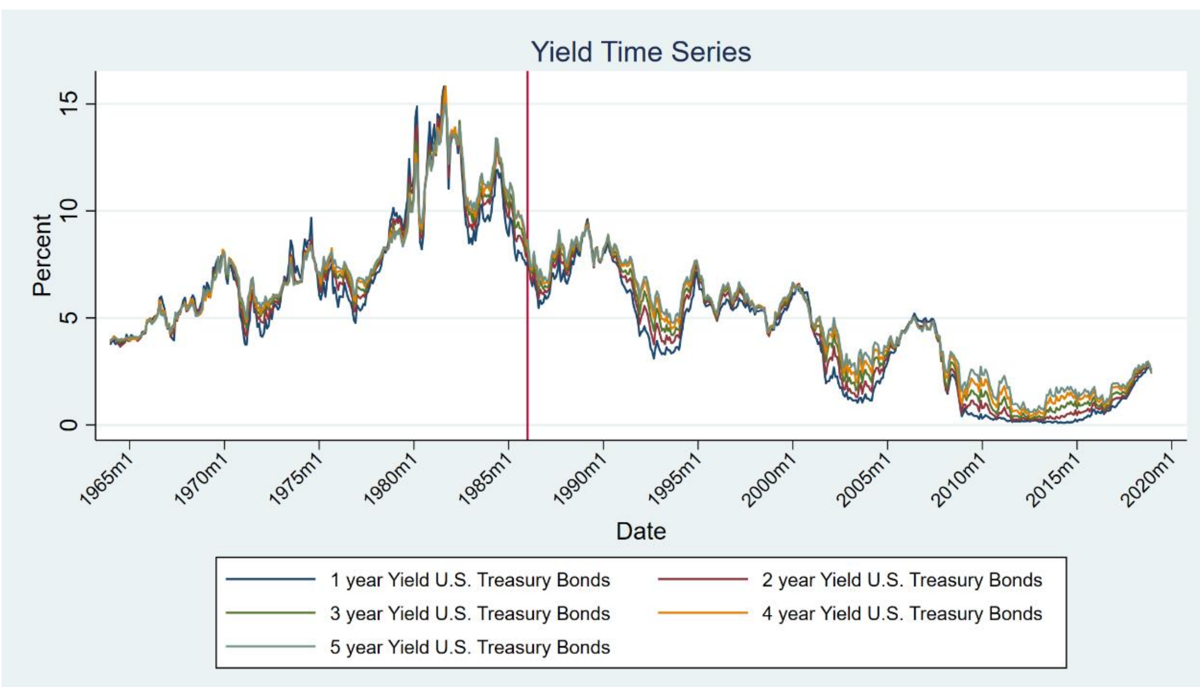

Figure 1: Time-Series plot on U.S Treasury Bonds

Figure 2 and 3 illustrate a time series for 1- through 5-year yield on the AAA-rated Euro Central Government bonds and U.S Treasury Bonds for the period 2006-2018, as tested in hypothesis 3. The time-series plot shows the time plot between the yield on different maturities for both bonds (y-axis) in the observed month (x-axis), which is kept constant from 2006-2018.

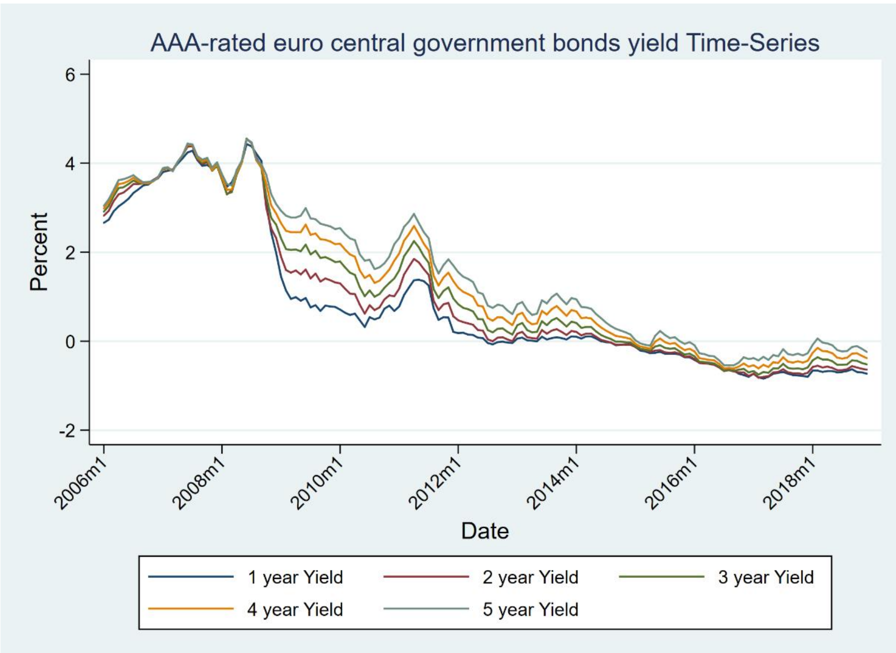

Figure 2: Time-Series plot on AAA-rated Euro Central Government bonds yields

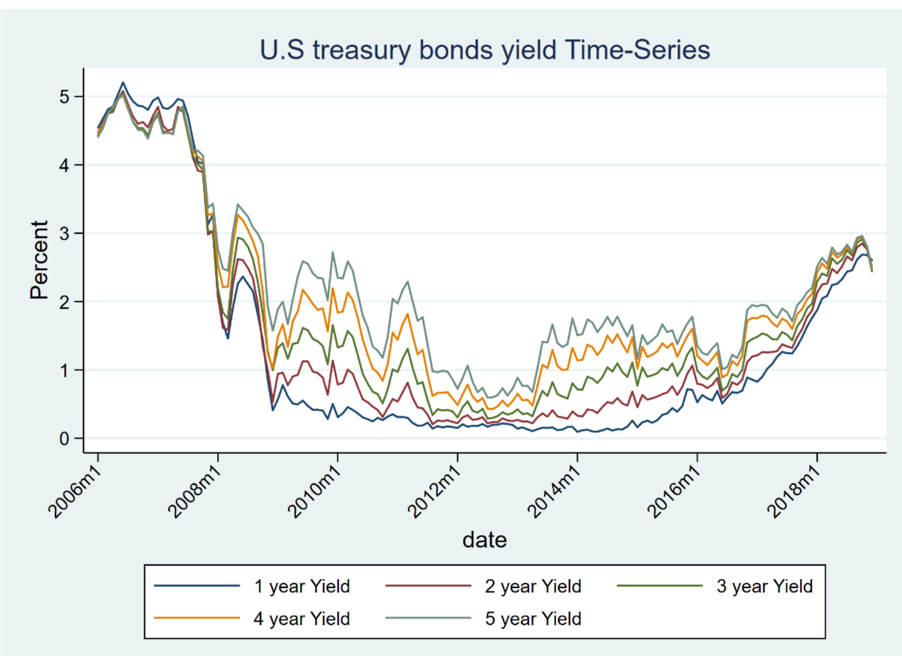

Figure 3: Time-Series plot on U.S Treasury Bonds yields

4. Methodology

4.1.1 Empirical Model

The Fama-Bliss (1987) regression uses 3 variables to calculate the term premium; [1] holding period returns ($\boldsymbol{hpr_{t+1}^{(n)}}$) , [2] 1-year Yield ($\boldsymbol{y_{\mathrm{t}}^{(1)}}$) and [3] Forward price of a bond ($\boldsymbol{f_t^{(n)}}$). The holding period return can be calculated by buying an n-year bond at time t and sell it at time t + 1 where its remaining maturity has decreased to n−1. The 1-year yield is the current yield on a bond of 1-year maturity and is called the spot rate. The forward price of a bond is defined as the current expectation of $\boldsymbol{y_{\mathrm{t+k}}^{(1)}}$, i.e. the one-year rate at a certain time in the future.

The transformations made to get to the Fama-Bliss (1987) regression from the yield data is listed below, with the Fama-Bliss regression defined as:

$$(1)\quad \boldsymbol{hpr_{t+1}^{(n)} - y_{\mathrm{t}}^{(1)} = \alpha + \beta\left(f_t^{(n)} - y_{\mathrm{t}}^{(1)}\right) + \epsilon_{t+1}^{(n)}}$$

where $\boldsymbol{hpr_{t+1}^{(n)} - y_{\mathrm{t}}^{(1)}}$ can be defined as the excess return and $\boldsymbol{f_t^{(n)} - y_{\mathrm{t}}^{(1)}}$ can be defined as the forward-spot spread. Corresponding Newey-West standard errors will be reported to correct for any heteroskedasticity and serial correlation. Cochrane & Piazzesi (2005) show that by using excess returns, we can focus directly on the risk premia, as inflation and interest rates level are netted out. This approach to construct yields for bonds is uncommon as it uses forward rates instead of a discount curve. These forward rates are referred to as “unsmoothed Fama-Bliss” forward rates. Under the Pure Expectations Hypothesis, we would expect $\boldsymbol{\beta = 0}$, as the forward-spot spread, or any variable shouldn’t be able to forecast returns. On the contrary, the Liquidity Preference Hypothesis would show an increasing term premium ($\boldsymbol{\beta}$) as the maturity increases due to the expectations that investors would demand a higher premium for higher maturity bonds as these carry more risk.

A disadvantage of this model is that it's old and it might be that currently other state variables might forecast bond excess returns and it will thus produce results that are not significant and different from what more advanced models would have predicted. In the next steps this paper will look to decompose the Fama-Bliss regression and show the data transformation from the yield dataset that will need to take place.

The price or yield to maturity of a bond gives little information about its return if different maturities are compared to each other. Therefore, a holding period return of 1 year is used, where bonds of all maturities are normalized to period of 1 year. The holding period return on an n−year maturity bond can be described as buying an n-year bond at time t and sell it at time t + 1 where its remaining maturity has decreased to n−1 and is defined as

$$(2)\ hpr_{t+1}^{(n)} = \ln P_{t+1}^{(n-1)} - \ln P_t^{(n)}$$

Where ln indicates the natural logarithm and $P_t^{(n)}$ is the price of an n-year discount bond at time *t*. $P_t^{(n)}$ can be calculated from the Yield to Maturity $Y_t^{(n)}$ by using the formula

$$(3)\ \mathrm{P}_t^{(n)} = \frac{1}{(1+\mathrm{Y}_t^{(n)})^{n}}$$

where $$(4)\ \ln Y_t^{(n)} = \ln\left(1 + \frac{(Y_t^{(n)}}{100}\right)$$

The Yield to Maturity ($Y_t^{(n)}$) is the total return a bond will generate if the investment is held until its maturity.

Finally, the forward prices are necessary to compute the forward-spot spread and is defined as

$$(5)\ F_t^{(n)} = F_t^{(n-1)} / F_t^{(n)} - 1$$

where $$(6)\ f_t^{(n)} = \ln(1 + F_t^{(n)})$$

and $$(7)\ f_t^{(n)} = \ln P_t^{(n-1)} - \ln P_t^{(n)}$$

4.1.2 Time-varying premium

Besides observing the term premium by using the Fama-Bliss regression, it can also be used for forecasting purposes. To do this, a time-varying coefficient model using a rolling window-based regression is considered, which also shows if the estimated parameters are constant over different time periods. Although a rolling window implies a smaller data set to work with, it is better applicable in this paper as older data might not be as representative of the current yield behavior and its term premium component. The rolling window model defines a window of observations that is kept constant when running the Fama-Bliss regression. Next, the rolling window is moved one observation forward in time and the regression process is repeated. I then construct a time-series of the term premium calculated at each step of the rolling window.

This time-varying estimation allows the stability or the lack thereof to be assessed over time, as the model is not assumed to be time-invariant. To calculate the term premium, I estimate the beta by using Equation 1. Before the estimation of this model, I assess the instability of the term premium in Appendix B Table 12 by estimating the beta in Equation 1 for the full sample period as well as 5 different period of 11 year each.

The betas reported in Table 12 show a substantial difference over the 5 sub-samples used. The 2, 3 and 4-year term premium show large swings with 2-year term premium even turning negative in the latest sub-sample. Moreover, the last three sub-samples show a term premium that is smaller than the term premium for the full sample period. The evidence presented in Table 12 suggests that lower maturity term premium tend to have more variation.

4.2 Hypothesis Development

To examine if the term premium as observed by Fama & Bliss (1987) over the period 1964-85 has been arbitraged away and is no longer present in U.S. treasury bonds, the dataset is divided into 2 sub-samples where sub-sample 1 represents the period 1964-85, the sample used in the original regression, and sub-sample 2, which is the data from 1986-2018. To test this, the following Equation 1 will be used for both samples.

This regression uses the forward-spot spread as the independent variables to predict excess return on a bond to establish the term premium. If the term premium observed by Fama & Bliss (1987) over the period 1964-85 is no longer present in the period 1985-2018 for U.S. treasury bonds, we would expect $\boldsymbol{B_1 = 0}$ for sub-sample 2**.** A T-test is done on the term $\boldsymbol{B_1}$ to test the null hypothesis that $\boldsymbol{B_1}$ is different from 0**.** Accordingly, the first hypothesis and its alternative are formulated as follows:

Hypothesis 1a: The term premium observed by Fama & Bliss (1987) over the period 1964-85 is no longer present in U.S. treasury bonds. The dataset for 1986-2018 shows no term premium.

Hypothesis 1b: There is still a term premium available for investors within the data from 1986-2018.

To further test the development of the term premium, it is hypothesized that the term premium observed by Fama & Bliss (1987) over the period 1964-85 has remained the same over the period 1986-2018. To test this, the following hypotheses are constructed:

Hypothesis 2a: The term premium observed by Fama & Bliss (1987) over the period 1964-85 has remained the same and the data from 1986-2018 will show the same coefficients.

Hypothesis 2b: The term premium observed over the period 1986-2018 is different than the premium observed by Fama & Bliss (1987) over the period 1964-85.

The following test is used where $\boldsymbol{D_y}$ is a dummy variable that is coded 0 for sub-sample 1 and 1 for sub-sample 2:

$$(8)\ \boldsymbol{hpr_{t+1}^{(n)} - y_{\mathrm{t}}^{(1)} = a_1 + D_y a_2 + B_1 \left(f_t^{(n)} - y_{\mathrm{t}}^{(1)}\right) + D_y B_2 \left(f_t^{(n)} - y_{\mathrm{t}}^{(1)}\right) + \epsilon_{t+1}^{(n)}}$$

If $\boldsymbol{D_y = 0}$:

$$\boldsymbol{hpr_{t+1}^{(n)} - y_{\mathrm{t}}^{(1)} = a_1 + B_1 \left(f_t^{(n)} - y_{\mathrm{t}}^{(1)}\right) + \epsilon_{t+1}^{(n)}}$$

If $\boldsymbol{D_y = 1}$:

$$\boldsymbol{hpr_{t+1}^{(n)} - y_{\mathrm{t}}^{(1)} = (a_1 + a_2) + [\,B_1 + B_2] \left(f_t^{(n)} - y_{\mathrm{t}}^{(1)}\right) + \epsilon_{t+1}^{(n)}}$$

Again, the Fama-Bliss regression is used with the forward-spot spread as the independent variables to predict excess return on a bond to establish the term premium. If both sub-samples show the same term premium, we would expect $\boldsymbol{B_2 = 0.}$ To test this, a T-test is performed on $\boldsymbol{B_2}$ to test if the coefficient is equal to zero. A rejection of this test would show that the dataset shows a change in term premia.

In summary, Hypothesis 1 looks at the presence of a term premium while Hypothesis 2 tests if this observed term premium is the same throughout both periods.

For the second part of the research question, this paper will look at the interconnectivity of markets in our globalized world. The third hypothesis asserts that treasure bonds from the U.S. might have a spillover effect on European 1- to 5-year treasury bonds. Hördahl et al (2016) state that there is a strong linkage between interest rates in different currencies due to ultra-low interest rates. They observe that over the period 2005 to 2016, a 100-basis point rise in the US 10-year yield is on average correlated with a 70 to 80 basis point rise in the yields in other bond markets. Cohen et al (2018) reported a high correlation between the term premia of the Euro area and the U.S. Therefore, we test whether 1- to 5-year maturity AAA-rated euro area central government bonds and the U.S. treasury bonds have the same term premia over the period 2006-2018. Considering this, the following hypotheses are formulated:

Hypothesis 3a: 1- to 5-year maturity AAA-rated euro area central government bonds and the U.S. treasury bonds have the same term premia over the period 2006-2018
Hypothesis 3b: 1- to 5-year maturity AAA-rated euro area central government bonds and the U.S. treasury bonds have different term premia over the period 2006-2018

The following test is used where first a dummy variable $\boldsymbol{Euro}$ is coded 1 for the AAA-rated euro area central government bonds and 0 for U.S. treasury bonds:

(9) $$\boldsymbol{hpr_{t+1}^{(n)} - y_{t}^{(1)} = a_1 + Euro\ a_2 + B_1 \left(f_t^{(n)} - y_t^{(1)}\right) + Euro\ B_2\left(f_t^{(n)} - y_t^{(1)}\right) + \epsilon_{t+1}^{(n)}}$$

If $\boldsymbol{Euro = 0}$ **:**

$$\boldsymbol{hpr_{t+1}^{(n)} - y_{t}^{(1)} = a_1 + B_1 \left(f_t^{(n)} - y_t^{(1)}\right) + \epsilon_{t+1}^{(n)}}$$

If $\boldsymbol{Euro = 1}$ **:**

$$\boldsymbol{hpr_{t+1}^{(n)} - y_{t}^{(1)} = (a_1 + a_2) + [B_1 + B_2] \left(f_t^{(n)} - y_t^{(1)}\right) + \epsilon_{t+1}^{(n)}}$$

This regression uses the forward-spot spread as the independent variables to predict excess return on a bond to establish the term premia for both countries. If 1- to 5-year maturity AAA-rated euro area central government bonds and the U.S. treasury bonds show the same term premia, we would expect $\boldsymbol{B_2 = 0}$, as this is the added term premium that can be contributed to a Euro bond**.** To test this, a T-test is performed on $\boldsymbol{B_2}$ to test if the coefficient is equal to zero. A rejection of this test would show that the two different areas shows a significant change in term premia.

5. Results

5.1 Methods

Before results can be interpreted the data and regressions have to be checked for heteroskedasticity and autocorrelation. Heteroskedasticity results in standard errors under- or over-estimating the variance in the dataset and thus any inference made could be misleading. To test for heteroskedasticity, the White's Heteroskedasticity test will be ran on the 3 samples used. Autocorrelation will also result in wrong standard error estimates and is tested by using the Breusch-Godfrey test with 12 lags due to the data being monthly while maturities being yearly. Table 6 shows the result for both tests and concludes that the data sub-samples either have autocorrelation, heteroskedasticity or both. To correct for this, the Newey-West procedure is applied where the amount of lags *m* is chosen by the rule of thumb as presented by Stock & Watson (2009):

$$(10)\ \boldsymbol{m = 0.75T^{1/3}}$$

Where *m* is the number of lags used and *T* is the amount of observations within a certain sample. This formula strikes a balance between the number of observations in the sample and the number of lags used. Newey & West (1987) show that by using this rule-of-thumb, the estimator is a consistent estimator of the variance of Beta.

Table 6: Tests for serial correlation and heteroskedasticity

Dataset	*Maturity*	*White's test**	*Breusch-Godfrey test**
U.S treasury bonds 1964-1985	2	0.141	0.000*
	3	0.731	0.000*
	4	0.967	0.000*
	5	0.117	0.000*
U.S treasury bonds 1986-2018	2	0.000*	0.000*
	3	0.015*	0.000*
	4	0.041*	0.000*
	5	0.118	0.000*
AAA-rated euro central government bonds from 2006-2018	2	0.008*	0.000*
	3	0.007*	0.000*
	4	0.021*	0.000*
	5	0.065	0.000*

***A significance level of 5 percent is applied to all coefficient tests.**

5.2 Results for Hypothesis 1

Hypothesis 1 tests if the term premium observed by Fama & Bliss (1987) over the period 1964-85 is no longer present in U.S. treasury bonds over the period 1986-2018. Table 7 shows the term premium over the period 1986-2018, while Table 8 a comparison with the original term premium observed by Fama & Bliss. Fama & Bliss (1987) do not report the T-statistic for their tests done but state in their paper that the slopes of the Fama-Bliss regression are non-zero.

Table 7: Estimates of regression Hypothesis 1

Maturity	**1986-2018**				
	Beta	***Newey-West S.E***	***T-statistic***	***R-Squared***	***Prob > F***
2	0.46	0.32	0.152	0.04	0.152
3	0.66	0.37	0.076	0.05	0.076
4	0.91	0.38	0.017*	0.08	0.017
5	0.79	0.35	0.025*	0.05	0.025

***A significance level of 5 percent is applied to all coefficient tests.**

Table 8: Fama-Bliss (1987) estimates

Maturity	**1964-1985**		
	Beta	***Newey-West S.E***	***R-Squared***
2	0.91	0.28	0.14
3	1.13	0.37	0.11
4	1.42	0.45	0.11
5	0.93	0.53	0.05

***A significance level of 5 percent is applied to all coefficient tests.**

The T-statistic, which tests if the coefficients calculated are significantly different from 0, show that the coefficients for all the maturities are all positive, but only for the 4 and 5-year U.S treasury bond is the term premium significantly different from 0 in the period of 1986-2018.

Accordingly, we partially fail to reject Hypothesis 1, which states that *the term premium observed by Fama & Bliss (1987) over the period 1964-85 is no longer present in U.S. treasury bonds.* The dataset for 1986-2018 shows no term premium for all maturities, except for 4 and 5-year U.S treasury bonds. The intuition behind the disappearance of a term premium for lower maturity could be that investors are better at modelling their expectations for the future and thus require no compensation for holding shorter-term bonds compared to longer ones. Also, there is a decline in the Beta's which can be explained by the Quantitative Easing (QE) program of the US Federal Reserve. This decline is also seen in current literature. Furthermore, since mid-1980's, inflation expectations have been lower and thus making bondholders willing to accept less yield for term risk resulting in a lower expected term premium.

5.3 Results for Hypothesis 2

Hypothesis 2 deals with whether the term premium observed by Fama & Bliss (1987) over the period 1964-85 has remained the same over the period 1986-2018. The results for equation 9 are presented below in table 9:

Table 9: Estimates of regression Hypothesis 2

Numbers of observations for all regressions = 660						
Maturity	a_1 ***(p-values)***	a_2 ***(p-values)***	B_1 ***(p-values)***	B_2 ***(p-values)***	Prob > F	R-Squared
2	**-.002**	**.007***	**.910***	**-.448**	**0.00**	**0.14**
	(0.410)	*(0.044)*	*(0.000)*	*(0.272)*		
3	**-.005**	**.013***	**1.197***	**-.532**	**0.00**	**0.16**
	(0.199)	*(0.045)*	*(0.000)*	*(0.267)*		
4	**-.009**	**.016**	**1.382***	**-.471**	**0.00**	**0.18**
	(0.130)	*(0.067)*	*(0.000)*	*(0.380)*		
5	**-.010**	**.021**	**.808**	**-.020**	**0.00**	**0.13**
	(0.233)	*(0.053)*	*(0.139)*	*(0.975)*		

***A significance level of 5 percent is applied to all coefficient tests.**
****Newey-West standard errors**

For the period of 1986-2018 the coefficient $\boldsymbol{B_2}$, which shows the added term premium in the second period, are all negative but not significantly different from zero. Consequently, the test fails to reject the hypothesis that the term premium has remained the same throughout the second sub sample. This result is inconsistent with the existing literature and with the Beta found in hypothesis 2. Kim and Wright (2005) use expected future short-term interest rates, term premia and surveys of financial market participants to decompose yields on bonds, while Fama and Bliss (1987) only look at forward rates. A possibility is that for the second sub-sample, the forward rates are not as explanatory for yields as in the first sub-sample.

5.4 Results for Hypothesis 3

Hypothesis 3 tests whether 1- to 5-year maturity AAA-rated euro area central government bonds and the U.S. treasury bonds have the same term premia over the period 2006-2018 using equation 10. Results for this test can be found in table 10.

Table 10: Estimates of regression Hypothesis 2

Numbers of observations for all regressions = 336

Maturity	a_1 ***(p-values)***	a_2 ***(p-values)***	B_1 ***(p-values)***	B_2 ***(p-values)***	*Prob > F*	*R-Squared*
2	**.005**	**-.001**	**-.346**	**.893**	**0.21**	**0.06**
	(0.053)	*(0.747)*	*(0.402)*	*(0.124)*		
3	**.007**	**-.002**	**.158**	**.751**	**0.14**	**0.05**
	(0.238)	*(0.781)*	*(0.743)*	*(0.249)*		
4	**.006**	**-.001**	**.633**	**.555**	**0.04**	**0.11**
	(0.573)	*(0.945)*	*(0.219)*	*(0.424)*		
5	**.003**	**.000**	**.911**	**.514**	**0.01**	**0.16**
	(0.818)	*(0.992)*	*(0.073)*	*(0.466)*		

***A significance level of 5 percent is applied to all coefficient tests.**
****Newey-West standard errors**

$\boldsymbol{B_1}$ is the term premium for U.S. treasury bonds and $\boldsymbol{B_2}$ is the added term premium if the dummy variable $\boldsymbol{Euro = 1}$. The regression fails to show any significance for the variables and thus the different areas do not seem to show a significant difference in term premia, which confirms and can be attributed to the high correlation seen by Cohen et al. (2018). Furthermore, the failure to reject $\boldsymbol{B_1 = 0}$ & $\boldsymbol{B_2 = 0}$ can be explained by the disappearance of the term premium as a direct result of Quantitative Easing (QE). The Federal Reserve started their QE program in 2007 and the European Central Bank started theirs in 2009. As this research only looks at 2006 through 2018, it could be capturing the effect of QE on the bonds of U.S. treasury bonds as well as AAA-rated euro area central government bonds.

5.5 Time-varying premium

To illustrate the time-variance in term premium, a rolling window approach is with a window size of 12 to account for the 12 months of data for each year. Results for this regression can be found in figure 4 below.

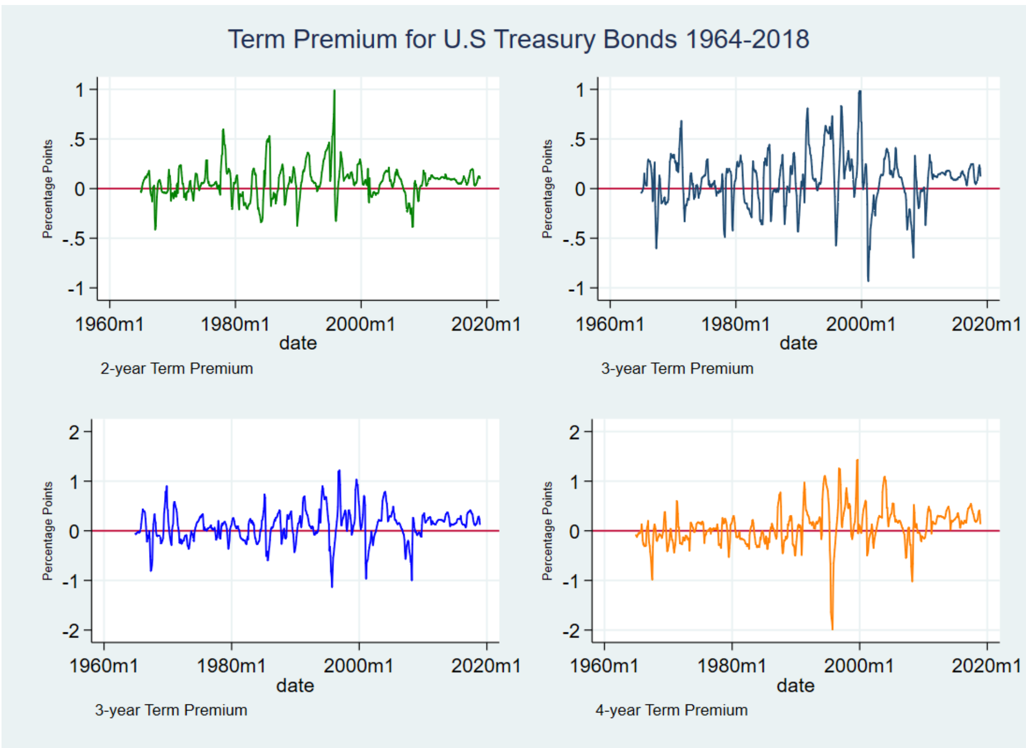

Figure 4: Twelve-month-ahead forward premia (1964-2018)

Overall, the observed time-varying term premium confirms the assumption by Fama & Bliss (1987) that the term premium in bonds tends to be mean reverting, depending on business cycles and that some instability might be present over the period 1964-2018.

6. Conclusion and Discussion

6.1 Conclusion

This paper looks to answer the research question of to what extent has the term premium in treasury bonds changed compared to the period of 1964-85 and does the European Union show similar premia?

Contrary to the dataset used by Fama & Bliss (1987), the dataset for 1986-2018 shows no term premium for all maturities, except for 4 and 5-year U.S treasury bonds. However, when combining the datasets, we fail to reject the hypothesis that the term premium has remained the same throughout the second period. This conclusion can be explained by the fact that investors are demanding less compensation for holder longer-term bonds as they expect a less risky climate with lower inflation outlook. Additionally, recent Quantitative Easing (QE) programs by Central Banks also play a role in the development of the term premium.

On a global level, the term premium for U.S. treasury bonds and AAA-rated euro area central government bonds do not show a significant difference and thus confirming their high correlation as seen by Cohen et al. (2018) and Hördahl et al. (2016). Furthermore, this paper confirms the mean reversion of term premia in U.S. treasury bonds.

6.2 Limitations

A significant limitation of the Fama-Bliss (1987) model is that it assumes that yields are driven by forward prices, which is only a small set of factors that make up yield data and the term structures. Also, despite the extensive research on term structures and yield on bonds, there is little replication of the Fama-Bliss regression using more recent data or data from other countries.

6.3 Future developments

Existing literature states that current term premia are significantly different from past ones mainly due to unconventional monetary policies such as the Quantitative Easing (QE) programs by Central Banks. However, this research illustrates the contrary, which raises the question whether the Fama-Bliss methodology is still applicable for current yield curves to determine their term premium. The fundamental change in how interest rates and QE programs are used by Central Banks could result in forward rates not being as predictive or not capturing the term premia. Besides standard estimation procedures, survey data with expectations from financial analyst can serve as a useful source of information on future expectations in the market, under the assumption that the term premia reflect the risk in the economy. However, as there is no objective way to calculate the term premia, more research is needed in the data collection, modelling and estimation of the term premia to have a better interpretation of its impact. That said, estimating the term premia remains to be a daunting task as current models suffer from a wide variety of problems.

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Appendix A

Table 11: Fama-Bliss Regression 1964-85

						Residual Autos (Yearly Lag)				
Dependent	a2	s(a)	b2	s(b)	R2	1	2	3	4	5
2-year Excess Return	-.21	.41	.91	.28	.14	-.01	-.12	-.07	-.17	-.01
3-year Excess Return	-.51	.68	1.13	.37	.11	-.18	-.12	.03	-.17	-.05
4-year Excess Return	-.91	.92	1.42	.45	.11	-.23	-.10	.03	-.14	-.08
5-year Excess Return	-1.06	1.31	.93	.53	.05	-.17	-.11	.03	-.17	-.10

Appendix B

Table 12: Sub-Sample Betas

Term Premium of Maturity	***Sample***					
	Full**	1964-1974*	1975-1985*	1986-1996*	1997-2007*	2008-2018*
2	0.82	0.78	0.85	0.73	0.37	-0.32
3	1.10	1.04	1.23	0.92	0.63	0.17
4	1.33	1.54	1.32	1.32	0.62	0.66
5	1.12	0.65	0.81	0.74	0.70	0.95

***Number of observations = 132**
****Number of observations = 660**