Term Spread Combinations: Its ability to Span different Macro-economic variables and explain their future movements.

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Abstract

In this paper, I show how different combinations and components of term spread have varying shapes, which can be analyzed in order to understand movements in the economy. Calculating term spread dispersion can help us better price risk in the bond market. Term spread combinations have varying power in explaining future movements in macro variable. It shows that the spanning hypothesis of the term spread against a macro variable might hold true depending on the combination and component of term spread that we are taking into consideration. This paper provides a mechanism through which we can identify the best combination of a term spread for creating an efficient macro fiance model.

1 Introduction

1.1 What is the Term Spread?

$$Term\ Spread = Long\ Term\ Interest\ Rate\ -\ Short\ Term\ Interest\ Rate$$

Term Spread comprises of the difference between the long term and short term yield curve. The short term yield is the interest paid by the government on its bonds over a short horizon. It is a monetary policy tool used by the government to achieve its macro economic objectives of price stability, full employment, and economic growth. It short term usually ranges from 1 month $[y_t^{1m}]$ up until 18 months $[y_t^{18m}]$.

The long run yield curve, on the other hand, constitutes of two parts: the expectation component and the term premium component.

$$y_t^{10y} = \frac{1}{10y} \sum_{i=0}^{10y-1} E\left[y_{t+i}^{1m}\right] + TP_t^{10Y}$$

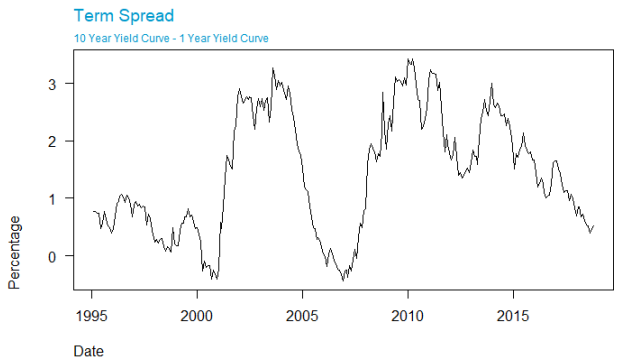
As shown in the above equation, the 10 year long run yield curve comprises of the expectation of the short run interest rate over the 10 year horizon plus the term premium component. The government cannot control the long run interest rate as it is determined by people's expectation about the future of the economy and the bond risk premium that they require in order to compensate for it.

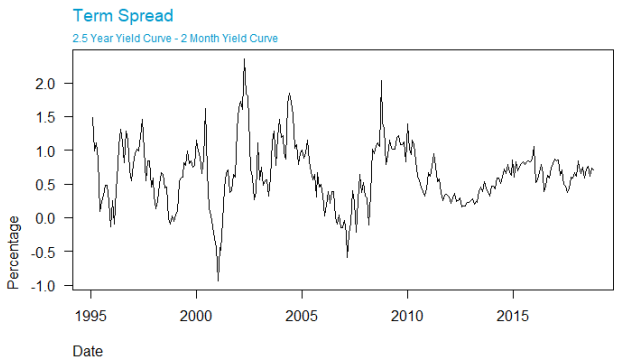
The difference between the long and short run yield curve holds valuable information about macro economic and financial variables in the economy. In the United States, the 10 year minus 3 months term spread has been a great indicator of future recession in the economy. Throughout history, the term spread inversion forecasted 7 recessions in the US economy out of which 6 were true. This indicates that the term spread holds valuable information about the economy. For years, economists have been researching on the potential of term spread in understanding the economy. This led to the development of various complex term spread models such as the expectation component term spread and the term premium component term spread. The expectation component term spread comprises of the difference between the expectation of the long run and short run interest rate, while the term premium component comprises of the difference between the long run and the short run term premium.

Different components and combinations of term spreads have had varying power in explaining movements in the economy.. In this paper, I intend to explore a mechanism through which we can identify the best combination and component that can be used to develop a term spread in order to better understand movements in macro economic variables.

1.2 Different Combinations of Long Run and Short Run Yield Curve result in varying Term Spreads

The shape of the yield curve tend to change depending on the long run and short run yield curve that we use to construct it. It appears that the further apart the long term and short term yield curves are the wider the term spread gets. The volatility of the term spread also reduces or increases based on the combination that we take. All of this indicates that different combinations might be useful in explaining different macro economic and financial variables.





As we can see in the graphs above, the 2.5 years minus 3 months term spread appears to be more volatile than the 10 year minus 1 year term spread. The percentage difference also appears to vary across the term spreads. This varying shape of the term spreads is what motivated me to develop a model that looks at all possible combinations of a term spread in order to identify the best possible combination.

1.3 Paper Structure

This paper consists of five major sections each of which looks at a different research question that can be used to understand the effectiveness of term spread combinations in explaining macro variables and movements in the economy.

Research Questions:

1. Does it matter what short term and long term yield curve combinations we use to calculate the term spread?

2. Does the dispersion of spreads have any explanatory power for understanding the Term Premium term spread?

3. Are Macro economic variables captured in all different combinations of term spread?

4. Can different term spread combinations be used to explain future movements in macro variables?

5. Can the 1st Principle Component Analysis of all different combinations of term spread give us the best possible term spread model?

2 Does it matter what short term and long term yield curve combinations we use to calculate the term spread?

2.1 Term Spread Model Setup

$$TS_t^i = y_t^{Long\ Run} - y_t^{Short\ Run}$$

To construct all possible different combinations of term spread the following set up was used:

- **Long Run** is assumed to range from 24 months **to** 120 months which is 97 different long term values.

- **Short Run** is assumed to range from 2 months **to** 18 months which is 17 different short term values.

- **i** indicates all 1649 different possible combinations of Term Spread.

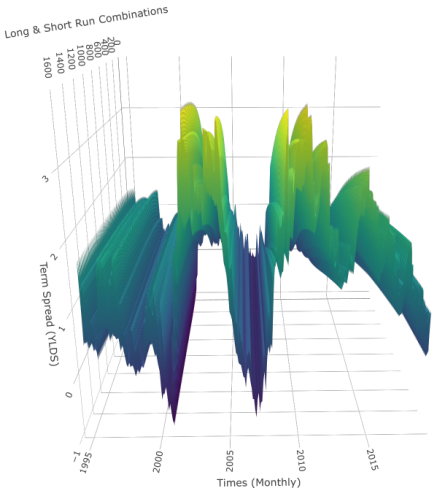
- **t** indicates monthly data which ranges from 1995-01-30 **to** 2018-10-31 which is 286 observations for every single combination of term spread.

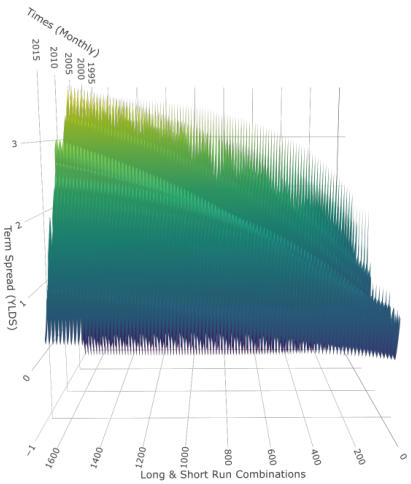
- The same model was used to construct three different types of term spread:
  - Yield Curve Term Spread
  - Expectation Component Term Spread
  - Term Premium Component Term Spread

2.2 Major Results

2.2.1 Yield Curve Term Spread

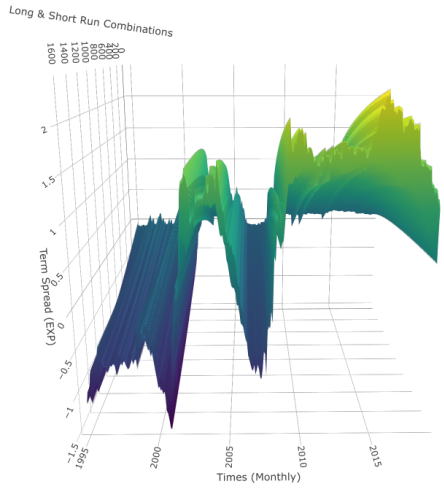
$$TS_t^i = y_t^{Long\ Run} - y_t^{Short\ Run}$$

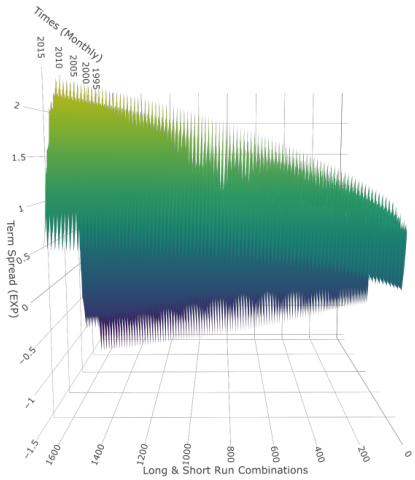




2.2.2 Expectation Component Term Spread

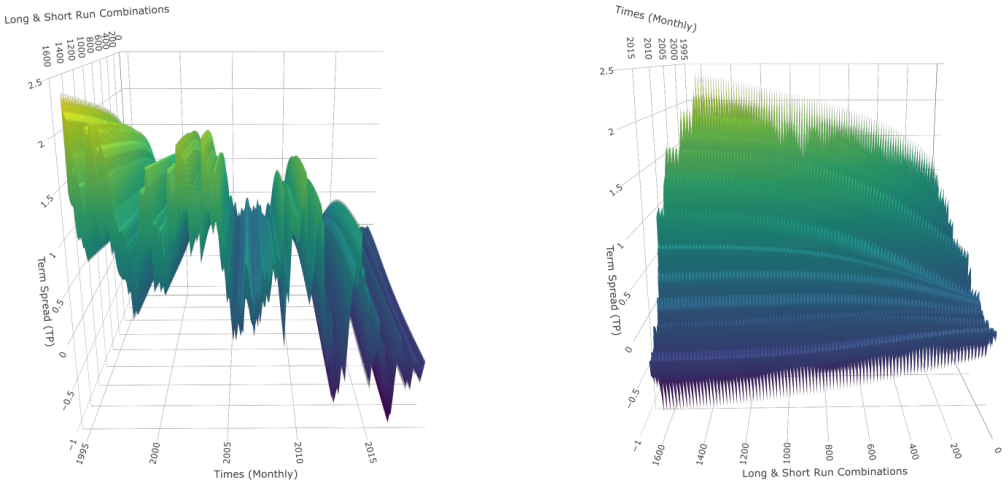
$$TS_t^i = EXP_t^{Long\ Run} - EXP_t^{Short\ Run}$$





2.2.3 Term Premium Component Term Spread

$$TS_t^i = TP_t^{Long\ Run} - TP_t^{Short\ Run}$$



2.3 Analyzing the Results

2.3.1 Interpretation

In the results above, The x-axis indicates the time horizon which ranges from 1995 to 2015, the y-axis indicates the long and short run combination being considered, and the z-axis indicates the term spread coefficient. The change in color from purple to yellow of the term spread shows the increase in the term spread coefficient.

- **Yield Curve term spread,** shows how the term spread changes not only across time but also across the long and short run combination being considered. Almost all term spread combinations appears to invert before the early 2000s recession and 2008 financial crisis. As we start taking values for short and long run yield curve that are further apart the term spread shape appears to change by becoming wider.
- **Expectation component term spread,** shows similar results in that the term spread changes not only across time but also across the long

and short run combination being considered. It appears to fall below -0.5 before 2000s recession and 2008 financial crisis. In the case of the expectation component, the wideness between the term spread based on the short and long term combination appears to change over time. During 1995 combinations were not as wide as those after the 2015. This might be because increase in technology for sharing and analyzing information might have allowed people to better formulate expectations about the long run interest rate compared to short run interest rate.

- **Term Premium component term spread,** shows similar results in that the term spread changes not only across time but also across the long and short run combination being considered. It does not appear to have any major indication before the 2000s recession and 2008 financial crisis. In the case of the term premium component, the wideness between the term spread based on the short and long term combination appears to reduce over time and invert after almost 2012. This might be because after 2012, bond risk premium on long term yield started to reduce as people started to expect stable inflation and economic growth over the long run.

2.3.2 Major Takeaway

The Term spread shape appears to change across different combinations of short and long run horizon. This indicates that the different combinations would have varying explanatory power in describing movements in the economy.

3 Does the dispersion of spreads have any explanatory power for understanding the Term Premium Term Spread?

3.1 Spread Dispersion Model Setup

$$Dispersion_t^i = TS_t^i - TS_t^{10y\,3m}$$

$$TP\_TS_t^i = \alpha^{(i)} + \beta^{(i)} Dispersion_t^i + \varepsilon_t^{(i)}$$

This model calculates the dispersion of all possible yield curve term spreads from the 10 year minus 3 months term spread. The 10 year minus 3 months term spread is the most widely used term spread. I hypothesized that dispersion of all other term spread combinations from this standard term spread might have explanatory power for understanding movements in the term premium term spread. This is because dispersion of the term spread might influence the bond risk premium resulting or term premium resulting in an affect on the term premium term spread.

- **i:** {1,1649}

- $TP\_TS_t^i$ indicates the Term Premium Term Spread

- **t** indicates monthly data which ranges from 1995-01-30 **to** 2018-10-31 which is 286 observations for every single combination of term spread.

3.2 Major Results

3.2.1 Regression of Term Premium term spread against Dispersion and EXP

$$TP\_TS_t^i = \alpha^{(i)} + \beta_1^{(i)} Dispersion_t^i + \beta_2^{(i)} EXP\_TS_t^i + \varepsilon_t^{(i)}$$

Table 1

	Dependent variable:	
	TermPremium	
	(1)	(2)
Dispersion	0.100^{***}	0.060^{***}
	(0.001)	(0.001)
Expectation		-0.201^{***}
		(0.001)
Constant	0.566^{***}	0.631^{***}
	(0.001)	(0.001)
Note:	*p<0.1; **p<0.05; ***p<0.01	

The 1st regression above shows that a 1 percent dispersion of the term spread from the standard term spread leads to a 0.1 percent increase in the term premium term spread value. All the coefficients in the above regression appear to be significant at 1 percent level. In the 2ndregression, the expectation component term spread was also included to understand its relationship with the term premium term spread. The expectation component appears to have a negative relationship with term premium component. This was also was also shown in the term spread combination graphs in Section (2.2) Including the expectation component term spread also reduced the effect of term spread dispersion on the term premium term spread by 0.04 percentage point.

3.2.2 3 Months - Lagged Regression of Term Premium term spread against Dispersion.

$$TP\_TS_t^i = \alpha^{(i)} + \beta_1^{(i)} Dispersion_{t-3}^i + \varepsilon_t^{(i)}$$

Table 2

	Dependent variable:
	TermPremium.3
Dispersion.3	0.142***
	(0.001)
Constant	0.585***
	(0.001)
Note:	*p<0.1; **p<0.05; ***p<0.01

Here, a lag of 3 months was created in order to check whether it would have any impact on the dispersion coefficient or its significance. The effect of dispersion of different combinations of term spread from the standard term spread still appears to be positive with a significance level of 1 percentage point.

3.3 Analyzing the Results

3.3.1 Major Takeaway

The yield curve term spread dispersion from the standard yield curve does appear to have explanatory power for understanding the term premium term spread. This might be because as the dispersion of term spread start to increase people might start demanding more bond risk premium on the long term bond compared to the short term bond as a result of increased uncertainty about future economic conditions.

3.3.2 Limitations

The term spread dispersion result are not very conclusive because of the following limitations:

- It might be better to take just term premium instead of term premium term spread as the dependent variable. This might result in varying results that will better help us understand the relationship between term spread dispersion and bond risk premium.
- Changing the standard term spread from 10 year minus 3 months to another combination might have varying effects which needs to be taken into consideration.
- The term spread dispersion also needs to be compared against exchange rate risk premium and stock market risk premium before making any major conclusions about the relationship between term spread dispersion and risk.

4 Are Macro-economic variables captured in all different combinations of term spread?

4.1 Spanning Hypothesis Model Setup

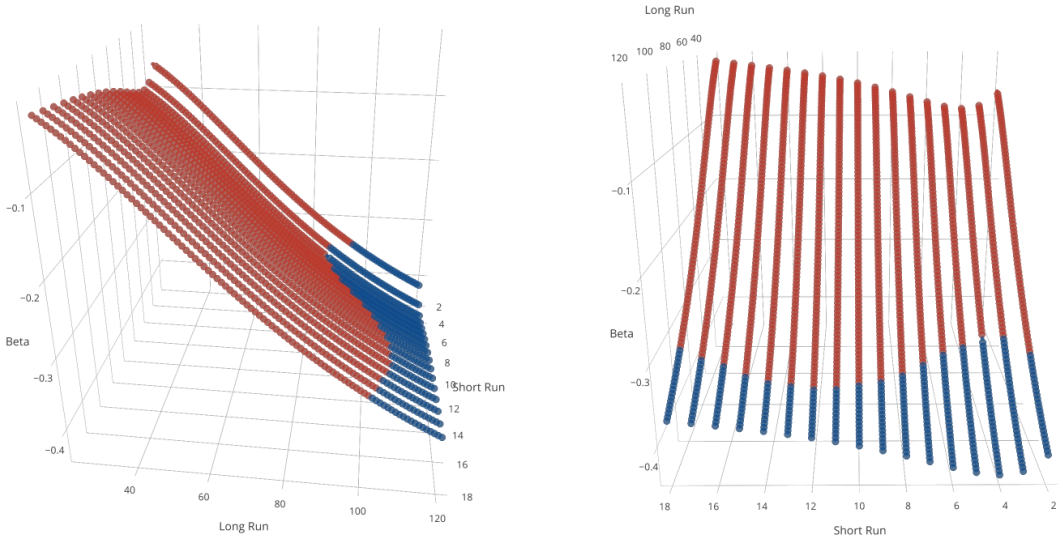
$$TS_t^i = \alpha^{(i,m)} + \beta^{(i,m)} macro_t^m + \varepsilon_t^{(i,m)}$$

According to Spanning Hypothesis, current interest rates span, or contain all information that is relevant for forecasting interest rates, so according to this hypothesis we would not need to look beyond the current yield curve as all macro economic data is already adjusted in the yield curve. I hypothesized that different combinations of term spread would span different macro variables. To test this, I developed the model above to check for the spanning of Consumer Price Index and Unemployment in different combinations of term spread:

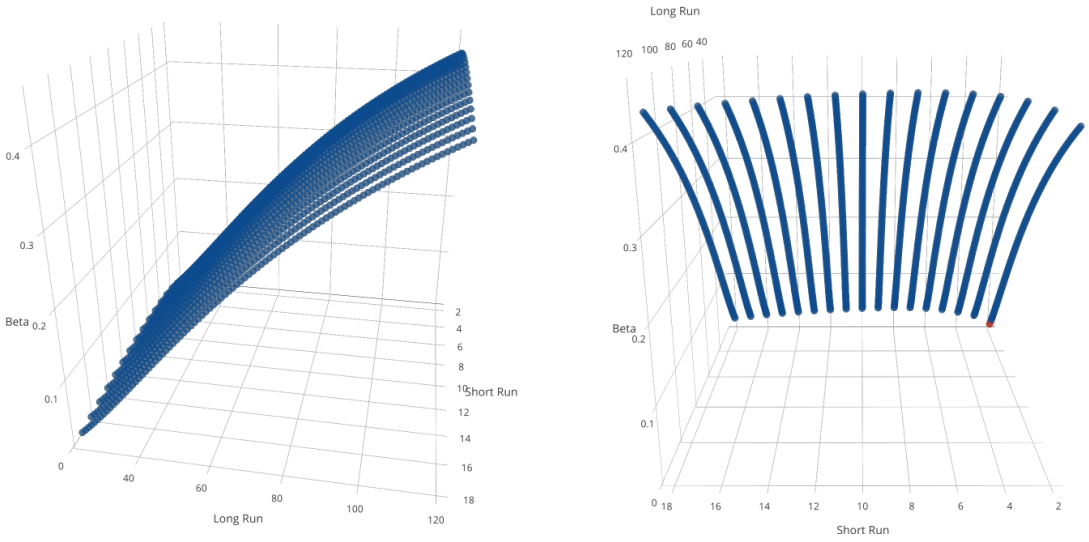
- **i:** {1,1649}
- $macro_t^m$: $\{\triangle\pi_t^{CPI}, u_t\}$
- $\triangle\pi_t^{CPI}$: Yearly Change in Inflation
- u_t : Civilian Unemployment Rate
- **t** indicates monthly data which ranges from 1995-01-30 **to** 2018-10-31 which is 286 observations for every single combination of term spread.
- The Spanning Hypothesis test against CPI and UNEMP was done for Yield Curve Term Spread, Expectation Term Spread, and Term Premium Term Spread.

4.2 Major Results

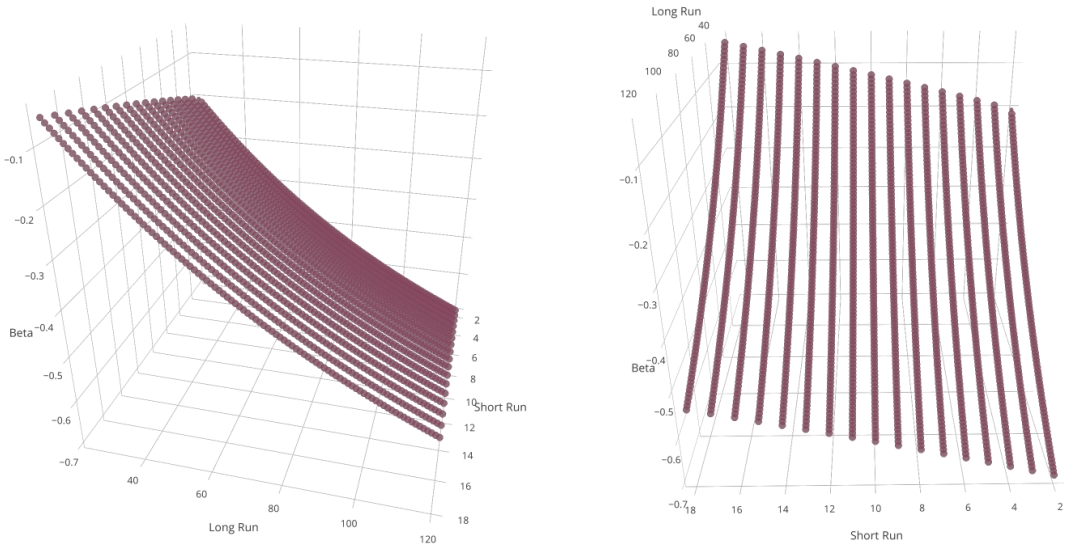
4.2.1 Spanning Test of Yield Curve Term Spread against CPI



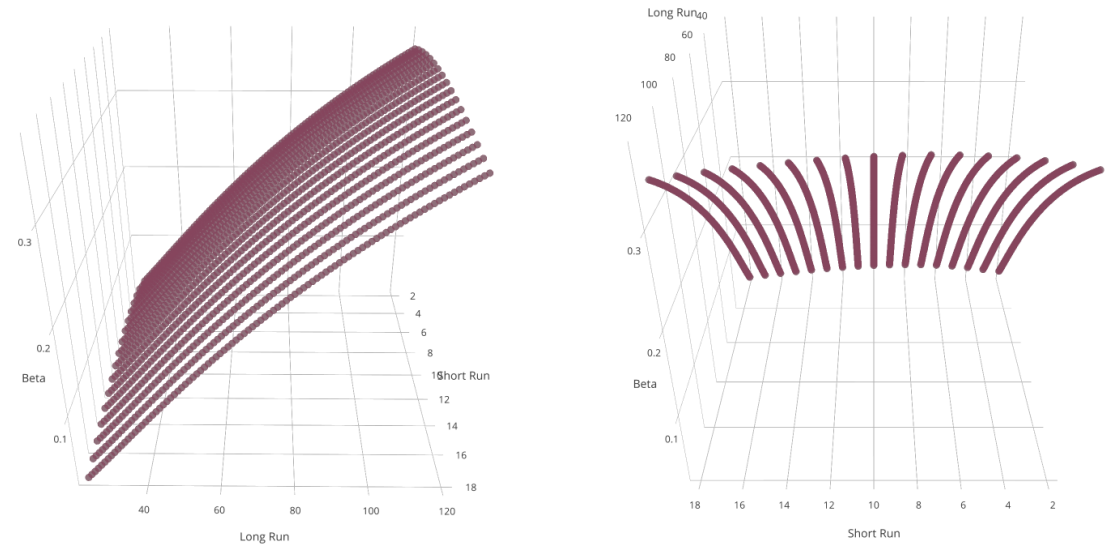
4.2.2 Spanning Test of Yield Curve Term Spread against UNEMP



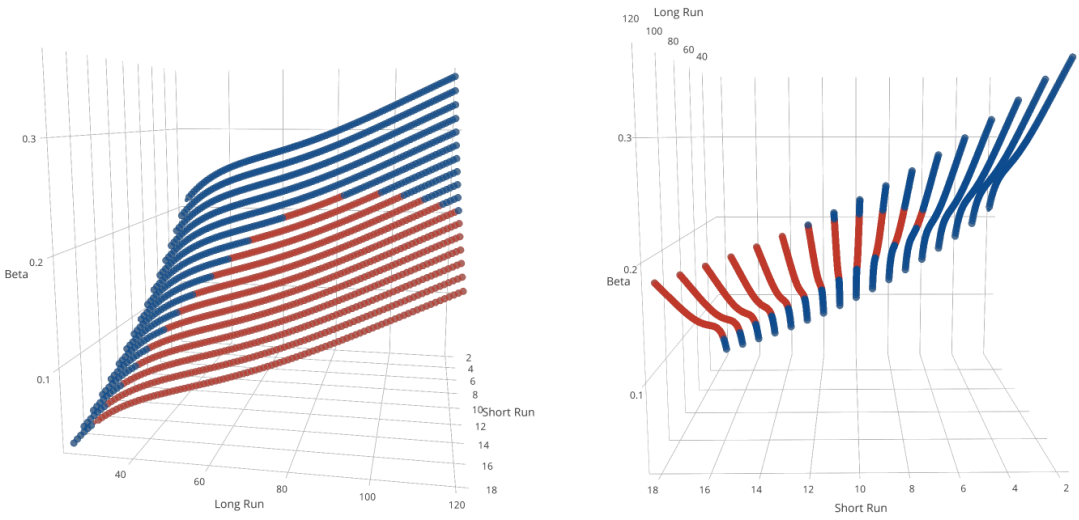
4.2.3 Spanning Test of Expectation Term Spread against CPI



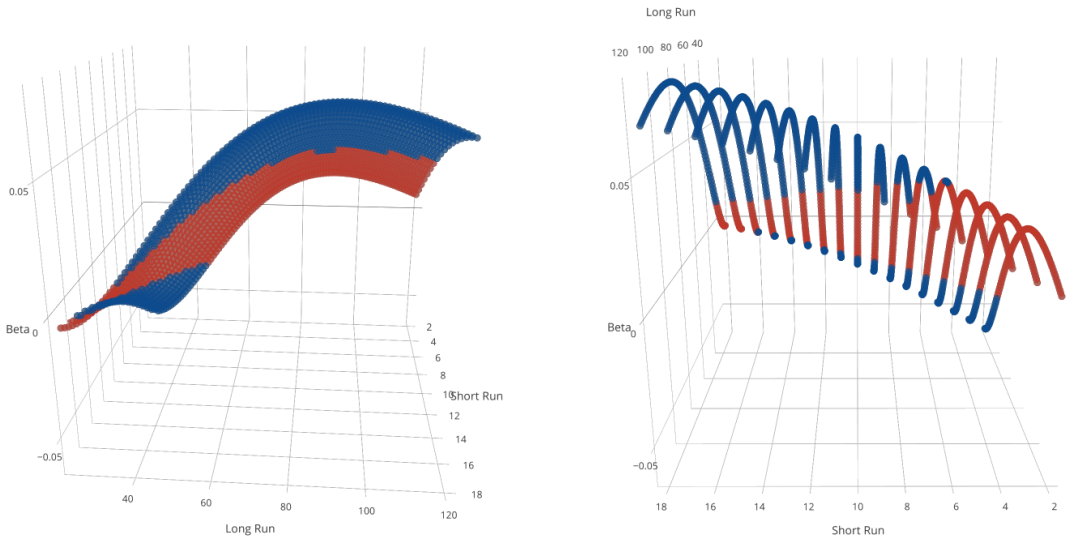
4.2.4 Spanning Test of Expectation Term Spread against UNEMP



4.2.5 Spanning Test of Term Premium Term Spread against CPI



4.2.6 Spanning Test of Term Premium Term Spread against UNEMP



4.3 Analyzing the Results

4.3.1 Interpretation

In the results above, The x-axis indicates the long term which ranges from 24 months to 120 months, the y-axis indicates the short term which ranges from 2 months to 18 months, and the z-axis indicates the beta coefficient of the regression results of different term spread combinations against the macro variables being considered . The blue color indicates significance level of at least 10 percent, while the red color indicates that the results are not significant. If all points in the graph are pink, it indicates that all results are significant at 10 percent level or less.

- **Spanning test for yield curve term spread,** shows that almost all combinations of long run and short run yield curve spans the unemployment macro variable as all of them appear of be significant. The same does not appear to be the case in the spanning against CPI. The movement along the long run end seems to mainly determine whether the term spread combination would span CPI or not. It appears that only long run ranging from 100 to 120 months spans for inflation in the economy, while anything below 100 months doesn't appear to significantly adjust itself according to inflation. On the short run axis, it does not matter which value we take as long as we are above 100 months on the long run axis. This might be because the yield for 100 months and beyond would adjust itself more quickly than that of the shorter end. The longer end of the yield curve is based on the expectation of people about the future of the economy. If inflation in an economy goes up, the long end would adjust itself more quickly then the short end because people will expect the real value of their money they are going to earn in the future to reduce which might lead them to demand for more bond risk premium. If the longer end adjusts itself more quickly to inflation than term spread constructed from its combination would better span for CPI. The shorter end of the long run axis does not appear to adjust itself according to inflation which does not make sense as it should also take inflation into account while determining the yield required. Further, research would be required to understand why this is the case.

- **Spanning test for expectation term spread,** appears to be significant in spanning both CPI and UNEMP at a 10 percent significance level or less. According to the results above, it is only the expectation term spread in which the combination being used does not matter as all of them appear to successfully spans the macro variables being considered. For further work, spanning test for expectation term spread needs to be conducted against other macro variables,such as GDP growth, to identify if all combinations also span other macro variables and not just CPI and UNEMP.

- **Spanning test for term premium term spread,** appears to have varying results for both CPI and UNEMP. It shows that the combination

of short and long term being considered plays a significant role in determining whether the term spread will span CPI and UNEMP or not. In case of CPI, changes along both the short run axis and the long run axis determine whether the term spread adjusts itself to inflation or not. It appears that on the short run axis any combination between 2 months and 6 months successfully span for CPI, while anything above 6 months appear to depend on the value being considered along the long run axis in determining whether the term spread will adjust itself according to inflation or not. The same appears to be the case in term of UNEMP, where some combinations of term spread do appear to span for it while others do not. The TP and CPI appears to show the opposite relationship of that being seen in the yield curve and CPI relation. Further research and more testing would be required to understand why this is the case.

4.3.2 Major Takeaway

The results in this section indicate that some combinations and components of term spread hold better for Spanning Hypothesis of CPI and UNEMP than others. This shows that different segments of the term spreads have different macro variables spanned. For this reason, it is important to use this approach while developing macro fiance models in order to identify the best combination of term spread that can be used for the respective model.

5 Can different term spread combinations be used to explain future movements in macro variables?

5.1 Explaining Future Movements Model Setup

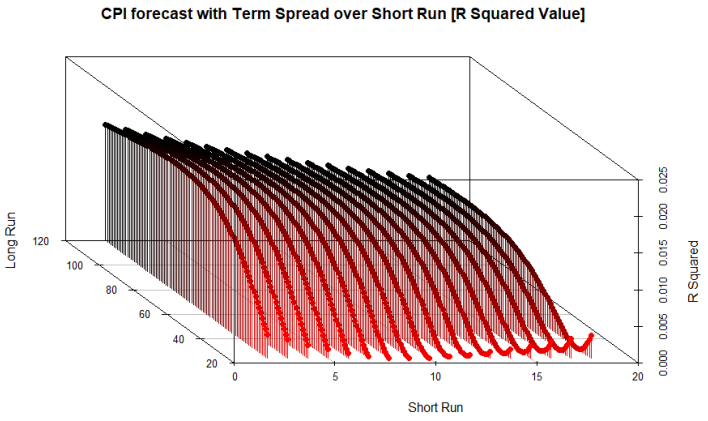
$$macro_t^m = \alpha^{(i,m,h)} + \beta^{(i,m,h)} TS_{t-h}^i + \varepsilon_t^{(i,m,h)}$$

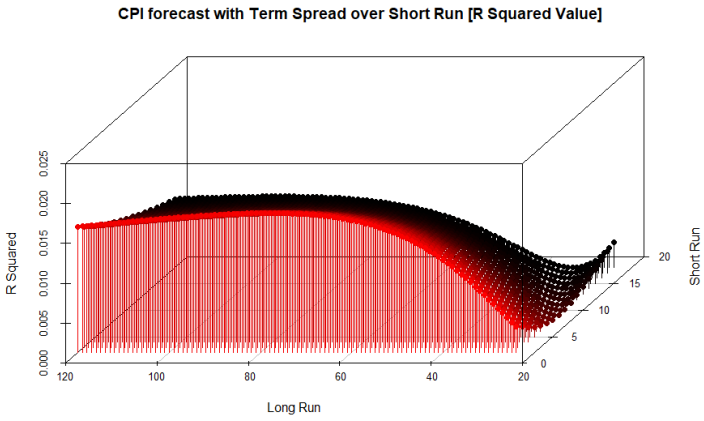
The following model was created, to check how different combinations of term spread explain future movements in CPI and UNEMP:

- **i:** {1,1649}
- $macro_t^m$: $\{\triangle\pi_t^{CPI}, u_t\}$
- $\triangle\pi_t^{CPI}$: Yearly Change in Inflation
- u_t : Civilian Unemployment Rate
- h : {3,120}months
- **t** indicates monthly data which ranges from 1995-01-30 **to** 2018-10-31 which is 286 observations for every single combination of term spread.
- Only the Yield Curve Term Spread was used to explain future movements in CPI and UNEMP over the short run (3 months) and the long run(10 years).

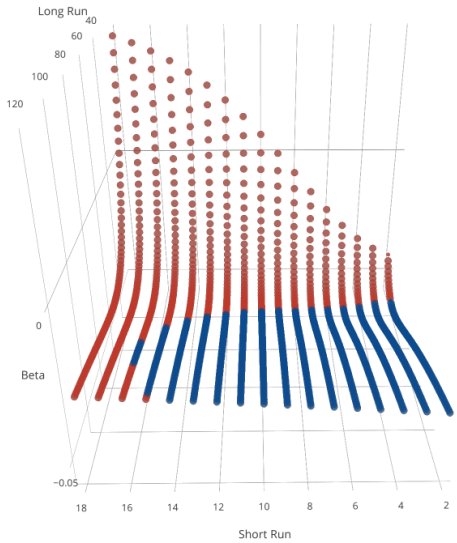
5.2 Major Results

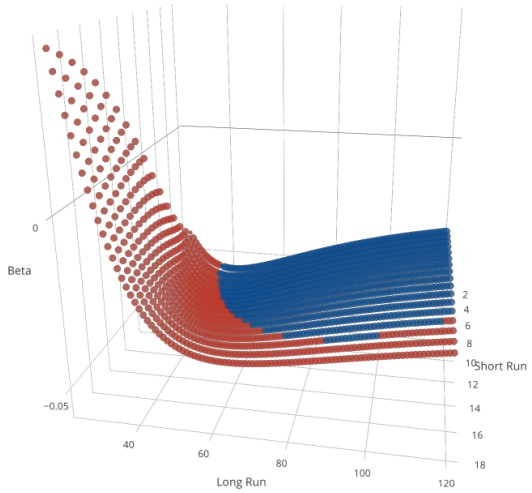
5.2.1 R Squared Value for CPI over the Short Run



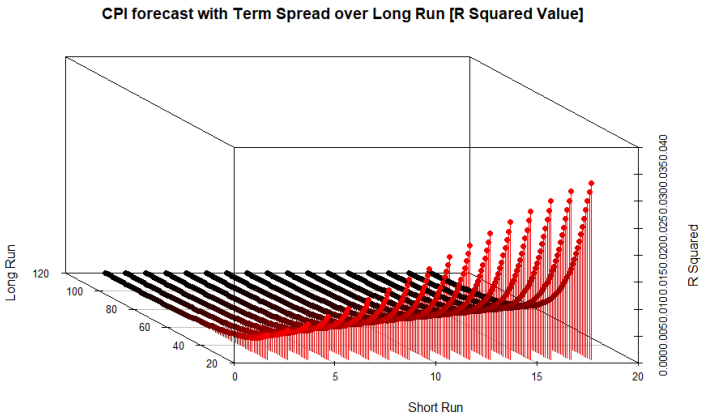


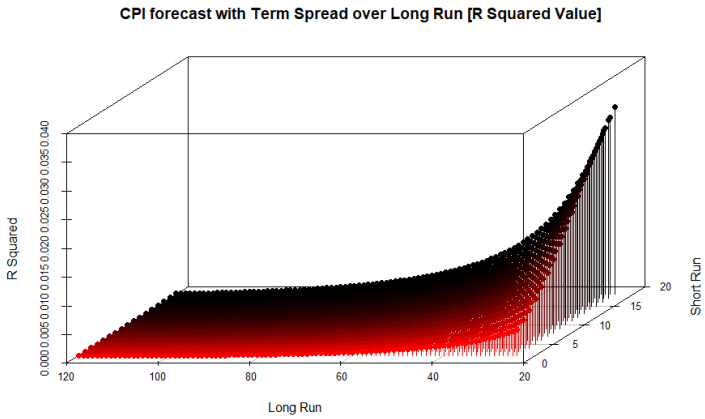
5.2.2 Beta Value and Significance for CPI over the Short Run



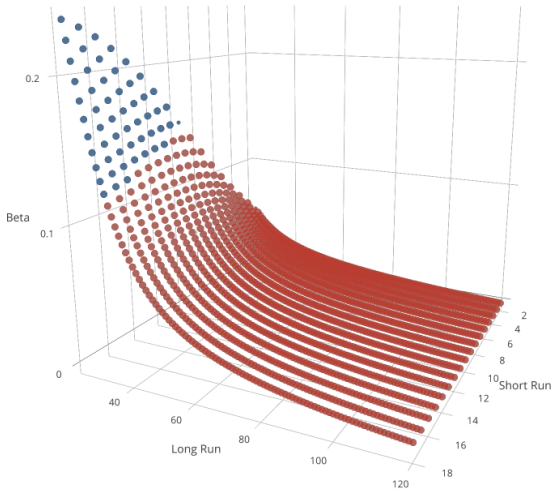


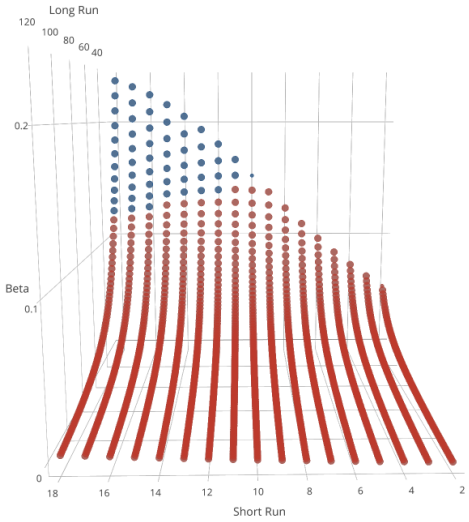
5.2.3 R Squared Value for CPI over the Long Run



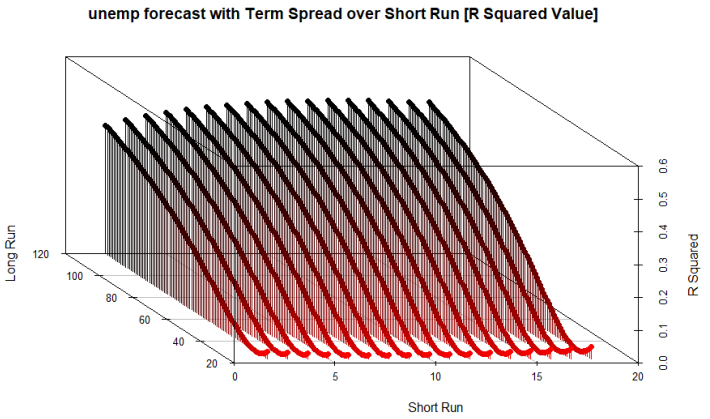


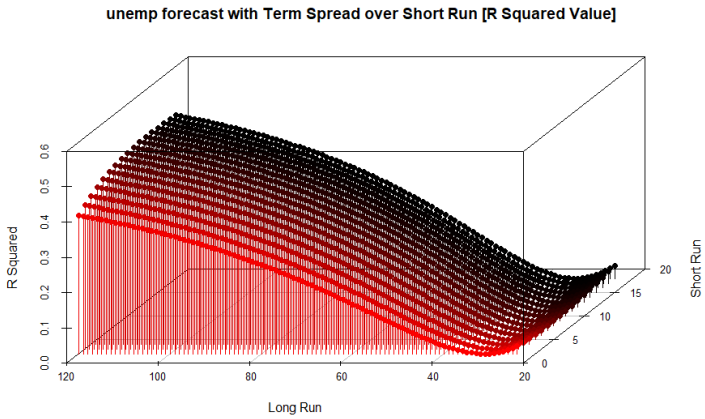
5.2.4 Beta Value and Significance for CPI over the Long Run



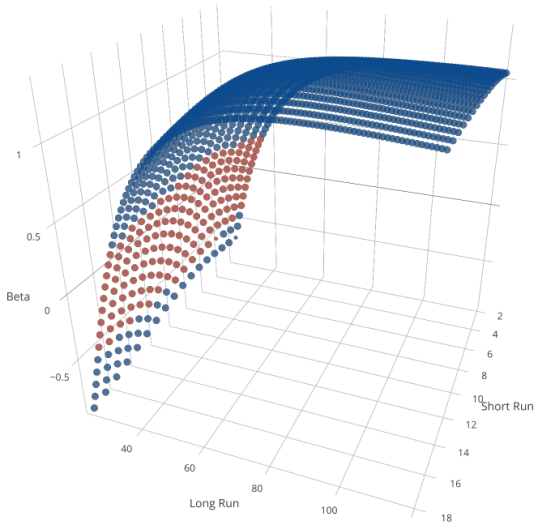


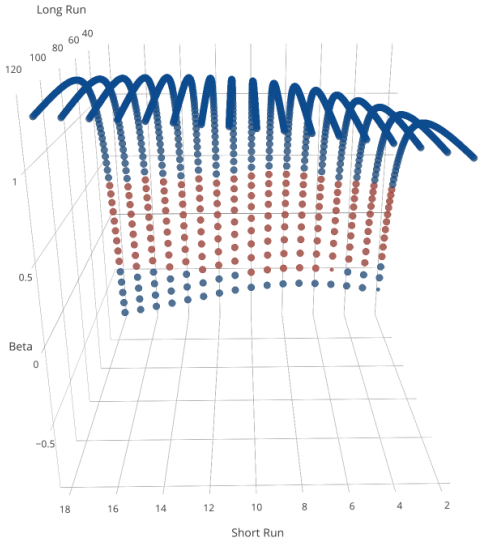
5.2.5 R Squared Value for UNEMP over the Short Run



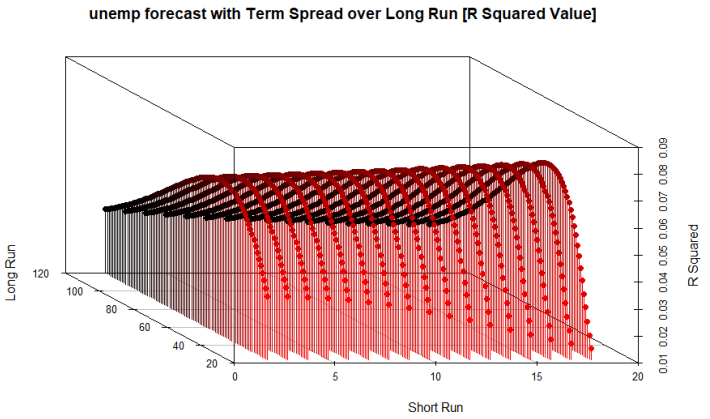


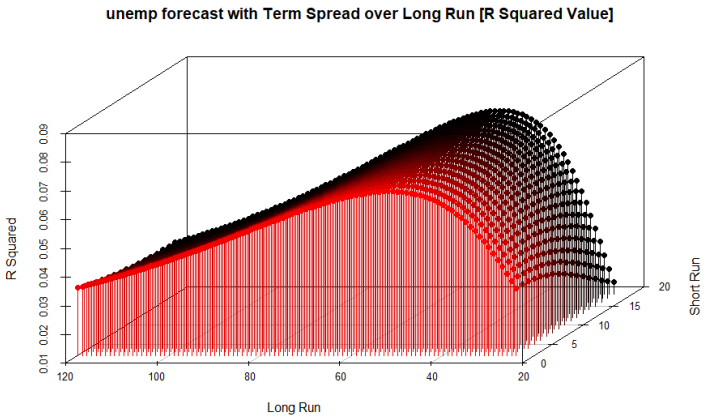
5.2.6 Beta Value and Significance for UNEMP over the Short Run



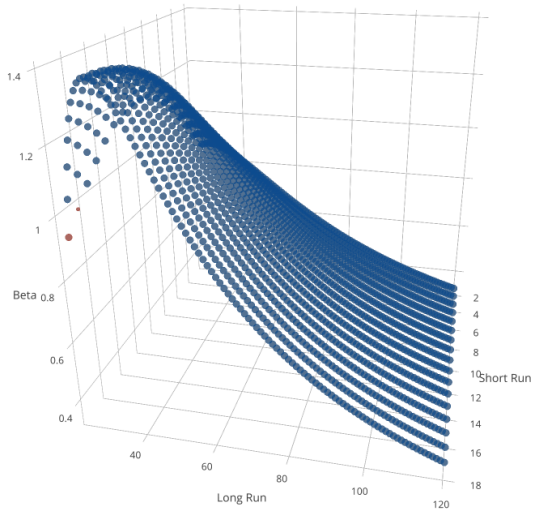


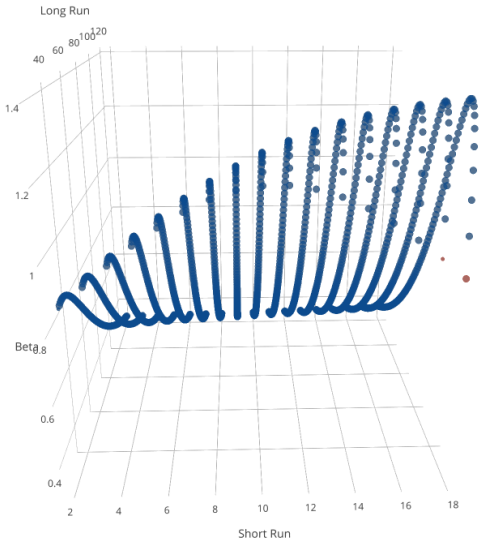
5.2.7 R Squared Value for UNEMP over the Long Run





5.2.8 Beta Value and Significance for UNEMP over the Long Run





5.3 Analyzing the Results

5.3.1 Interpretation

In the results above, The x-axis indicates the long term which ranges from 24 months to 120 months, the y-axis indicates the short term which ranges from 2 months to 18 months, and the z-axis indicates either the beta coefficient of the regression results of different term spread combinations against the macro variables being considered, or the r squared value . The blue color indicates significance level of at least 10 percent, while the red color indicates that the results are not significant.

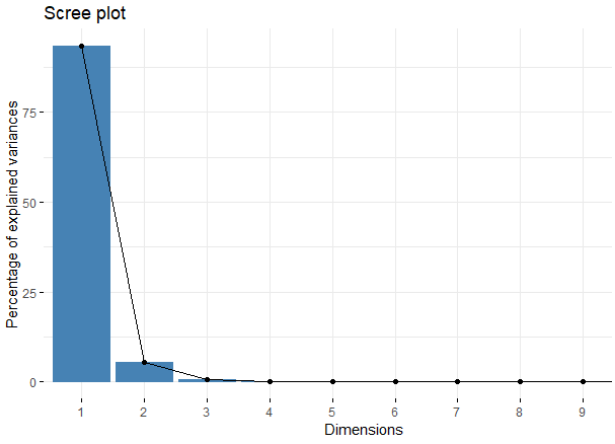
- **CPI,** appears to be better explained by different term spreads over the short and the long run. Over the short run, the significant combinations of term spread appears to have a negative impact on CPI. Indicating that a one percent increase in term spread will lead to up to 0.05 percent negative impact on the CPI in the economy. The R squared value appears the increase over the long run axis going until about 0.0175. Over the long run, the significant combinations of term spread appears to have a positive impact on CPI. Indicating that a one percent increase in term spread will lead to up to about 0.24 percent increase in CPI. The R squared seems to improve on the shorter end of the long run axis and the longer end of the short run axis going up to about 0.035. Stronger relation between CPI and term spread appears to exist over the long run. For short run, wider term spread appears to be significant in explaining CPI, while over the long run thinner term spread appears to be significant in explaining CPI.
- **UNEMP,** appears to be explained better over the short run rather than the long run. As over the short run the value of R squared goes up to about 0.5 while over the long run it only goes up to about 0.09. Both over the long and the short run, significant coefficients of term spread mostly appears to have a positive relationship with change in unemployment. Over the long run, almost all combinations of term spread appears to have a significant impact on unemployment, while over the short run, mostly only the term spreads along the longer end of the long run axis appear to have a significant impact on UNEMP.The shape of both the R squared curves and the beta coefficient curves for UNEMP appears to change over the short and long run horizon.

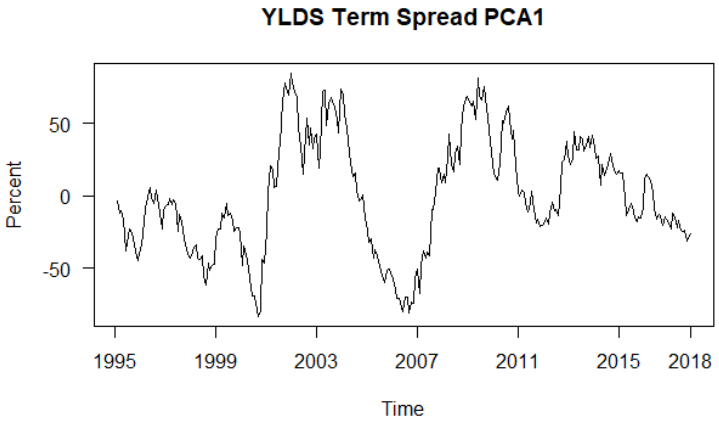
5.3.2 Major Takeaway

The results in this section indicate that different combinations of the term spread have varying power in explaining future movements in CPI and UNEMP. This approach can be used to identify the best combination of term spread that can be used to explain future movements in macro economic variables.

6 Can the 1st Principle Component Analysis of all different combinations of term spread give us the best possible term spread model?

6.1 1st PCA of all combinations of yield curve term spread.





- The first Principle Component Analysis appears to account for more than 80% of variance for all different combinations of term spread.
- The shape of the 1st PCA graph appears to be similar to that of most term spreads.
- The first PCA seems to go as high as 50 percent or more and as low as 50 percent of less.
- This is surprising, because most term spreads do not have such high values.

6.2 Using 1st PCA to explain macro variables

6.2.1 Regression of CPI against 1st PCA

$$CPI_t = \alpha + \beta_1 PCA_t + \varepsilon_t$$

Table 3

	Dependent variable:
	us.cpi
us.termspread.pca1	-0.001
	(0.0004)
Constant	0.182^{***}
	(0.016)
Note:	*p<0.1; **p<0.05; ***p<0.01

6.2.2 Regression of UNEMP against 1st PCA

$$UNEMP_t = \alpha + \beta_1 PCA_t + \varepsilon_t$$

Table 4

	Dependent variable:
	us.unemp
us.termspread.pca1	0.024^{***}
	(0.002)
Constant	5.789^{***}
	(0.080)
Note:	*p<0.1; **p<0.05; ***p<0.01

6.2.3 Interpretation

The first PCA only appears to be significant in explaining changes in unemployment and not in inflation. A 1% change in first PCA appears to cause a 0.024% change in unemployment.

6.3 Spanning Hypothesis Test for 1st PCA

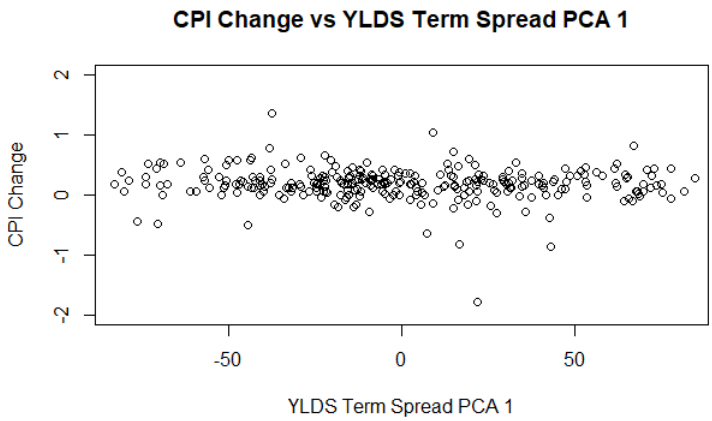
6.3.1 Regression of 1st PCA against CPI and UNEMP

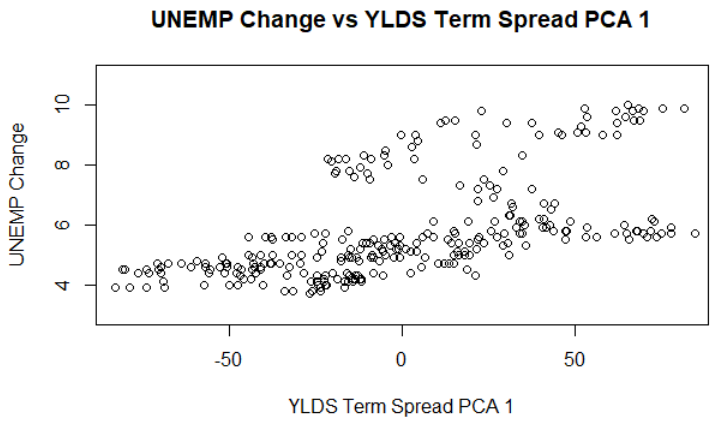
$$PCA_t = \alpha + \beta_1 CPI_t + \beta_2 UNEMP_t + \varepsilon_t$$

Table 5

	Dependent variable:	
	us.termspread.pca1	
	(1)	(2)
us.cpi	−12.477	−5.657
	(8.616)	(7.091)
us.unemp		13.577***
		(1.151)
Constant	2.274	−77.562***
	(2.799)	(7.149)
Note:	*p<0.1; **p<0.05; ***p<0.01	

6.3.2 Scatter Plots of 1st PCA against CPI and UNEMP





6.3.3 Interpretation

The first PCA only appears to span for UNEMP and not for CPI. The UNEMP coefficient is significant at 1% level, while the CPI coefficient is not significant. However, in the scatter plots above, the first PCA seems to be more correlated with CPI than UNEMP. This might be an indication that the first PCA do adjust itself in accordance with inflation in the economy. Further research will be required to identify the efficiency of the first PCA of different combinations of term spreads in spanning different macro variables.

6.4 Main Takeaway

The first Principle Component Analysis of all different combinations of term spread does not appear to give us the best term spread to use. This is because it helps to explain some macro variables such as UNEMP, while fails to explain others such as CPI. This result can also be seen in spanning hypothesis test as it adjusted in accordance with change in unemployment but not in accordance with inflation.

7 Conclusion

The cross section of all different combinations of term spreads appear to reveal important information about movements in the economy. The dispersion of the all combinations of term spreads from a standard term spread can be used to understand the pricing of risk premium in the bond market. Different combinations and components of term spread have varying power in explaining movements in macro variables in the economy. They also have varying power in spanning for different macro variables. The first principle component analysis appears to account for more than 80% variance of all different combinations of term spread but it still does not appear to be the best term spread to use as it only fails to explain changes in some macro variables. This indicates that the only best way to identify the best combination for a term spread is to look at all possible different combinations of a term spread and then pick the ones that are more relevant to your specific model. This paper provided you with a mechanism which you can use to identify the best term spread in order to understand the macro economic variable of your interest. Further research will be required to not only come up with economic intuition for varying results of different combinations and components of term spreads in explaining macro variables, but also to understand its relation with changes in financial variables.