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Forecasting macroeconomic variables through the term structure of interest rates in Portugal

Research Master's Thesis submitted by:
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Abstract

During the second half of the 20th century, researchers started to notice that the slope of the yield curve could predict the evolution of the economic activity of a country, especially the US, in the near future. This included the prediction of recession periods after a big decrease or even an inversion of the yield curve, which was measured by the term spread of interest rates, i.e. the difference between the long-term and short-term interest rates. This study, whose focus is the analyses of this relationship between the term spread and the Portuguese GDP growth, found a significant relation between the GDP growth with the values of the term spread of the 1st, 7th and 8th trimesters prior to it. But, while performing the out of sample testing, the results obtained were extremely poor, especially considering the r-squared of the estimated values between the end of 2005 and 2008 with the information available in 2005 was lower than zero, which means that an horizontal line describes better the actual data than the model. Besides that, while analysing the effects on the Portuguese recessions, it is visible a drop before the 2002 crisis, a negative term spread at the beginning of the subprime crisis and an abrupt stop of a steep increase of the term spread before the debt crisis.

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Introduction

The ability to predict correctly the output one, two or more periods in the future is something that would be appreciated by most due to the high importance that these predictions take in the decision-making process for several sectors in the economy. For example, investors use predictions about the economy in order to make their strategies and central banks when writing their policies take into account whether the state of the economy is expected to be expansionary or recessionary.

Over the years there has been some discussion on the predictive ability of the term spread of interest rates, i.e. the difference between the long-term and the short-term interest rates, when it comes to the output. This is idea was primarily proposed by Stock and Watson (1989). The authors found that the term spread of interest rates was extremely useful when predicting the future GDP of the US.

This relationship was later further analysed, and several authors try to explain the reasons behind it, but no consensus has been reached concerning the why. On the other hand, researchers agree that indeed there is a relationship between the term spread and output, even though it was more visible before the 1980s, according to D'Agostino, Giannone, and Surico (2006).

When the term spread has a big decrease, the literature has shown that it is usually followed by a recession. Sometimes the term spread even reaches negative values, which are unnatural if we think that usually the long-term interest rates are higher due to the risk associated with higher maturities.

Due to the fact that usually countries have some specific and different characteristics among them, and the literature is focused mainly on the US and the UK, I decided to choose my home country, Portugal, to be the centre of this study. So, this report will analyse the predicting abilities of the term spread when it comes to the Portuguese GDP and also to predict recessions.

It is important to keep in mind that the aim of this study is not to find a model that better describes the growth of the Portuguese GDP, but to analyse the relationship between the Portuguese GDP growth and the terms spread of interest rates through a simple regression model with the term spread as the only regressor, as suggested by Haubrich and Dombrosky

(1996). In order to better analyse this relationship, besides doing the regression with all the available data, I will also perform out of sample testing that can possibly contribute in a positive way to strengthen the relationship that I am trying to find.

Although it will be possible to see on this study a significant relation only between GDP growth with the values of the term spread of the 1st, 7th and 8th trimesters prior to it, it will be more visible the drop of the term spread before a recession, especially before the 2002 and the subprime crisis. The poor results obtained in this study, particularly in the out of sample test, may be due to the small quantity of data available.

This study contains several parts. One is the literature review of the main ideas on the subject of the relationship between the output and the term spread of interest rates, starting by talking about business cycles, mentioning the possible theoretical reasons behind the predicting ability of the term spread and terminating with the main empirical evidence until the moment. The other parts are all the analysis that I will perform on the term spread and its connection with the GDP, and, at the end, the concluding remarks.

Literature Review

Business cycles

Recessions and expansions go hand in hand when it comes to business cycles, since when the end of one is the beginning of the other. Arthur Okun defined the beginning of a recession or the end of an expansion as the first two consecutive quarters of decline in real GDP. For the opposite, meaning the beginning of an expansion or the end of a recession, he defined it as the first of two consecutive quarters of growth of real GDP. These moments, the beginning and end of an expansion or a recession are called the turning points in real GDP, that can be a peak or a trough. A peak is the beginning of a recession, while the trough is the end.

Burns and Mitchell (1946) define business cycles as "a type of fluctuation found in the aggregate economic activity of nations that organize their work mainly in business enterprises: a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle; this sequence of changes is recurrent but not periodic; in duration business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own."

This definition shows us three things really important that define the business cycles: duration, for the recession should be long; depth, since the output should suffer a substantial decline; and diffusion, because it should not be isolated, meaning it has to touch several sectors of the economy. So together, diffusion, depth and duration are the three Ds, some of the main characteristics of business cycles. (Negro, 2001)

The leading indicators (LEI) are usually preferred to econometric models because they are easier to understand and more intuitive to the general public. Even though models are more complex than the other, they both suffer from the same evil: they are really good at predicting past recessions. For the econometric models, it means that they work really well in-sample, since they were estimated based on past recessions, which is not a guarantee that it will have the same ability to predict a future recession, the out-of-sample performance of the model. For the LEI, the list is regularly updated with new information that indicates that some of the items were not good predictors after all. (Negro, 2001)

The term spread and its predicting ability

To understand better this possible explanation for the relationship between the term spread and the economic activity, it is important to keep in mind the expectations hypothesis of the term structure of interest rates, which states that the long-term interest rates are a sum three things: current short-term rates, the expectation on future short-term rates and a term premium. The term premium is the main reason why the yield curve is upward sloping but there can be an inversion of the slope if the short-term interest rates expectations decrease. (Wheelock &. Wohar, 2009)

The slope of the yield curve, usually represented by the spread between long-term and short-term government bond rates, is considered by several authors a significant variable in regressions whose objective is to predict economic indicators such as inflation or real GDP growth. The strongest results in these predictions in literature occur in European and North American economies. (Estrella, 2005)

Although it appears that the term spread of interest rates has some predicting abilities, the theory behind it is still unknown or, at least, not consensual among different authors. Benati and Goodhart (2008) mentioned that the term spread predicting ability remains a "stylized fact in search of a theory".

Monetary Policy as an explanation

One explanation that has been supported by several economist is the fact that a contration in the monetary policy leads to a flattening of the yield curve and, also, to a downturn in inflation and in economic activity, usually with a lag. (Estrella, 2005)

Arturo Estrella (2005) defends that monetary policy is not the only factor related to the predictive power of the yield curve when it comes to output growth. The author has the opinion that the predictive powers rest more on the structure of the macroeconomy and on the magnitude of the reaction parameters. This thought is based on the fact that, first, monetary policy is reactive when there are deviations of output from potential, which means that the magnitudes of the reaction parameters are the most important factor for the predicting relationships. Second, there are certain output goals that the monetary authority intends to reach

and, so, the yield curve predictive power depends extremely on the structure of the macroeconomy.

Theory of intertemporal consumption as an explanation

Besides the theories based on the monetary policy, there are the ones based on intertemporal consumption. Harvey (1998) defends that consumers in general lower their consumption if their income is decreasing, but when it is rising, they usually prefer a stable consumption instead of a higher one. These facts translated to the financial markets, it means that when people expect a recession, they will want some kind of security for the expected trying times. So, they sell the instruments with the shortest maturities and buy some that could provide some income for them in one year, when they expect the recession to hit. If the offer of the short-term interest rates increases and the demand decreases, the price will go down, and so the interest rates decrease. This will cause the term spread to diminish or a flattening of the yield curve.

The theory has some implications on the term structure that is adjusted for expected inflation, the real term structure. The main problem that arises from these implications is related to the empirical evidence. Most of the empirical evidence refers to the nominal term structure instead of the one adjusted to inflation. So, although apparently this theoretical explanation does not align perfectly with the empirical evidence, it all depends on the inflation persistence. If inflation follows a random walk, then the expected inflation would suffer shocks permanently always by a similar amount, which means that the slope of the yield curve of the nominal interest rates would not suffer from the inflation shocks. But if it is the other way around, meaning if the inflation does not follow a random walk and therefore has little persistence, the inflation change will have a bigger effect on close expected inflation timewise than on the long-term one, having then an impact on the yield curve of the nominal interest rates. In conclusion, the theoretical explanation based on intertemporal consumption is consistent with the empirical evidence if inflation follows or were to follow a random walk. The persistency of the inflation is also connected to the monetary regime in place. The higher persistency is usually observed in fiat monetary regimes, while the metallic and inflation-targeting ones show little persistence when it comes to inflation. (Wheelock &. Wohar, 2009)

Empirical evidence

There are many studies about the term spread of interest rates and its ability to predict the evolution of the economic activity. These studies support the idea that the term spread can predict variations in the output until one year in advance, but the quality of these predictions can differ over time and according to the country. Another interesting and important fact is that the term spread predicting ability has diminished in the most recent years, but it can still be really useful when detecting recessions in the upcoming future. (D'Agostino, Giannone, and Surico, 2006)

The yield curve at a given moment in time is a plot of the yields for different maturities of similar or comparable securities. Usually the yield curve is upward sloping, meaning the yield of the long-term interest rates is higher than the short-term interest rates, which makes sense because for a greater maturity, the interest rates should be bigger, meaning, for example, if you lend money for five years, you would charge a higher rate than if the loan would be for 3-years maturity. Researchers have found that the slope of the yield curve has a connection with recessions, especially the fact that a sharp drop in the slop of the yield curve is followed by a recession. Sometimes this decline of the slope is immensely high and there is an inversion of the curve, meaning the shortest maturities reach higher values than the long-term securities. This situation can be clearly observed in the following graph. (Wheelock &. Wohar, 2009)

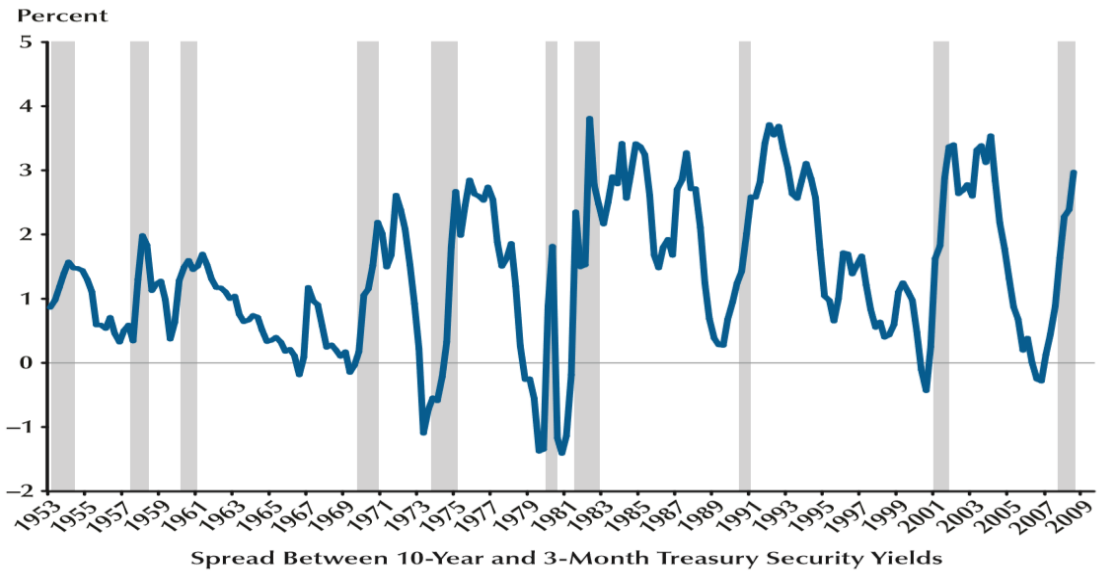

Figure 1 - Evolution of the US term spread with the recession's periods in grey. Source: Wheelock and Wohar (2009)

This graph shows us the term spread of the 10-year and 3-month US Treasury securities, with the grey areas in the background symbolizing the periods defined as recessions by the National Bureau od Economic Research. We can distinctly see that from 1953 until, at least, 2009, every recession in the UK has been preceded by a sharp decrease of the term spread of the interest rates, meaning a decline of the slope of the yield curve. There were even some occasions where an inversion of the curve did occur. Furthermore, not only every recession follows a big drop of the yield-curve slope, but also almost every sudden decline of the slope is followed by a recession. The only exception is in 1966 where we can see a fall of the term spread and the next recession only happens after another sharp drop down the line.

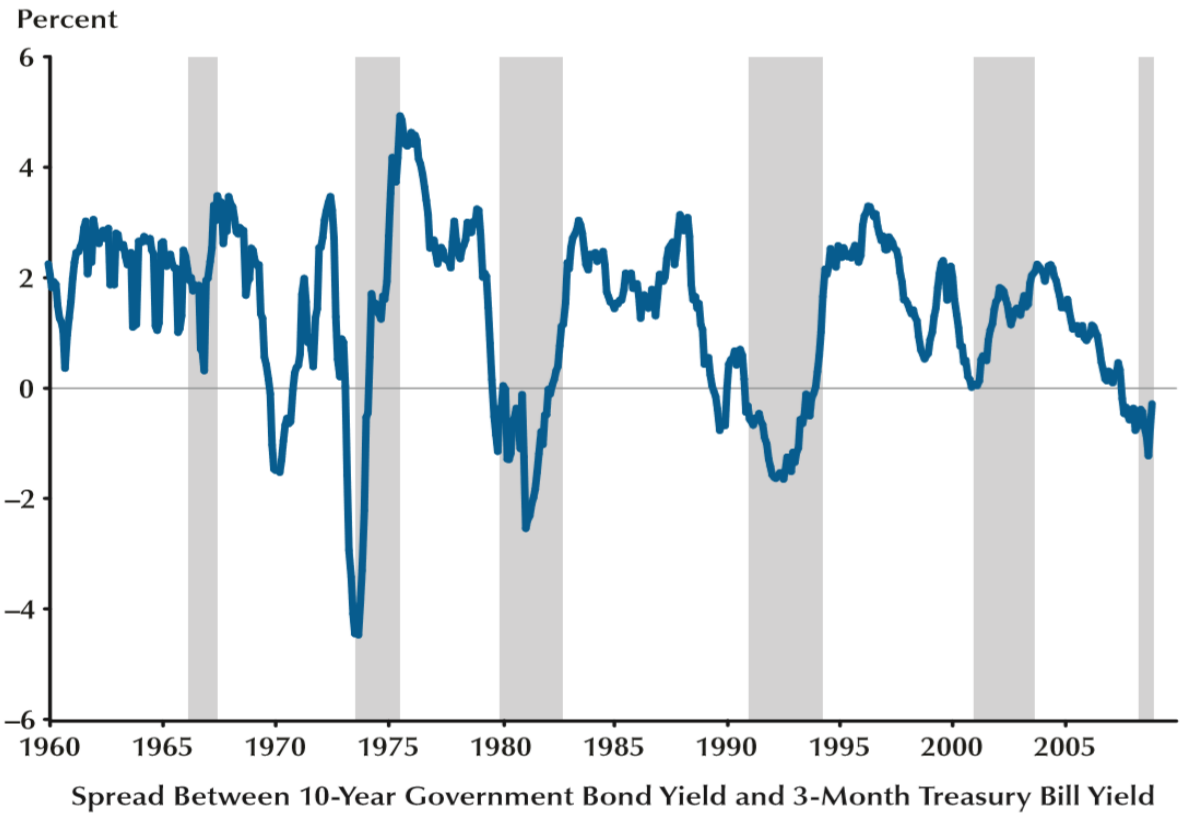

Figure 2 - Evolution of the Germany term spread with the recession's periods in grey. Source: Wheelock and Wohar (2009)

This picture shows us the same information as the previous one, but in respect to Germany, being the term spread between the 10-Year Government Bond Yield and the 3-Month Treasury Bill Yield and the recessions were defined by the Economic Cycle Research Institute.

In the German case, we can say that every recession followed a sharp drop of the term spread, with the only exception being the recession starting in 1970. There was a drop of the

term spread anticipating this recession, but before it started, the term spread rose again, which means that the recession was not immediately preceded by a fall of the term spread of the interest rates.

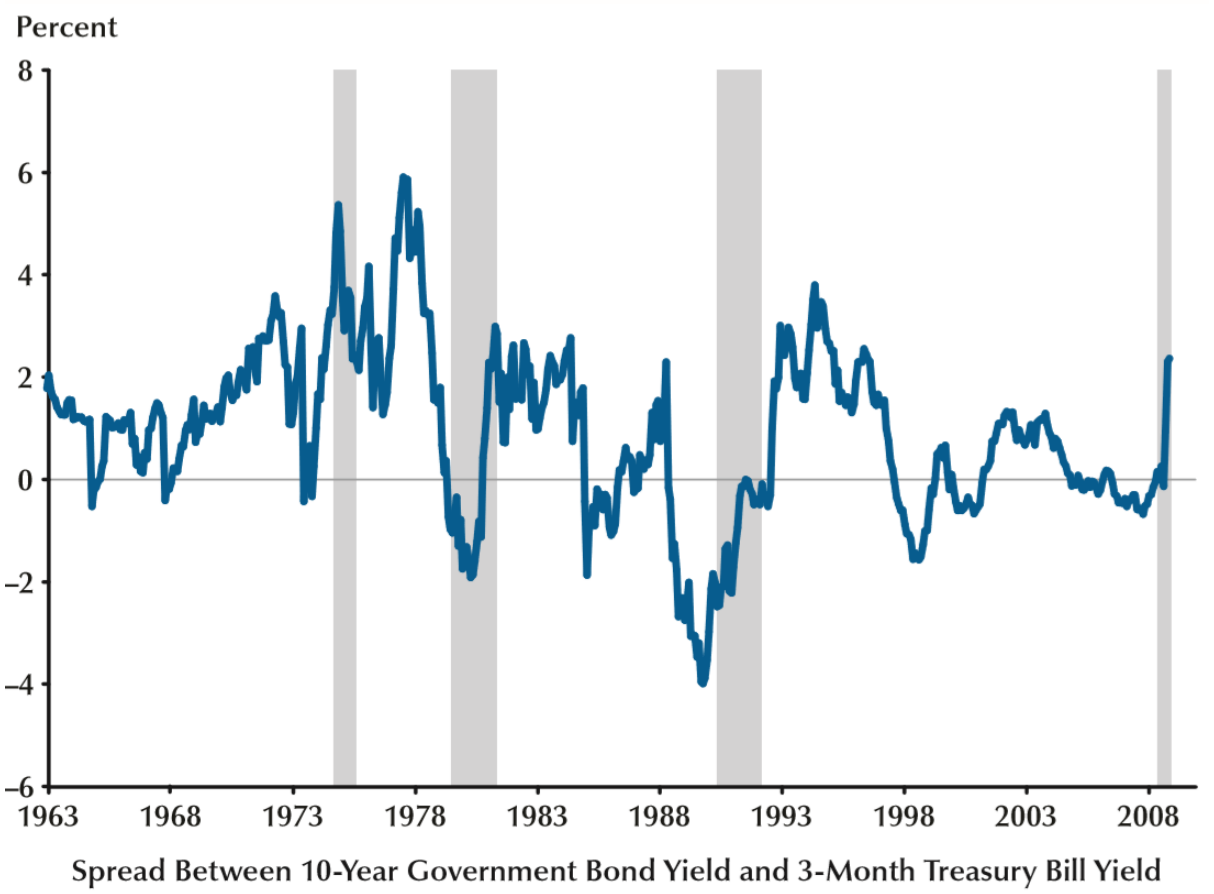

Figure 3 - Evolution of the UK term spread with the recession's periods in grey. Source: Wheelock and Wohar (2009)

This graph shows us the same information as the previous ones, but in respect to the United Kingdom, being the term spread between the 10-Year Government Bond Yield and the 3-Month Treasury Bill Yield, and the recessions were defined by the Economic Cycle Research Institute.

This picture shows that the UK recessions were always preceded by an inversion of the yield curve.

The studies also show a positive correlation in the US between the real GDP growth and the term spread lagged by one quarter, meaning the higher the difference between the long and the short interest rates (the slope of the yield curve), the higher the growth of the real GDP in the following period. (Wheelock &. Wohar, 2009)

Methodology

In order to explore the relationship between the term spread of interest rates of the Portuguese Government and the economic activity of the same country, I used a simple regression model whose independent variable is the difference between the 10 years and 3 months interest rates and the dependent variable is the real GDP growth.

Taking into account the available data, I was able to assemble values from all the variables with a quarterly frequency. This gives me already a reasonable number of observations while if the data frequency were to be annual, it would be a much too small number.

The following equation represents the model used in this report, where we can test if the term spread of period can influence the growth of the real GDP of the following period.

$$RealGDPgrowth_t = \alpha + \beta * Termspread_{t-i} + \mathcal{E}_t \quad (1)$$

The $RealGDPgrowth_t$ was calculated as the percentage growth of the real GDP in the time period between *t-1* and *t*. The $Termspread_{t-i}$ is the difference between the 10 years interest rates and the 3 months interest rates of the Portuguese Government at the moment *t-i*, which represents the slope of the yield curve in *t-i*. Due to the fact that we will observing the effect on the GDP of the term spread until 2 years in the past, *i* will take the values 1, 2, 3, 4, 5, 6, 7 and 8. α is the constant element in this model, while β is the coefficient of the *Termspread* variable. $\mathcal{E}_t$ is the residual error in *t*.

Before performing the first regression, it is necessary to do the Unit Root test in order to verify if the term spread series is stationary, meaning its mean and autocovariances do not depend on time. If that is the case, we are able to make some inferences and draw some conclusions based on this series.

By performing the AFD test on Eviews, I came to the conclusion that the term spread series only got a significant positive value for the stationary test at 1st difference and not at level, with a 10% significance level.

This problem was solved by doing a regression of the term spread on a dummy variable that took the value one in the periods between 2010 and 2014 and zero the remaining periods. I performed the same AFD test to the residuals of this regression ($\mathcal{E}'_t$) and they were stationary.

$$Termspread_t = \beta * Dummy_t + \mathcal{E}'_t \quad (2)$$

So, instead of the equation 1, we will have a new equation (2) translating the relationship between the growth of the Portuguese GDP and the slope of the yield curve of interest rates.

$$RealGDPgrowth_t = \alpha + \beta_1 * TermspreadR_{t-i} + \beta_2 * Dummy_{t-i} + \mathcal{E}_t \quad (3)$$

Where, among the differences from the previous equation, there is the $TermspreadR_{t-i}$, which is the variable representing the residuals of the regression of the term spread on the dummy variable at the moment *t-i*. As explained before, *i* will take the values 1, 2, 3, 4, 5, 6, 7 and 8. The *Dummy* is the same dummy variable used in order to obtain the stationary residuals. β_1 and β_2 are the coefficients of the *TermspreadR* and the *Dummy*, respectively.

I will also be performing in and out of sample testing to verify the quality of the model. The in-sample period will be from the beginning of the sample (1995) until the first semester of 2005 inclusive. The out-of-sample period will start at the end of the in-sample and finish at the end of 2008. This is a very important process since the idea is to try and predict what would be the GDP growth from the second semester of 2005 until 2008 with the information available until the end of the first semester 2005 and then compare the predictions with the actual values that occurred.

In order to analyse the quality of the regression model and the estimations in the out of sample test, I will analyse the R-squared and the Mean Absolute Deviation (MAD) values.

The R-squared was calculated by the following formula:

$$R^2 = 1 - \frac{\sum_{t=1}^{T}(y_t - \hat{y}_t)}{\sum_{t=1}^{T}(y_t - \bar{y}_t)} \quad (4)$$

They are both useful but in different ways. While the MAD shows us the average deviation, meaning how far is in average the model or the predicted values from the actual ones, the r-squared indicates how much the actual values are explained by the model in question. For example, the maximum r-squared is 1, which represents the perfect fit between the model and the actual values.

Results and Analysis

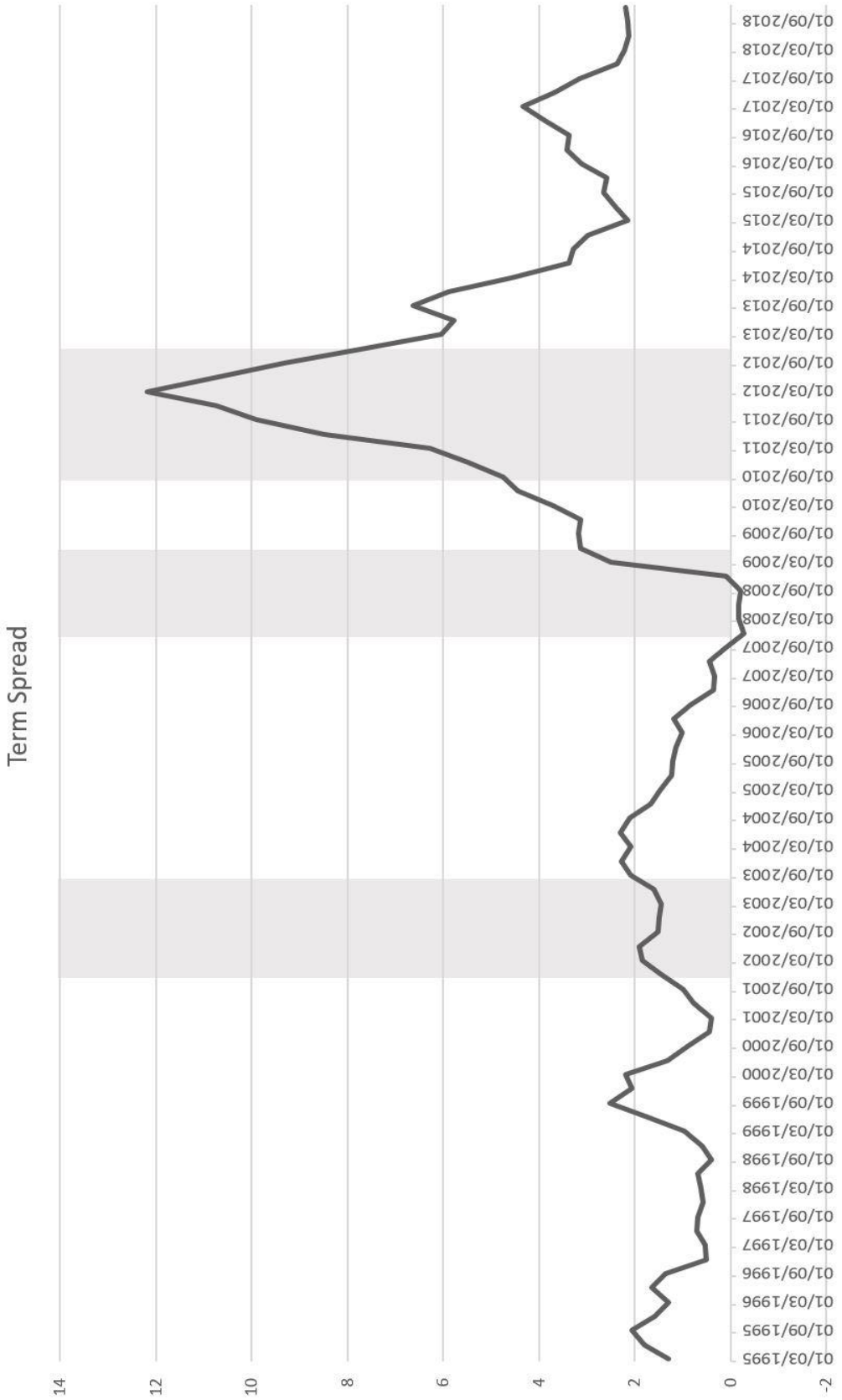

Figure 4 - Evolution of the Portuguese term spread with the recession's periods in grey in the background.

In the graph above, we can see the Portuguese term spread over time, with the grey periods in the background indicating the recessions Portugal went through during this period. The recessions were established by the Banc of Portugal, that requires a minimum decrease of the GDP growth for two consecutive periods of three months.

We can clearly observe a drop of the term spread before the crisis of the new millennium starting in 2001 and also before the subprime crisis, when it reaches negative values. When it comes to the debt crisis starting at the end of 2010 we do not see a big drop of the term spread but we can observe a break in the steep increase of the term spread that had been occurring at the end of the subprime crisis. There is the possibility that we cannot observe a clear drop of the term spread of the interest rates in this specific period because the crisis are not far apart, only being separated by a little more than a year.

The abnormal values of the term spread of the interest rates in years of 2011 and 2012, during the debt crisis, can possibly be explained by the risk premium required for the long-term interest rates. Since Portugal was under a debt crisis, there was a problem of trust in the ability of the government to repay the bills and the bonds, which may have caused the extremely high value during this period.

There are two big decreases of the term spread that are not immediately followed by a recession which are in 1996/1997 and 2014/2015.

From the graph we can not clearly say that a drop of the yield curve slope leads to a recession, but we can see that all of Portuguese recessions, with the exception of the debt crisis, in this period were preceded by a drop of the term spread. The debt crisis although it was not preceded by one, there was the fact that it was extremely close timewise to the previous recession and before there was a sudden stop in the increase of the term spread that had been happening during the subprime crisis.

Regression

As mentioned in the methodology, I performed regressions with the data from 1995 of the GDP growth on the values of the term spread of the trimesters that preceded it with a limit of 2 years.

1 lag	Coefficient	P-value
Constant	2,569676	0,0000
TermspreadR	-0,29348	0,0331
Dummy	-3,658105	0,0000
Prob (F-statistic)	0,000109	
R-squared	0,181764	
MAD	2,1252592	

Table 1 - Regression results for the term spread of one trimester behind of GDP (t-1).

As we can see from the table 1 with the regression results for the lag of one period, the p-value (0.0331) of the coefficient of the $TermspreadR$ variable is smaller than 0.05, which means that we reject the null hypothesis for β1 and it is significant for a 5% significance level. So, for an increase of 1% in the $TermspreadR$, there is a decrease of 0.420348% of the GDP growth, ceteris paribus. Meaning that an increase of 1% in the stationary part of the term spread leads to a decrease of 0.420348% of the GDP growth. Furthermore, the Prob(F-statistic) is 0.000109, which means that the model is overall significant explaining the GDP growth variable for a 5% significance level.

There is an interesting factor when we look at the coefficient of the dummy variable, which is significant (p-value = 0.0000) for a 5% level. We can observe that the value of the coefficient is -3.658105, which implies that in the period where the dummy variable holds the value 1, the GDP decreases more 3.658105% when compared to the other time periods, ceteris paribus.

7 lag	Coefficient	P-value
Constant	0,916384	0,0611
TermspreadR	0,464334	0,0306
Dummy	-1,519757	0,0787
Prob (F-statistic)	0,002546	
R-squared	0,131118	
MAD	2,3441984	

Table 2 - Regression results for the term spread of seven trimesters behind of GDP (t-7).

When using the term spread values of 7th period before the GDP growth value, we can observe that the $TermspreadR$ have a significant coefficient for a 5% significance level (p-value = 0.0306). We reject the null hypothesis and so for a 1% increase in the residuals, there

is a 0.464334% increase in the growth of the GDP seven periods in the future. Furthermore, the dummy variable is not significant, so we do not reject the null hypothesis.

8 lag	Coefficient	P-value
Constant	0,827159	0,0933
TermspreadR	0,449056	0,0418
Dummy	-1,172338	0,1772
Prob (F-statistic)	0,010536	
R-squared	0,102735	
MAD	2,365971064	

Table 3 - Regression results for the term spread of eight trimesters behind of GDP (t-8).

When using the term spread values of 8th period before the GDP growth value, we can observe that the $TermspreadR$ have a significant coefficient for a 5% significance level (p-value = 0.0418). We reject the null hypothesis and so for a 1% increase in the residuals, there is a 0.449056% increase in the growth of the GDP seven periods in the future. Furthermore, the dummy variable is not significant, so we do not reject the null hypothesis.

2 lag	Coefficient	P-value
Constant	2,240928	0,0000
TermspreadR	-0,201545	0,3189
Dummy	-3,501368	0,0001
Prob (F-statistic)	0,000235	
R-squared	0,169495	
MAD	2,171313886	

3 lag	Coefficient	P-value
Constant	2,028033	0,0000
TermspreadR	-0,081291	0,6904
Dummy	-3,269551	0,0002
Prob (F-statistic)	0,000473	
R-squared	8,354410	
MAD	2,203724108	

4 lag	Coefficient	P-value
Constant	1,698837	0,0006
TermspreadR	0,102704	0,6198
Dummy	-2,829494	0,0013
Prob (F-statistic)	0,001034	
R-squared	0,144649	
MAD	2,249156109	

5 lag	Coefficient	P-value
Constant	1,374206	0,0054
TermspreadR	0,256488	0,2185
Dummy	-2,354641	0,0069
Prob (F-statistic)	0,001574	
R-squared	0,137889	
MAD	2,278794652	

6 lag	Coefficient	P-value
Constant	1,189436	0,0157
TermspreadR	0,309359	0,1422
Dummy	-1,971224	0,0234
Prob (F-statistic)	0,003809	
R-squared	0,121503	
MAD	2,306622003	

Table 4 - Regression results for the term spread of two, three, four, five and six trimesters behind of GDP (t-2, t-3, t-4, t-5 and t-6).

All the other tests resulted in a non-significant coefficient for the $TermspreadR$, meaning we do not reject the null hypothesis. This means that the term spread does not predict the growth of the Portuguese GDP 2, 3, 4, 5 and 6 trimesters in the future.

Now I will focus on the significant results. The 1st, the 7th and the 8th period behind the GDP show a significant coefficient for the $TermspreadR$ but while in the 1st one it is a negative value, in the other ones, it is a positive value. This seems to be contradictory information because one is saying that when the term spread increases, the GDP growth decreases, while the others are saying the opposite, that when the term spread increases, the GDP growth increases.

If we look at the values from the 1st until the 8th what happens is an increase of the coefficient that starts negative and reaches positive values in the 8th period, which explains the non-significant coefficients in between the 1st and the 7th, since it was the moment where the coefficients were extremely close to zero, being harder to reject the null hypothesis. This change in signal means that according to the results, the most recent term spread has a negative influence in the GDP growth, while the oldest ones have a positive one.

When it comes to the R-square, one of the elements that measures the quality of the model, we can see that all the results are poor, all in the interval between 0.10 and 0.20. These values of the R-square although it is not good, we have to take into consideration that it is a model to predict the GDP growth with only one independent variable.

When we look at the Mean Absolute Deviation (MAD), the values are between 2.12 e 2.37, which are not small values, especially when we take into account the fact that the dependent value is always between the values -9.20 and 8.91, approximately. This means that the MAD is between 10% and 15% of the universe of values of the GDP growth.

It is also important to notice that the MAD increases from the 1st until the 8th period in analysis and the 1st period is also the one with the better r-squared.

Out of sample

In order not to incur in any problem with the non-stationary term spread, I chose to do the out of sample testing before the term spread series becomes non-stationary. I did the regression for the first ten years of data, meaning from 1995 until 2005, and used the coefficient and constant obtained to predict the GDP growth until 2008.

1 lag	Coefficient	P-value
Constant	4,420861	0,0001
Termspread	-1,419389	0,0440
Prob (F-statistic)	0,043961	
R-squared	0,102545	

2 lag	Coefficient	P-value
Constant	3,883426	0,0008
Termspread	-1,012804	0,1616
Prob (F-statistic)	0,161589	
R-squared	0,052256	

3 lag	Coefficient	P-value
Constant	4,014853	0,0006
Termspread	-1,124452	0,1253
Prob (F-statistic)	0,125317	
R-squared	0,064032	

4 lag	Coefficient	P-value
Constant	3,925325	0,0010
Termspread	-1,072059	0,1584
Prob (F-statistic)	0,158406	
R-squared	0,056023	

5 lag	Coefficient	P-value
Constant	3,147215	0,0091
Termspread	-0,549478	0,4909
Prob (F-statistic)	0,490917	
R-squared	0,014063	

6 lag	Coefficient	P-value
Constant	2,635905	0,0280
Termspread	-0,23524	0,7727
Prob (F-statistic)	0,772694	
R-squared	0,002564	

7 lag	Coefficient	P-value
Constant	1,213466	0,3039
Termspread	0,916758	0,2818
Prob (F-statistic)	0,281841	
R-squared	0,036094	

8 lag	Coefficient	P-value
Constant	1,581912	0,1889
Termspread	0,544077	0,5343
Prob (F-statistic)	0,534263	
R-squared	0,012583	

Table 5 - Regression results for the term spread of all the periods until two years behind of GDP, from 1995 until 2005.

Since for all the time span, the only one which had a significant coefficient (for a 5% significance level) was the one with the term spread from the period before. So, I will only do the out of sample testing for the values obtained in that one.

R-squared	MAD
-1,380492222	3,225422355

Table 6 - R-squared and MAD of the predicted values of the out of sample test.

The value for the MAD is 3.22, which is a lot higher than the previous values. For the R-squared, the value calculated was -0.22 approximately. This value is lower than zero, which should be impossible. It is only explained by the poor fit of the model since the value means that the model fits worse than a horizontal line.

This means that even though it was a small sample, the model was not helpful in predicting the future GDP growth when using the information available at that moment in time.

Conclusion

Until today, as seen in the literature review, there has been a lot of speculation about the relationship between the output and the term spread of interest rates and its origins. Although there has not been a consensus about why this relationship exists, the literature is sure that there is a connection which was more visible in the 80s. Economists find it extremely interesting the ability of the term spread to predict not only the output growth but especially recessions, which are usually preceded by a big drop in the term spread of interest rates.

When applying this knowledge to the Portuguese case since 1995, I was able to observe the relationship between the term spread and the Portuguese recessions. Although it is not the case that a steep drop in the term spread always leads to a recession period, the 2002 crisis was preceded by a drop of the term spread and at the beginning of the subprime crisis, the term spread reached negative values and it had been overall dropping during the 2 to 3 years before. The debt crisis was the only one that was not preceded or coincided by a drop in the term spread, but we can see that there was an abrupt stop of the climbing of the term spread that had been taking place at the time.

When it comes to the model used to establish the relationship between the output growth and the term spread, the results were heterogeneous. Since 1995 until today, I found a significant relation between the GDP growth with the values of the term spread of the 1^{st}, 7^{th} and 8^{th} trimesters prior to it, while in the other periods it was not possible to reject the null hypothesis. According to the results, the term spread of the previous trimester has a negative effect on the current GDP growth and the ones 7 and 8 trimesters reveal to have a positive correlation. Even though the coefficients were significant, the R-squared and the MAD revealed that the results were not really good.

In conclusion, the regressions offered disappointing results with the term spread not revealing a good predicting power of the Portuguese GDP, but, on the other hand. when speaking of the recessions, the predicting power of the yield curve is higher.

It is important to keep in mind that the time span due to the availability of data used is small and it does not belong to the period where according to literature was more prominent, noticeable and visible the relationship between the output and the term spread of interest rates.

It would be interesting to continue to study the phenomenon that is this relationship and open up the research to other countries, especially the ones in development and not developed since there is less literature speaking about those countries' cases.

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Appendix A – Table with the GDP growth and the term spread over the years

Time	GDPgrowth	Termspread
30/06/1995	0,012497364	1,78967
30/09/1995	0,004520135	2,04633
31/12/1995	0,007288442	1,580996
31/03/1996	0,005980473	1,283333
30/06/1996	0,012535337	1,636667
30/09/1996	0,01461142	1,346667
31/12/1996	0,003882155	0,503334
31/03/1997	0,015024295	0,516667
30/06/1997	0,009045763	0,7
30/09/1997	0,013542491	0,679999
31/12/1997	0,006643087	0,57
31/03/1998	0,014217262	0,623333
30/06/1998	0,014677075	0,67
30/09/1998	0,0119704	0,39
31/12/1998	0,007422851	0,593334
31/03/1999	0,013196929	0,9626
30/06/1999	0,005232152	1,735933
30/09/1999	0,008785803	2,507266
31/12/1999	0,006662814	2,0502
31/03/2000	0,02229319	2,191033
30/06/2000	-0,005816336	1,317
30/09/2000	0,013999171	0,865733
31/12/2000	0,007591571	0,439166
31/03/2001	-0,002375404	0,384967
30/06/2001	0,008506164	0,765901
30/09/2001	0,001273654	0,982167
31/12/2001	0,013964105	1,453167
31/03/2002	0,002557818	1,844433
30/06/2002	-0,004527907	1,904
30/09/2002	-0,006091827	1,509334
31/12/2002	-0,00628374	1,494533
31/03/2003	0,000617499	1,448233
30/06/2003	-0,008001338	1,594433
30/09/2003	0,00748177	2,0791
31/12/2003	0,004904456	2,2647
31/03/2004	0,009137196	2,082734
30/06/2004	0,006072719	2,2972
30/09/2004	-0,001226617	2,101033

31/12/2004	-0,001797084	1,6694
31/03/2005	0,007567367	1,4617
30/06/2005	0,004189893	1,224067
30/09/2005	-0,006196786	1,193667
31/12/2005	0,002087692	1,133533
31/03/2006	0,00802064	0,995433
30/06/2006	0,009289042	1,1765
30/09/2006	-0,001710974	0,8233
31/12/2006	0,007349195	0,346533
31/03/2007	0,011177114	0,336494
30/06/2007	0,003916426	0,431228
30/09/2007	0,001742453	0,094856
31/12/2007	0,011044339	-0,276446
31/03/2008	0,000286373	-0,167883
30/06/2008	-0,005118264	-0,165539
30/09/2008	-0,002319681	-0,213426
31/12/2008	-0,013439635	0,089335
31/03/2009	-0,023002846	2,491056
30/06/2009	0,001343177	3,128548
30/09/2009	0,00935541	3,175783
31/12/2009	-6,10229E-05	3,131774
31/03/2010	0,009531451	3,6857567
30/06/2010	0,005590545	4,4278383
30/09/2010	0,001807883	4,7504156
31/12/2010	-0,002789162	5,477823
31/03/2011	-0,007515027	6,265853
30/06/2011	-0,004553937	8,482904
30/09/2011	-0,007450919	9,911883
31/12/2011	-0,015818254	10,733443
31/03/2012	-0,004336802	12,18014
30/06/2012	-0,013709528	10,6867666
30/09/2012	-0,010944176	9,3070013

31/12/2012	-0,016400575	7,7194137
31/03/2013	0,003040873	6,0342873
30/06/2013	0,007075466	5,761511
30/09/2013	-0,001206056	6,619516
31/12/2013	0,00952114	5,874537
31/03/2014	-0,004934011	4,5641307
30/06/2014	0,004111791	3,3622213
30/09/2014	0,001790948	3,2814843
31/12/2014	0,006442052	2,96823033
31/03/2015	0,006796599	2,13729967
30/06/2015	0,003970872	2,409866334
30/09/2015	0,001424047	2,644467
31/12/2015	0,00347476	2,57916666
31/03/2016	0,004167797	3,1127337
30/06/2016	0,00392415	3,414767
30/09/2016	0,011464159	3,374767
31/12/2016	0,007781331	3,839167
31/03/2017	0,007389468	4,321133
30/06/2017	0,003826705	3,6732997
30/09/2017	0,005744959	3,1596333
31/12/2017	0,008046709	2,372133
31/03/2018	0,004543803	2,2183
30/06/2018	0,005949916	2,1152333
30/09/2018	0,00251403	2,1395
31/12/2018	0,003626857	2,1853333

Appendix B – Table with the Dummy variable and the residuals of the regression of the term spread on the dummy variable

Time	GDPgrowth	TermspreadR	Dummy
30/06/1995	4,998945683	1,78967	0
30/09/1995	1,808054113	2,04633	0
31/12/1995	2,915376978	1,580996	0
31/03/1996	2,392189149	1,283333	0
30/06/1996	5,014134673	1,636667	0
30/09/1996	5,844567961	1,346667	0
31/12/1996	1,552862108	0,503334	0
31/03/1997	6,009718151	0,516667	0
30/06/1997	3,618305144	0,7	0
30/09/1997	5,416996317	0,679999	0
31/12/1997	2,65723499	0,57	0
31/03/1998	5,686904717	0,623333	0
30/06/1998	5,870830137	0,67	0

30/09/1998	4,788160035	0,39	0
31/12/1998	2,969140351	0,593334	0
31/03/1999	5,278771753	0,9626	0
30/06/1999	2,092860629	1,735933	0
30/09/1999	3,514321033	2,507266	0
31/12/1999	2,665125405	2,0502	0
31/03/2000	8,917275928	2,191033	0
30/06/2000	-2,326534351	1,317	0
30/09/2000	5,599668326	0,865733	0
31/12/2000	3,036628434	0,439166	0
31/03/2001	-0,950161603	0,384967	0
30/06/2001	3,402465741	0,765901	0
30/09/2001	0,509461598	0,982167	0
31/12/2001	5,585642036	1,453167	0
31/03/2002	1,023127229	1,844433	0
30/06/2002	-1,811162657	1,904	0
30/09/2002	-2,436730665	1,509334	0
31/12/2002	-2,513496106	1,494533	0
31/03/2003	0,246999708	1,448233	0
30/06/2003	-3,20053515	1,594433	0
30/09/2003	2,992708182	2,0791	0
31/12/2003	1,961782479	2,2647	0
31/03/2004	3,654878526	2,082734	0
30/06/2004	2,429087698	2,2972	0
30/09/2004	-0,490646757	2,101033	0
31/12/2004	-0,718833769	1,6694	0
31/03/2005	3,026946871	1,4617	0
30/06/2005	1,675957098	1,224067	0
30/09/2005	-2,478714293	1,193667	0
31/12/2005	0,835076917	1,133533	0
31/03/2006	3,208256109	0,995433	0
30/06/2006	3,715616631	1,1765	0
30/09/2006	-0,684389677	0,8233	0
31/12/2006	2,939678184	0,346533	0
31/03/2007	4,470845779	0,336494	0
30/06/2007	1,566570349	0,431228	0
30/09/2007	0,696981371	0,094856	0
31/12/2007	4,41773548	-0,276446	0
31/03/2008	0,11454904	-0,167883	0

30/06/2008	-2,047305699	-0,165539	0
30/09/2008	-0,927872418	-0,213426	0
31/12/2008	-5,375854014	0,089335	0
31/03/2009	-9,201138202	2,491056	0
30/06/2009	0,537270883	3,128548	0
30/09/2009	3,742163903	3,175783	0
31/12/2009	-0,024409152	-3,846837	1
31/03/2010	3,812580521	-3,2928543	1
30/06/2010	2,236217863	-2,5507727	1
30/09/2010	0,723153376	-2,2281954	1
31/12/2010	-1,115664643	-1,500788	1
31/03/2011	-3,006010684	-0,712758	1
30/06/2011	-1,821574611	1,504293	1
30/09/2011	-2,980367741	2,933272	1
31/12/2011	-6,327301488	3,754832	1
31/03/2012	-1,73472074	5,201529	1
30/06/2012	-5,483811114	3,7081556	1
30/09/2012	-4,377670494	2,3283903	1
31/12/2012	-6,56023015	0,7408027	1
31/03/2013	1,216349164	-0,9443237	1
30/06/2013	2,830186406	-1,2171	1
30/09/2013	-0,48242245	-0,359095	1
31/12/2013	3,808455941	-1,104074	1
31/03/2014	-1,973604581	-2,4144803	1
30/06/2014	1,644716444	3,3622213	0
30/09/2014	0,716379339	3,2814843	0
31/12/2014	2,576820941	2,96823033	0
31/03/2015	2,718639644	2,13729967	0
30/06/2015	1,588348988	2,409866334	0
30/09/2015	0,569618631	2,644467	0
31/12/2015	1,38990388	2,57916666	0
31/03/2016	1,667118932	3,1127337	0
30/06/2016	1,569660015	3,414767	0
30/09/2016	4,585663704	3,374767	0
31/12/2016	3,11253247	3,839167	0
31/03/2017	2,955787326	4,321133	0

30/06/2017	1,530681973	3,6732997	0
30/09/2017	2,297983461	3,1596333	0
31/12/2017	3,218683633	2,372133	0
31/03/2018	1,817521382	2,2183	0
30/06/2018	2,379966207	2,1152333	0
30/09/2018	1,005611907	2,1395	0
31/12/2018	1,450742973	2,1853333	0

Appendix C – Table with the predictions of the GDP growth in the out of sample test

Time	GDPactualgrowth	Termspread	GDPpredgrowth
30/09/2005	-2,478714293	1,193667	2,683433765
31/12/2005	0,835076917	1,133533	2,726583191
31/03/2006	3,208256109	0,995433	2,811936729
30/06/2006	3,715616631	1,1765	3,00795435
30/09/2006	-0,684389677	0,8233	2,750949842
31/12/2006	2,939678184	0,346533	3,252278036
31/03/2007	4,470845779	0,336494	3,928995872
30/06/2007	1,566570349	0,431228	3,943245118
30/09/2007	0,696981371	0,094856	3,80878072
31/12/2007	4,41773548	-0,276446	4,286223437
31/03/2008	0,11454904	-0,167883	4,813245411
30/06/2008	-2,047305699	-0,165539	4,659152283
30/09/2008	-0,927872418	-0,213426	4,655825236
31/12/2008	-5,375854014	0,089335	4,723795517

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