UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

# Credit Spread Changes in the Euro Area

## An Empirical Study of the Relationship Between Interest Rates and Credit Spreads in the Euro-denominated Corporate Bond Market

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Authors:
Hampus Johansson 940917 – 5636
Rickard Rehnberg 931107 – 5379

Supervisor:
Jian Hua Zhang

# Abstract

The behaviour of credit spreads is of importance for a wide array of stakeholders. We test the relationship between changes in risk-free interest rates and credit spreads in European bond market by running OLS regressions using weekly European market data for investment grade and non-investment grade bond indices. We collect data from 1999 – 2017 and subsequently separate the time series into three periods in an effort to examine differences in different market settings. The findings strengthen that of previous research and support an inverse relationship between changes in interest rates and credit spreads. Furthermore, we detect the coefficients being different in the different periods and attribute part of the change to the growth of European bond market. We also find the residuals from our regressions being heavily correlated and suspect, as previous researchers, that corporate bond spreads carry a large systematic component.

# Acknowledgements

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# 1. Introduction

## 1.1. Background

In the wake of the financial and sovereign debt crises central banks have repeatedly lowered interest rates to spur economic activity and inflation. Borrowing costs for corporates have moved accordingly but tougher capital requirements on banks has restricted the availability of new loans in the traditionally bank reliant European market. As a result, corporate bonds have become a more attractive source of debt capital. Especially medium and large-size non-investment grade firms, that is, firms with a credit rating below BBB, have utilised this market thus driving growth in market value. Since early 2009 the euro-denoted market for these non-investment grade bonds, often referred to as high yield bonds due to the relatively high coupon they pay, has grown by almost 700%.

The credit spread, the difference between the yield of a risky bond and the risk-free equivalent, is a central component when pricing and assessing corporate bonds. Credit spreads can have different implications depending on the stakeholder in question. For an investor it is the premium required in return for taking on the risk that the bond issuer defaults on its debt. They can use corporate bonds to gain a higher return instead of buying high yielding long maturity government bonds. This implies giving up the interest rate risk of high duration bonds in order to gain exposure to default risk of the issuer. Hedge funds use credit spreads when they take high levered positions on corporate bonds, using short positions on risk-free bonds to hedge against interest rate risks. (Loncarski & Szilagyi, 2012) For the individual firm, it is of course a question of its cost of borrowing. Comparing credit spreads to previous terms and its competitors' is useful for negotiations and capital budgeting.

Policy makers are monitoring the credit market to look for, and manage, sources of instability. Since data on bank loans is typically difficult to collect, the bond market is of interest. Variations in credit spreads could be used not only as an indicator of potential hazards but also to evaluate the effect from changes in monetary policy (Boss & Scheicher, 2002). Since June 2016 the European Central Bank has also been involved more directly than previously in the market for corporate debt as it rolled out its Corporate Sector Purchase Programme, allowing them to intervene in the market by buying and selling corporate bonds (European Central Bank, 2016).

Consequently, credit spreads have been the subject of a great number of studies. A majority of the empirical research has determined a negative relationship between changes in credit spreads and changes in interest rates. Longstaff & Schwartz (1995) constructed a simple two-factor model for valuing risky corporate debt. The two factors, interest rate and asset value, respectively showed negative correlation to credit spreads. Duffee (1998), criticised the creators of the two-factor model for not having taken into account the effect of callability. Duffee (1998) subsequently performed a test of his own, whereby he established a weaker yet still negative relationship between changes in credit spreads and rates of interest.

Common for the majority of research on this topic is the focus on investment grade corporate bonds. Furthermore, the US market has been the most popular subject for the empirical analysis.

## 1.2. Purpose and delimitations

Despite a great deal of research having already been produced on the topic of corporate debt and the nature of corporate yield spreads, the subject is still a relevant one for continued investigation. Previous research focuses on the North American bond markets and comparing different ratings within the investment grade segment. This paper in turn focuses on the European market and incorporate a comparison between investment grade and non-investment grade bonds. We argue that the European market is especially interesting due to the structural changes it has been subject to since its inception in 1999. Especially the increased demand for bonds as a source of capital from lower rated firms, but also the negative interest rate environment this market has been subject to, makes this line of research relevant.

**Research question:**

"How does changes in interest rates affect changes in credit spreads in the European bond market?"

In this thesis we shine new light on the traditional view of the behaviour of credit spreads by applying old models to European market data. Furthermore, we capture the effect of the uniquely low and negative interest rate environment by dividing our data into three time periods.

The outer frame for this study is euro denominated corporate bonds. We have chosen an index level approach instead of a bond specific approach. This implies a restriction with regards to our independent variables which, as they cannot be firm-specific, will be on an aggregate level. The research includes two rating categories of bonds, investment grade and high yield. Also, we limit our investigation to the use of two models. There are many ways to estimate the relationship between risk-free rates and credit spreads. However, we have chosen to limit ourselves to two regression models. First we run the two-factor model, developed by Longstaff & Schwartz (1995). Secondly, with the inspiration of among others Duffee (1998) and Collin-Dufresne et al. (2001), we add a third factor that accounts for the slope of the euro area yield curve.

The rest of the thesis is organised as follows. The next section explains important theoretical concepts, the third section contains a more comprehensive literature review of previous research and the fourth presents our hypothesis and expected results. Thereafter, in the fifth section we present our data and method. The empirical findings are found in the sixth section and finally the seventh section concludes the thesis.

# 2. Theoretical Framework

## 2.1. Pricing of Bonds

The shared premise for all bonds is the promise to pay future cash flows to the investor. Some bonds pay coupons to investors while other only pay a principal, or face value, amount when the bond expires. The price of a bond equals the present value of all its future payments.

$$P = PV(Cash\ Flows)$$

As the cash flows from the bonds are being discounted into their present value, the price of the bonds will have an inverse relationship with the interest rate. That is, if the interest rate increase, the cash flows of the bonds would have to be discounted at a higher rate thereby lowering their present value. The sensitivity of a bond's change in price due to a change in the interest rate is measured by duration. The higher a bond's duration, the more sensitive it is to changes in the interest rate. Furthermore, a bond's duration increases with longer time to maturity and lower coupons. (Berk & DeMarzo, 2013)

## 2.2. Bonds with Embedded Options

Compared to conventional bonds, it is a more complex task to determine the yield to maturity of a bond with embedded options due to the existence of several possible redemption dates. The embedded options are grouped into three main categories: puts, calls and sinking funds.

Callable bonds have gain superior popularity over other special redemption types and thus regular and callable bonds make the vast majority of all corporate bonds. Therefore, this theoretical part will focus more on callable bonds rather than putable or sinking funds.

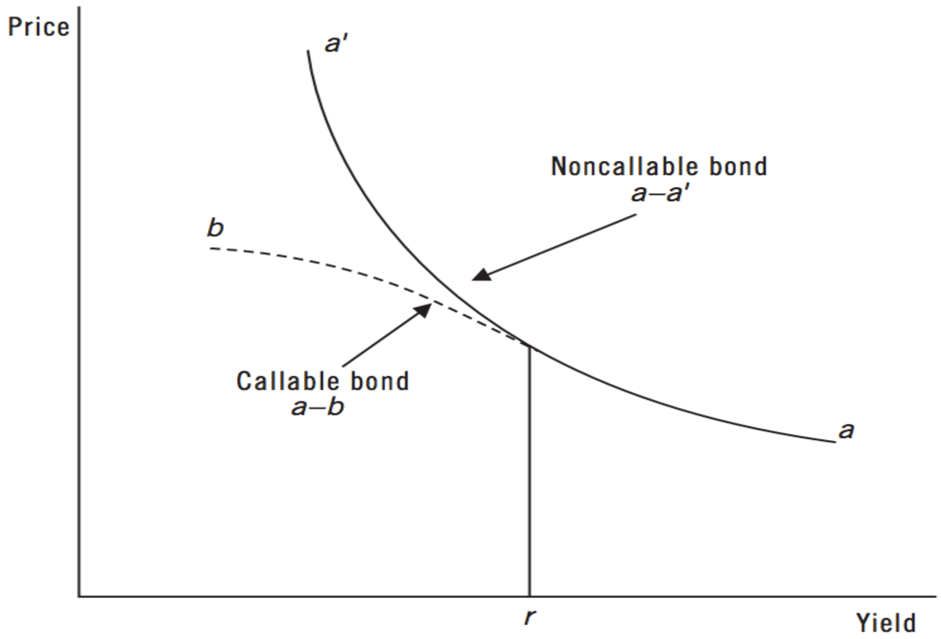
An option is a contract between two parties, a *buyer* and a *writer*. The buyer has the option, but is not obliged, to buy or sell the underlying asset of the option contract at a predetermined price in the future. The price which determines if an option is to be exercised is called the *exercise* or *strike price*. The expiry date is the last day the option can be exercised. The buyer can either exercise during a period – so called American style options – or at a certain date which is called European style options. Thus, the writer takes on a short position on the contract whereas the buyer has a long position. The price of an option contract is referred to as a premium and is paid by the byer to the writer. The value of an option is made up of two components, the intrinsic value and the time value. The intrinsic value is the difference between the strike price and the current market value of the underlying asset. Simply put, it is the value the buyer of an option would receive were he or she to exercise the option today, however, it is never less than zero. The time value on the other hand is the difference between the premium and the intrinsic value. Finally, the profit and loss profile of an option contract differs for the two parties. The buyer's loss is limited to the premium paid to the writer and the profit is theoretically infinite and vice versa for the writer. (Choudhry, 2010)

Now, a callable bond is essentially a bond in which the issuer reserves the right to repay the principal, and by extension the remaining coupon payments, before the final date of expiration. To that end, a callable bond can be viewed as a portfolio consisting of a conventional bond and a call option, where the investor who buys the bond will simultaneously write a call option to the bond issuer. However, it is not possible to strip the bond of its option and thusly separate the cash flows. It also follows that the value of a callable bond should equal the value of the portfolio. (Choudhry, 2010) Therefore, market value of the bond can be formulated as follows:

$$P_{Callabe\ Bond} = P_{Conventional\ bond} - P_{Call\ option}$$

The provisions regulating the early redemption varies widely. The figure below contains a simplified illustration of the impact on the relationship between price and yield.

**FIGURE 1: THE IMPACT OF AN EMBEDDED CALL OPTION ON THE YIELD AND PRICE RELATIONSHIP OF A BOND (CHOUDHRY, 2010, S. 273)**




Normally, when interest rates fall bond prices increase. However, if the bond issuer is able to repay the bond prior to its expiry at a set price, the potential pay-off to the bond holder is limited. Should interest rates fall dramatically, the issuer of the bond will simply repurchase its outstanding debt and refinance itself through a new bond issuance at a lower cost of debt.

## 2.3. Credit Risk and Credit Spread

Corporate bonds carry credit risk, i.e. the risk that the issuer will default and not be able to pay all promised payments. Hence, risky instruments demand a higher return than identical risk-free ones. By discounting the promised future cash flows, the yield of bonds with different risk profiles will reflect a difference due to the different risk. This is commonly referred to as the credit spread (Berk & DeMarzo, 2013). In other words, the credit spread is the difference between yield on a risk-free government bond and the yield on a risky bond with equivalent time to maturity.

## 2.4. Option-Adjusted Spread

Traditional risk measures such as Modified Duration and Convexity are inappropriate for analysing bonds with embedded call options. The uncertainty in the cash flows needs to be taken into account and hence, a commonly used method has become the *option-adjusted spread* measure, commonly referred to as OAS. The OAS between two bonds with similar default risk would reflect the value of the option only (Choudhry, 2010). However, praxis is to measure OAS versus equivalent government bond yields which reflects the value of the option element as well as the default risk. This is also what BofA Merrill Lynch provides in their indices which therefore constitutes the empirical data for our analysis. The calculations will not be made by us as they are provided by BofA Merrill Lynch. However, to give the reader a better understanding of the concept we will in the following section describe the procedure as explained by Choudry (2010) and BofA Merrill Lynch (2013).

The OAS versus a risk-free interest rate is calculated against the government yield curve of the same currency of denomination. It's a stochastic model that uses a simulation method, such as Monte Carlo, to allow for different scenarios. These scenarios are called interest rate paths where, for each path, the value of a cash flow is different, but also less or more likely to occur due to the imbedded option (Choudhry, 2010). The average of these discounted values makes up the corporate bond's price. Conceptually, and as the Bond Index Almanac of BofA Merrill Lynch (2013, s. 17) puts it, "OAS is the number of basis points that must be added to the one-month semi-annually compounded forward zero curves in each scenario in order to match the average present value of discounted cash flows across all scenarios to the bond's price". The method has become popular among investors as it makes it possible to compare and measure bonds with different features to each other.

# 3. Literature Review

## 3.1. Longstaff and Schwartz

In an effort to overcome shortcomings of previous research conducted in the field Longstaff and Schwartz (1995) wrote a paper named *A Simple Approach to Valuing Risky Fixed and Floating Rate Debt*. In the paper they constructed a simple structural model for valuing risky corporate debt. Through their research, new ways to look at the valuation of risky corporate debt and how to hedge it rose. They believed that some of the most quoted research had some shortcomings. To be more specific, Black-Scholes (1973) and Merton (1974) keep interest rates fixed in their models after which the default risk of a risky security is calculated through option pricing theory. This approach assumes that default only occurs when the firm exhausts its assets, which according to Longstaff and Schwartz is rather unrealistic. It also tends to lead to smaller anticipated credit spreads than the actual. Other important research such as Black and Cox (1976) adjusted to a more flexible default definition and were thereafter able to estimate credit spreads closer to actual market observations. However, this approach was also under fixed interest rate assumptions and thus something Longstaff and Schwartz wanted to develop. So, in their research they incorporated both the default risk and interest rate risk through the simplest possible model:

$$\Delta S = a + b\Delta Y + cI + \varepsilon$$

*Where $\Delta S$ is the change in the credit spread, $\Delta Y$ is the change in the 30-year Treasury bond yield, and $I$ is the return for a (depending on industry group) corresponding equity index.*

This model showed estimates of credit spreads close to actual spreads. It also showed that the credit spreads of firms with a comparable default risk can vary significantly if their assets (measured by the corresponding equity index) have different correlations with changes in interest rates. This is an explanation for why similarly rated firms and bonds have different credit spreads cross industries.

The main points from Longstaff and Schwartz (1995) was their findings from running their model on Moody's corporate bond yield averages. They found a significant negative relationship between changes in credit spreads and interest rates. Since previous research had ignored interest rates as a risky variable this was an important finding.

One important interpretation from the negative relationship is that it makes the duration, and thus interest rate risk, of a risky bond lower as an increase in the interest rates is partially offset by the decline in the credit spread. This makes the price change for a risky bond smaller than for a risk-free bond. Further, the explaining power from the risk-free interest rate is greater than from a change in firm value according to their model. This is another strong argument against previous models that assumed interest rates to be constant and that firm value determines the credit spread.

## 3.2. Duffee

A majority of the bonds issued by US corporates have an imbedded call option, a feature often referred to as callability. As such a feature adds a significant amount of uncertainty for the investor it cannot be ignored when investigating the pricing and the risk of a bond. Gregory R. Duffee (1998) was quick to point out this shortcoming in the research conducted by Longstaff and Schwartz (1995) who had used indices from Moody's that included both callable and non-callable bonds. Duffee tested whether the spread of a corporate bond's yield over Treasury bond's yield is dependent on the imbedded call option and was able to confirm this hypothesis.

Bonds that are callable will behave differently when yields change because a part of the variation in the price will be due to the change in the value of the option. The correlations between the risk-free interest rate and credit spread were still negative in his regressions but Duffee showed that callable bonds are more sensitive to yield changes and that it depends on how far in the money the bond is. For out of the money bonds, the yield spreads move similarly as with non-callable bonds. On the other end of the spectra, the spread of an in the money callable bond shows a far stronger negative correlation with risk-free yields. Also, bonds that are call-protected, i.e. have a call option that is not eligible to call for at least another year (Duffee's definition), behave more like callable bonds than non-callable.

## 3.3. Continued Research

In response to the findings of Longstaff and Schwartz a number of researchers has conducted studies with various methods and datasets.

Collin-Dufresne and his partners (2001) elaborated on the two-factor model with several variables in order to come closer to the true determinants of credit spreads. They used individual non-callable bonds to test for the effect from the changes in firm leverage, slope of the government yield curve and implied volatility of S&P 500 in addition to the risk-free interest rate and return of S&P 500. The results concluded that interest rates are negatively correlated with spreads and that bonds of firms with higher leverage show a stronger correlation since they are more exposed to interest rate risks. Most of the other variables showed statistical significance and made economic sense in their interpretation. Still, these variables failed to explain more than around 0.25 of the variance in the spreads as measured by adjusted R-squared. Therefore, Collin-Dufresne et al. investigated the residuals from their regressions and concluded that a large part of explaining credit spreads is related to a systematic component that their variables could not capture.

Although with higher explanatory power in their regressions, Boss and Scheicher (2002) at the Bank for International Settlements wrote a research paper on credit spread determinants in the at that time very young euro market. Using different bond indices instead of individual bonds they achieved R-squared values of around 0.45 but still found their residuals to be heavily correlated with each other and thus also suspect a systematic component that their models failed to capture.

Loncarski and Szilagyi (2012) who used daily data on US bonds also found a negative relationship between interest rates and corporate bond spreads but argue that the relative illiquidity in the bond market could cause delays in the effects. Other researchers have argued that credit spreads are event driven but also for a positive long run relationship between interest rates and credit spreads using a co-integrated approach as well as a lagged short-term interest rate (Morris, Neal, & Rolph, 1998; Lin & Curtillet, 2007).

# 4. Hypothesis

## 4.1. Hypothesis and Expected Results

We will run two regressions using the credit spreads of investment grade and non-investment grade bonds as dependent variables. The first model uses the risk-free rate and the return of a stock index as estimators of the dependent variable whereas the second model also includes a slope variable. Longstaff & Schwartz (1995), Duffee (1998) and others suggest a negative relationship between credit spreads and interest rate. Thus, we formalise our hypothesis as follows:

> $H_0$ = The relationship between the risk-free interest rate and credit spreads is positive or equal to zero.
>
> $H_1$ = The relationship between the risk-free interest rate and credit spreads is negative.

We form our expected results according to the findings of previous research. Longstaff & Schwartz (1995), Duffee (1998), Collin-Dufresne (2001), Boss & Scheicher (2002), Lin & Curtillet (2007) predict that changes in risk-free rate will have an inverse effect on changes in credit spreads. Furthermore, Longstaff & Schwartz (1995), Collin-Dufresne (2001), Boss & Scheicher (2002) and Lin & Curtillet (2007) finds a negative relation between equity index returns and changes in credit spreads. Lastly, Duffee (1998), Collin-Dufresne (2001), Boss & Scheicher (2002), Lin & Curtillet (2007) also find changes in the slope of the yield curve to be negatively related to changes in credit spreads.

Thus, in table one we register our expected signs of our three independent variables. In short, we believe our findings will show a significant negative relationship between risk-free interest rates and corporate bond spreads.

**TABLE 1: EXPECTED SIGNS FOR THE REGRESSION COEFFICIENTS.**

| Coefficient | Expected sign |
|---|---|
| Risk-free interest rate | - |
| Return on risky assets | - |
| Slope | - |

Further, we expect the estimators to change as the market matures in later periods of the time series. Likewise, we expect to the predictive power of our models to grow as the market matures. Compared to the first period, variables omitted from our model, i.e. liquidity risk, will probably not affect credit spreads as much in the larger and more developed market in the third period. However, the low interest rate environment might have an off-setting effect. Nevertheless, we expect a greater deal of variation to be explained by our model in later periods compared to earlier samples and the sample as a whole. Also, it is reasonable to expect that accuracy of our estimators and the predictive power of our regression models to be smaller in the volatile period around the financial crisis 2008.

# 5. Method

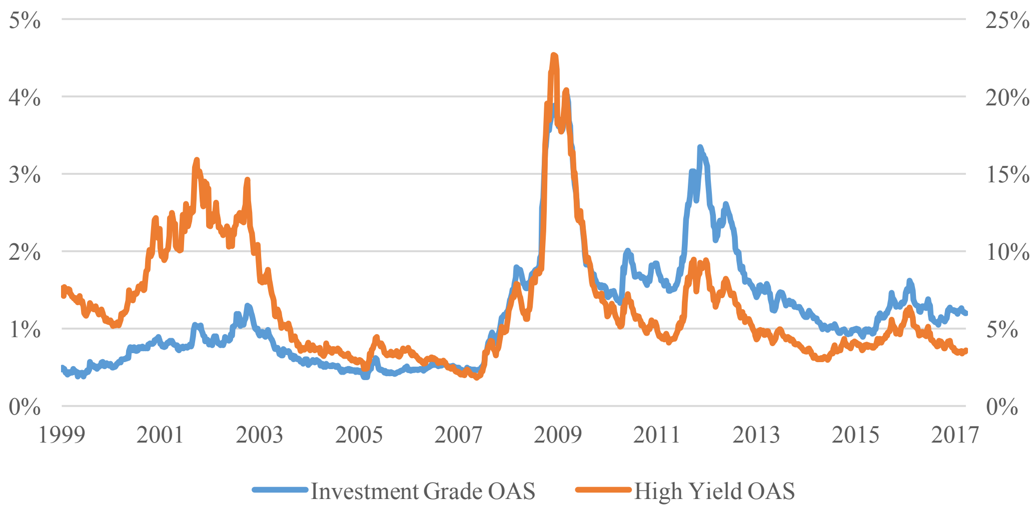
## 5.1. Data

The sample for our research consists of weekly data collected from the date of the launch of the Economic and Monetary Union, EMU, 1 January 1999, (The European Commission, 2017), up until the 31th of March 2017. This gives us 951 observations with no missing values. We divide the data into three sub-sets with the first stretching from 1999 to the end of 2006, the second from 2007 to the end of 2012 and the last from 2013 to the last week of March 2017 and we will hereafter refer to them as the first, the second and the third. The different subsets contain 416, 313 and 222 observations respectively and are supposed to reflect different market settings. Figure 3 below illustrates how the OAS of both the investment grade (bonds with a rating between AAA and BBB) and high yield (bonds with a rating below BBB) indices have fluctuated during the whole sample period. As can be seen, our interceptions occur between the periods with more volatility. Breaking up the data in this manner our first period includes the inception of the euro and the burst of the IT bubble. The second period includes the financial crisis and to a large extent also the sovereign debt crisis. The third period contains the era of low inflation and low interest rates. Since interest rates have fallen into negative territory this is also the period we are interest in the most. All of the data is collected through the Bloomberg

Terminal. Each variable is described in more detail in the following sub-sections, starting with the dependent variable in our regression.

**FIGURE 2: OAS FROM 1999 TO 2017.**

*Investment Grade is plotted in blue on the left axis and High Yield in red on the right.*




## 5.2. Dependent Variables

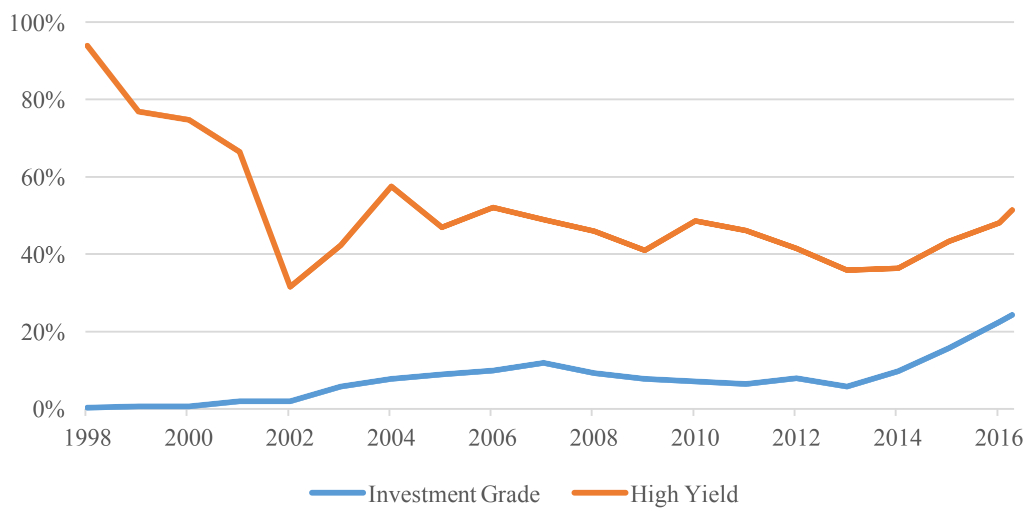
To approximate the performance of the investment grade bonds in the European bond market we will use the BofA Merrill Lynch Euro Corporate Index with ticker name ER00. The index tracks the performance of euro-denominated investment grade (based on the ratings of S&P, Moody's and Fitch) corporate debt which is publicly issued in the Eurobond markets or domestic markets of Euro member states. The non-investment grade equivalent will be approximated using BofA Merrill Lynch Euro High Yield Index, ticker HE00. The index tracks the performance of euro-denominated below investment grade corporate debt which is publicly issued in the Eurobond markets or domestic markets of Euro member states.

In order to estimate the CS, we will use the yield to maturity of the two indices and calculate the difference to another BofA Merrill Lynch index named EG13. EG13 consists of AAA rated euro-denominated government bonds with a maturity of five to seven years. This is close to the average maturities of the corporate bond indices that have been fluctuating between five to six years during the period of our study. Hence, credit spreads for both of the corporate bond indices are calculated as in the following equation:

$$CS_x = YTM_x - YTM_{EG13}$$

In accordance with Duffee (1998), using indices consisting of a combination of callable and non-callable bonds does not allow for accurate conclusion to be drawn with regards to variations in conventional yield spreads. To avoid this issue, previous research has commonly used indices which are exclusively comprised of non-callable corporate bonds. However, the smorgasbord of European corporate bonds is not as diverse as the American. As a consequence, the indices we use to approximate the yield on European corporate bonds include callable as well as non-callable securities. The proportion of callable bonds also changes over time for the two indices. With regards to the High Yield index, the fraction of callable bonds is falling over the time period. This would, according to Duffee (1998) bring about a weaker negative relation between the credit spread and the risk-free rate. For the investment grade index, the proportions are quite different. For the majority of the time period, callable bonds make up a negligible part of the index. In recent years, however, the proportion of callable bonds has grown significantly. To account for the effect of callability on the relationship of the risk free rate and CS, we will use the OAS figures.

**FIGURE 3: THE PROPORTION OF CALLABLE BONDS WITHIN BOFA'S INDICES.**




For our regressions we construct the weekly changes, in terms of absolute values, in the respective spread measure for the respective index as the first difference where the lowered x denotes either investment grade or high yield:

$$\Delta CS_x = CS_{x,t} - CS_{x,t-1}$$

$$\Delta OAS_x = OAS_{x,t} - OAS_{x,t-1}$$

## 5.3. Independent Variables

**Risk-free Interest Rate**

Our first independent variable is, just as in the structural model by Longstaff and Schwartz (1995), the risk-free interest rate. The risk-free rate in the EMU, as set by ECB, only ranges up to one year. Thus, in order to capture the effect of a longer term risk-free rate on the CS and OAS, we have chosen a ten-year generic government bond index named GECU10YR as a proxy for the risk-free interest rate. In the original two-factor model by Longstaff and Schwartz, 30-year Treasury bonds represents the risk-free interest rate component. In more recent research papers however, arguments have been made that using government bonds with shorter maturities is more appropriate. Government bonds with a maturity of ten, five or two years are more closely related to the maturities of corporate bonds and reflect changes in monetary policy more precisely (Collin-Dufresne, Goldstein, & Martin, 2001; Boss & Scheicher, 2002; Loncarski & Szilagyi, 2012; Batten, Jacoby, & Liao, 2014).

The GECU10YR index consists of generic government bonds with a maturity of 10 years issued, mainly, by the governments of Germany and France (Bloomberg, 2017). The weekly change is calculated in the same manner as the weekly changes in CS's and OAS's above.

$$\Delta riskfree = GECU10YR_t - GECU10YR_{t-1}$$

The intuition behind the negative relationship between risk-free interest rates and the credit spreads relies on the models of valuating risky debt by Black and Scholes (1973), Merton (1974) and Longstaff and Schwartz (1995). In structural models risky debt in a company can be seen as a put option of the firm value, thus an increase in the risk-free interest rate will discount the value of the option more and hence its value decreases. Also, in the original setup by Merton where the interest rate is equal to the drift of the risk-neutral process, a higher interest rate means a higher expected value increase of the firm. Together these two effects imply a lower cost of insurance against default, which is the value of the put option, with the consequence of narrowing credit spreads. (Merton, 1974; Boss & Scheicher, 2002)

**Asset Value Factor**

The second component in the two-factor model is the return on risky assets for which Longstaff and Schwartz (1995) uses the return of a stock market index as a proxy. Therefore, we will approximate the performance of the European stock market using a subset of the Euro Stoxx 600, ticker code SXXE. Stocks from all of the European Union are eligible for the full Euro Stoxx 600 index while only euro-denominated stocks qualify for the subset we use. It consists of a broad variety of stocks listed on small, mid and large cap lists in eleven Eurozone countries weighted by free floating market cap and is quoted as a price index (STOXX Ltd, 2017). The return of the index, in time period t, is calculated as follows:

$$\mathrm{R}_{\mathrm{t}}^{SXXE} = \frac{\mathrm{SXXE_t} - \mathrm{SXXE_{t-1}}}{\mathrm{SXXE_{t-1}}}$$

Unfortunately, the quotations of the SXXE is not perfectly aligned with the corporate bond and risk free rate indices. On 22 occasions, out of the 951 weeks in this sample, the performance of the equity index is not quoted on the same date as that of the bond indices. To approximate return for each of the 22 occasions, we will use the quoted performance on the stock index reported one day after the bond indices. We feel this is a reasonable approximation given that the time difference of the two indices are no more than one day. Furthermore, the 22 occasions are spread quite evenly over the time period we have chosen.

There are two main arguments for how and why the stock market returns should affect credit spreads. First, Longstaff and Schwartz (1995) state simply that the default risk of a firm increases when the value of its assets decrease. Hence, the relationship is negative and positive stock market returns implies more narrow credit spreads. Boss and Scheicher (2002) extrapolates on this argument. The default risk of a firm is to a large extent dependent on its leverage ratio which can be measured as the debt-to-equity, debt-to-assets or debt to another measure of firm value. Since both their research, as well as ours, is based on indices rather than firm specific data a more specific leverage ratio variable is not available. Using the stock market return as a proxy for firm value implies that for a fixed level of debt the leverage increase with a decrease in returns and hence default risk increase.

The second argument for the negative relationship build on the assumption that stock market returns can be seen as a proxy for the general condition of the economy. Even if default rates stay constant, expectations are that the recovery rate is higher in times of economic expansion than in times of contraction (Collin-Dufresne, Goldstein, & Martin, 2001). Thus, credit spreads should narrow when the stock market generates high returns.

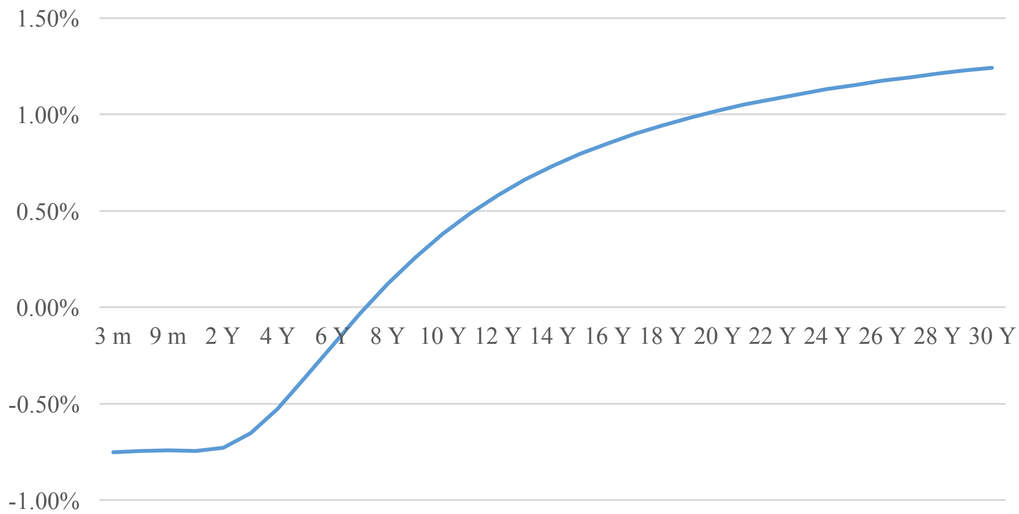
**Term Structure**

The term structure of the European risk-free rate contains information about market expectations for interest rates and is generally an important point of reference when assessing monetary policy conditions. In line with previous research, we too are interested in the information captured by the term structure of the risk-free interest rate. Duffee (1998) took inspiration from, among others, Litterman & Scheinkman (1991) who showed that a majority of the variance in US Treasury term structure can be conveyed by changes in its "level" and "slope". Duffee consequently decomposed the term structure variable in his research. He used the three-month Treasury bill as a proxy for the level and the spread of the 30-year Treasury yield over the three-month Treasury bill to approximate the slope of the term structure.

To illustrate the meaning of the two components let us examine the euro area yield curve as of the 31st of March 2017. The yield curve is displayed in figure 5 below.

**FIGURE 4: THE EURO AREA YIELD CURVE.**

*The euro area yield curve as of 31/3/2017. The yield curve shows separately AAA-rated euro area central government bonds and all euro area central government bonds (including AAA-rated).* (European Central Bank, 2017)




First, the yield curve may shift upwards or downwards. The location of the curve, as determined by where it is generally allocated along the y-axis, is referred to as the level of the yield curve. In our model 2, we will again use the GECU10YR index as a proxy for the level of the term structure and construct the following regression variable:

$$\Delta riskfree = GECU10YR_t - GECU10YR_{t-1}$$

In contrast to Duffee (1998), we use a ten-year index, rather than a three-month rate, to measure the level of the yield curve. Duffee mentions that choosing a maturity for the level coefficient is very much an arbitrary task as it can be measured anywhere along the yield curve. Therefore, we echo the argument from a previous section stating that the ten-year interest rate is more closely related to the corporate bond indices we use.

Second, the yield curve might rotate thereby making the slope of the curve steeper or flatter. The rotation of the curve has different meaning depending not only on the direction of the rotation, but also where along the curve the rotation axis is located. Following the reasoning of Duffe (1998) and others (Collin-Dufresne, Goldstein, & Martin, 2001; Boss & Scheicher, 2002; Batten, Jacoby, & Liao, 2014) we construct our Slope-coefficient by subtracting the yield of a risk-free index with shorter term to maturity from the GECU10YR index.

$$\mathrm{Slope}_1 = \mathrm{GECU10YR} - \mathrm{EURIBOR}_{3M}$$
$$\mathrm{Slope}_2 = \mathrm{GECU10YR} - \mathrm{EURIBOR}_{12M}$$
$$\mathrm{Slope}_3 = \mathrm{GECU10YR} - \mathrm{GECU2YR}$$
$$\Delta\mathrm{Slope}_n = \mathrm{Slope}_{n,t} - \mathrm{Slope}_{n,t-1}$$

We will construct our slope coefficients using three different short term interest rates: The three and twelve-month Euro Interbank Offer Rate, EURIBOR, and the GECU2YR. The EURIBOR is one of the most important reference rates in the European monetary system. It commonly serves as the foundation for the pricing of a great variety of financial products and services. It is determined by the average interest rate at which the 20 most important banks to the monetary union, the so called "panel banks", can borrow money from each other (European Money Markets Institute , 2017). The GECU2YR is the equivalent to GECU10YR but consists of government bonds with a maturity of two years rather than ten. (Bloomberg, 2017)

One drawback of measuring the slope and the level of the yield curve with the use of the same index, GECU10YR, is that it will not allow for a direct comparison with the findings of Duffee (1998). While the interpretation of changes in slope-estimates is the same in our thesis as in Duffee's research, they are measured in different ends of the yield curve. For Duffee, holding level unchanged and increasing the slope of the yield curve would in real terms translate to an increase in interest rates with longer maturity than the three-month T-bill. Conversely, in our regression outputs, the slope is determined by changes in the short term interest rate.

## 5.4. Method of Analysis

To analyse our data, we are running OLS-regressions with time series data in the statistical software Stata. This method is what most of the previous authors on the topic have used and also something we are familiar with. Therefore, we are confident for the results of our research to be valid.

We will commence our analysis by applying the two-factor model, i.e. model 1, as developed by Longstaff & Schwartz (1995), to our set of data. Despite it having been subject to criticisms, we incorporate the two-factor model to estimate how the traditional view of the relationship between credit spreads and risk free rates of interest complies to the last 18 years. The model regresses the change in credit spread on two independent variables: the change in risk free rate and the return on risky assets.

For the dependent variable, we use the two different types of spreads. In the first version of model 1 we run the regression with the weekly change in CS. In the second version we use the weekly change in option adjusted spread, OAS, as the dependent variable to take into account the imbedded options.

Model 1 a) $$\Delta CS = \alpha_0 + \alpha_1 \Delta riskfree + \alpha_2 R^{SXXE} + V$$

b) $$\Delta OAS = \alpha_0 + \alpha_1 \Delta riskfree + \alpha_2 R^{SXXE} + V$$

*Where* $\Delta$*riskfree is the change in the GECU10YR index and* $R^{SXXE}$ *is the return of the equity index.*

We then expand the two-factor model by adding a third coefficient.

Model 2 $$\Delta OAS = \beta_0 + \beta_1 \Delta riskfree + \beta_2 R^{SXXE} + \beta_3 \Delta Slope_n + W$$

*Where* $\Delta$*riskfree is the change in the GECU10YR index,* $R^{SXXE}$ *is the return of the equity index and* $\Delta$*Slope is the change in slope of the Euro area yield curve.*

Incorporating the Slope variable enables us to have a more detailed look into the relationship between the credit spread and the interest rates. We subsequently run the regression using the change in OAS spread for the period 1999 – 2017.

Thereafter, we will run the models on the different subsets of data that are divided as described into three periods. In so doing, we can compare the magnitude of the coefficients. As mentioned, of particular interest is of course the last period where risk-free rates have moved into negative territory.

## 5.5. Statistical Properties

Since our sample consists of time series data there are a number of properties that need to be checked. First, highly persistent variables. There are two common methods to overcome highly persistent variables. One is to use the first difference. This is what we do for all of our variables except for SXXE, where we use the return. How we have calculated the return of SXXE is approximately equal to logging the variable, which is the other common method for overcoming highly persistent variables. Subsequently, the different spreads correlates with themselves around a level of 0.2 to 0.3 and the $EURIBOR_{3M}$ has by far the strongest autocorrelation with a value of 0.49. This variable is, however, not a part of the main focus of regressions and interpretations and since none of the variables are near 0.9 we should not have a problem with highly persistent variables in our dataset.

Second, we check for seasonality. Table 12 in the appendix contains the P-values for regressions of every variable, separately, on quarterly dummies. We are unable to reject $H_0 = \gamma_1 = \gamma_2 = \gamma_3 = 0$, where $\gamma_n$ is the effect from $Q_n$ on the 5% significance level. Consequently, our data should not suffer from seasonality bias.

Finally, the risk of having heteroscedasticity in the error term is also needed to be dealt with. We simply use the *Robust* command in Stata for all our regressions which makes the standard errors larger and thus, less likely to reject a null hypothesis that a coefficient is equal to zero.

# 6. Empirical findings

## 6.1. Descriptive statistics

Table 2 below contains descriptive statistics for the whole sample period whereas the different subsets are available in the appendix.

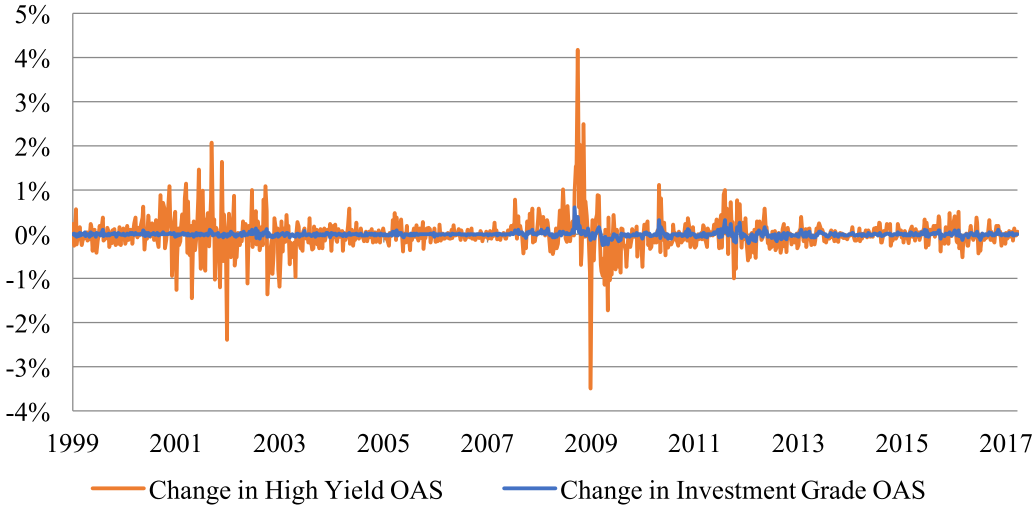
The 951 observations in our dataset are distributed fairly normally with mean values close to zero. As an example of the distribution of the variables figure 6 shows the weekly changes in OAS for both of the corporate bond indices. Even though the level of the spreads has been fluctuating the weekly changes are evenly distributed around zero. The few large outliers are mainly related to the financial crisis in 2007-2008 and thus, the sub-sample stretching over that period has higher standard deviations as well as minimum and maximum values further from zero for all variables compared to the other two sub-samples. Regarding credit spreads one should also note that for all periods, the standard deviation of the high yield index is substantially higher than for the investment grade index. The high yield index volatility decreases from the first to the third period, which is in line with expectations. As the market grows, gains more interest and becomes more efficient it should be behaving more and more like corporate bonds in more established segments with higher ratings.

**TABLE 2: DESCRIPTIVE STATISTICS, 1999-2017.**

| Variable | N | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| $\Delta CS_{IG}$ | 951 | 0.001% | 0.059% | -0.290% | 0.490% |
| $\Delta OAS_{IG}$ | 951 | 0.001% | 0.056% | -0.240% | 0.610% |
| $\Delta CS_{HY}$ | 951 | -0.003% | 0.445% | -4.050% | 4.540% |
| $\Delta OAS_{HY}$ | 951 | 0.004% | 0.403% | -3.490% | 4.170% |
| $\Delta EURIBOR_{3M}$ | 951 | -0.004% | 0.052% | -0.470% | 0.321% |
| $\Delta EURIBOR_{12M}$ | 951 | -0.003% | 0.060% | -0.296% | 0.321% |
| ΔGECU2YR | 951 | -0.004% | 0.099% | -0.421% | 0.423% |
| ΔGECU10YR | 951 | -0.004% | 0.100% | -0.356% | 0.356% |
| $R^{SXXE}$ | 951 | 0.059% | 2.888% | -21.761% | 13.369% |
| $\Delta Slope_1$ | 951 | 0.000% | 0.101% | -0.437% | 0.586% |
| $\Delta Slope_2$ | 951 | 0.000% | 0.096% | -0.323% | 0.543% |
| $\Delta Slope_3$ | 951 | 0.000% | 0.079% | -0.322% | 0.356% |

The interest rates show common characteristics however, the two year and the ten year have higher standard deviations. The three different slope variables also seem to behave pretty similarly when looking at the descriptive statistics. This is also what one could expect given their construction since they all share one factor (the GECU10YR) and the different short term interest rates are highly correlated.

**FIGURE 5: THE WEEKLY CHANGES IN HIGH YIELD AND INVESTMENT GRADE OAS 1999-2017.**




## 6.2. Model 1

We commence by running the two-factor model, developed by Longstaff and Schwartz (1995). The results from these regressions, shown in table 3, fail to surprise us. Both of the indices show a significant and negative relationship between the credit spread and the risk free interest rate. Furthermore, in accordance with the findings of Longstaff and Schwartz, our regression output also shows that the relationship increases for bonds with inferior rating.

Using the Option-Adjusted Spread provided by BofA Merrill Lynch, the coefficients change somewhat. According to the findings of Duffee (1998), the explanatory power of the risk-free interest rate is smaller for non-callable bonds. It is therefore little surprising that in the regressions where callability is taken into account, using the OAS, the risk-free coefficient is smaller than its CS equivalent. Apart from the change in the risk-free variable, the results are widely similar between the two sets of regression models.

With regards to the second coefficient, $\alpha_{2,}$ approximating the relation between credit spreads and changes in return on risky assets, there are no major deviations from the findings of Longstaff and Schwartz (1995). More precisely, there is a significant negative relationship which increases for companies with lower credit ratings. We cannot observe any major changes in this variable when altering the dependent variable to account for callability. Intuitively, changing the dependent variable should not affect its relation to risky asset returns as much as the risk-free rate of interest. While lower interest rates will directly impact the value of the embedded call option, the risky asset returns will only have an indirect effect.

Furthermore, given the proportion of callable bonds in the corporate bond indices we use, the risk-free coefficients are probably less likely to be consistent over time. Accordingly, they will likely cloud the true relation between credit spread and the variables we are interested in observing. Consequently, in pursuit of finding an accurate relationship between the risk free rate and the credit spread, moving forward, we will use OAS as dependent variable in our regressions.

**TABLE 3: RESULTS FROM MODEL 1, 1999-2017.**

*In this table the results from running the Longstaff and Schwartz model are presented. Two different dependent variables are used. ΔCS is the credit spread calculated as the difference between the YTM of the corporate bond index and an index of AAA rated government bond with a similar maturity. ΔOAS is the option adjusted spread over the government yield curve. Δriskfree is the weekly change in GECU10Y and $R_{SXXE}$ is the weekly return in the SXXE index. T statistics are given in the parentheses.*

Model 1 a) $\Delta CS = \alpha_0 + \alpha_1 \Delta riskfree + \alpha_2 R^{SXXE} + V$

Model 1 b) $\Delta OAS = \alpha_0 + \alpha_1 \Delta riskfree + \alpha_2 R^{SXXE} + V$

| | Investment grade | | High Yield | |
|---|---|---|---|---|
| | Model 1a | Model 1b | Model 1a | Model 1b |
| Intercept | 0.000 | 0.001 | -0.000 | 0.001 |
| | (0.17) | (0.52) | (-0.16) | (-0.21) |
| Δriskfree | -0.220 | -0.102 | -0.747 | -0.608 |
| | (-10.42)[C] | (-4.42)[C] | (3.80)[C] | (-3.51)[C] |
| $R^{SXXE}$ | -0.004 | -0.007 | -0.064 | -0.064 |
| | (5.30)[C] | (-6.73)[C] | (5.30)[C] | (-6.00)[C] |
| $R^2$ | 0.25 | 0.23 | 0.25 | 0.28 |
| Prop > F | 0.00 | 0.00 | 0.00 | 0.00 |

A p<0.10; B p<0.05; C p<0.01

## 6.3. Model 2

### Investment grade

Incorporating an estimator for the slope of the yield curve changes the coefficient value of the Δriskfree variable in the investment grade index. For model 2a and 2b, the effect of changes in our risk-free rate index seems to just about disappear. This is most likely explained by the lack of correlation between the credit spread and three and twelve month EURIBOR. $Slope_1$ and $Slope_2$ therefore behave much like the 10-year risk-free interest rate index which is confirmed in table 13 in the appendix where we can observe a correlation of 0.87 and 0.81 for the two

Slope coefficients with the 10-year risk-free interest rate. The models are likely suffering from a multicollinearity problem which would damage the accuracy of our predictors.

In model 2c, however, the value of the Δriskfree coefficient is more extreme than its two-factor model equivalent. Simultaneously the value of the Slope-coefficient has, quite unexpectedly, returned a positive value. Furthermore, as the GECU2YR index used in calculating our third slope has a higher correlation to the credit spread, correlation between $Slope_3$ and the risk-free rate coefficient is down to 0.41. In addition, the variable is significant at the one percent level.

What is more, we should note that the coefficient for return of the equity index experience almost no change at all across the regression outputs in model 2. This is largely a manifestation of the same effect we find when altering the dependent variable from CS to OAS. Risk-free interest rate and the slope of the yield curve are directly related whereas stock market return has a weaker relationship with the term structure.

Overall, adding the slope coefficient leaves us with about the same explanatory power, as measured by R-squared, as the two-factor model. This would suggest that model 2 is rather pointless as a tool for determining changes in credit spreads, at least among investment graded bonds in European bond market.

**High Yield**

If we alter the dependent variable to the high yield index OAS and rerun the regression, we produce the results in the right half of table 4. Similar to the results of the investment grade regressions we are probably seeing the effect of multicollinearity in the regressions using $Slope_1$ and $Slope_2$. Besides $Slope_1$ and $Slope_2$ turn out insignificant. For model 2c, however, the regression output suggests a quite strong and positive relationship between credit spreads and slope with a significance level of five percent.

In contrast to the investment grade regression outputs, the risk-free coefficient values are more negative for the high yield index in all versions of model 2. Stock returns are reflecting the same pattern in the high yield regression as in its investment grade equivalent. That is, the return of the stock market does not change by the addition of the level of the yield curve.

Lastly, with regards to the coefficient of determination, model 2a and b are rendered less useless compared to the two-factor model. 2c however, manages to produce a slightly higher R-squared.

**TABLE 4: RESULTS FROM MODEL 2, 1999-2017.**

*This table presents the regression outputs for our extended model. The table includes the regression outputs from model 1b) as a point of reference. The dependent variable is the $\Delta OAS$ spread for the investment grade and high yield indices. We use three different versions of Slope. Times series data collected for the period 1999-2017. $\Delta$riskfree is the change in level of the euro yield curve, $R^{SXXE}$ is the return of the SXXE index, and Slope is the slope of the euro yield curve.*

$$\text{Model 2 a-c) } \Delta OAS = \beta_0 + \beta_1 \Delta riskfree + \beta_2 R^{SXXE} + \beta_3 \Delta Slope_n + W$$

| | Investment grade | | | | High yield | | | |
|---|---|---|---|---|---|---|---|---|
| | Model 1b | Model 2a | Model 2b | Model 2c | Model 1b | Model 2a | Model 2b | Model 2c |
| Intercept | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 |
| | (0.52) | (0.75) | (0.70) | (0.31) | (-0.21) | (-0.27) | (-0.29) | (-0.31) |
| $\Delta$riskfree | -0.102 | -0.002 | -0.018 | -0.131 | -0.608 | -0.757 | -0.849 | -0.818 |
| | (-4.42)$^{C}$ | (-0.04) | (-0.52) | (-6.07)$^{C}$ | (-3.51)$^{C}$ | (-1.68)$^{A}$ | (-2.62)$^{C}$ | (-5.17)$^{C}$ |
| $R^{SXXE}$ | -0.007 | -0.007 | -0.008 | -0.007 | -0.064 | -0.064 | -0.064 | -0.061 |
| | (-6.73)$^{C}$ | (-6.72)$^{C}$ | (-6.71)$^{C}$ | (-6.85)$^{C}$ | (-6.00)$^{C}$ | (-6.00)$^{C}$ | (-6.02)$^{C}$ | (-6.20)$^{C}$ |
| $\Delta Slope_1$ | | -0.108 | | | | 0.161 | | |
| | | (-2.38)$^{B}$ | | | | (0.34) | | |
| $\Delta Slope_2$ | | | -0.106 | | | | 0.305 | |
| | | | (-2.93)$^{C}$ | | | | (0.79) | |
| $\Delta Slope_3$ | | | | 0.079 | | | | 0.560 |
| | | | | (2.81)$^{C}$ | | | | (1.98)$^{B}$ |
| $R^2$ | 0.23 | 0.24 | 0.24 | 0.24 | 0.28 | 0.28 | 0.28 | 0.29 |
| Prob > F | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

A p<0.10; B p<0.05; C p<0.01

## 6.4. Examining Differences in the Data Set

In order to observe the value and significance of each estimator in different episodes, we have divided the data into three periods. Also, because of the likelihood of collinearity issues, we exclude $Slope_1$ and $Slope_2$ from these regressions. The results are shown in table 5. Similar to our expectations, there are noticeable differences between the periods.

First, the explanatory power of both models is substantially lower in the first period compared to the latter. There are a few interpretations for this phenomenon. One could be the fact that the market value has increased dramatically over our time period. In consonance with our expectations, the two-factor model, and its expanded version, should produce more accurate results in a larger and more efficient market. Innately, variables which are omitted from our regression models, e.g. liquidity risk, will have less of an effect on changes in credit spreads in the third period. Another explanation is the fact that the correlation between stock return and credit spreads grows stronger throughout the time period. In the second period, the stock return naturally is a very important factor as the time frame houses a very volatile period for stock returns.

Second, the risk-free rate is not a significant component for the two-factor model in the second period. This is not very surprising as it captures two major economic events; the global financial crisis and the sovereign debt crisis. The two events brought about high levels of financial distress which accordingly disturbs the results of the two-factor model. Upon expanding the model, however, the Δriskfree coefficient becomes significant when using the investment grade index as dependent variable. To our surprise the regression returns a positive value for the slope coefficient. For the high yield index, however, expanding the model only generates an interest rate component which is significant at a 10 percent level in the second period. This suggests that companies with lower credit ratings were subject to greater financial distress during the two crises of the second time period. Their credit spreads should therefore be expected to vary much more like the stock index than the relatively stable risk free interest rates.

Third, the Δriskfree coefficient do vary between the different time periods but the interpretation of the change is not an easy one to call. Looking at the two-factor model, that is model 1b, and using the investment grade index as independent variable, the coefficient decreases a bit in the third period compared to the first. In contrast, for high yield, the coefficient dramatically increases in value. The latter is in line with what we expect but both of the changes can be explained with changes in volatility. For $OAS_{IG}$ volatility experience a minor increase whereas the volatility for $OAS_{HY}$ in period three is less than half the volatility in period one. With regards to the regression outputs of model 2c, we exhibit the same issues as when performing the regression on the entire time period. More concretely, we fail to find a realistic slope coefficient as it produces a positive value in each time period.

Finally, the last row of table 5 shows us the probability of rejecting a null hypothesis that all independent variables are equal to zero. We reject this null hypothesis for both models in all three time periods.

## TABLE 5: RESULTS FROM MODEL 1B AND 2C FOR TIME PERIOD 1, 2 AND 3.

*The table provides the results of regression models 1b and 2c. Dependent variables are the $\Delta OAS_{IG}$ and $\Delta OAS_{HY}$. $\Delta$riskfree is the weekly change in GECU10YR index, $R^{SXXE}$ is the return of the SXXE index, and $Slope_3$ is the change in the slope of the euro zone yield curve. The time series data is divided into three periods and the results of the regressions with regard to which period the result belongs to.*

| | 1999-2006 | | | | 2007-2012 | | | | 2013-2017 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Investment grade | | High Yield | | Investment grade | | High Yield | | Investment grade | | High Yield | |
| | Model 1b | Model 2c | Model 1b | Model 2c | Model 1b | Model 2c | Model 1b | Model 2c | Model 1b | Model 2c | Model 1b | Model 2c |
| Intercept | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.25) | (0.27) | (-0.46) | (-0.43) | (0.44) | (0.19) | (-0.03) | (-0.22) | (-0.22) | (-0.39) | (-0.03) | (-0.26) |
| $\Delta$riskfree | -0.098 | -0.102 | -0.730 | -0.811 | -0.059 | -0.122 | -0.342 | -0.583 | -0.122 | -0.257 | -0.438 | -1.225 |
| | (-6.16)$^{C}$ | (-6.10)$^{C}$ | (-3.82)$^{C}$ | (-4.21)$^{C}$ | (-1.13) | (-2.54)$^{B}$ | (-0.87) | (-1.70)$^{A}$ | (-5.57)$^{C}$ | (-3.95)$^{C}$ | (-4.63)$^{C}$ | (-4.81)$^{C}$ |
| $R^{SXXE}$ | -0.003 | -0.003 | -0.046 | -0.043 | -0.012 | -0.011 | -0.089 | -0.086 | -0.007 | -0.008 | -0.039 | -0.041 |
| | (-3.92)$^{C}$ | (-3.74)$^{C}$ | (-5.00)$^{C}$ | (-4.92)$^{C}$ | (-5.63)$^{C}$ | (-5.67)$^{C}$ | (-4.43)$^{C}$ | (-4.60)$^{C}$ | (-8.77)$^{C}$ | (-9.14)$^{C}$ | (-9.25)$^{C}$ | (-9.95)$^{C}$ |
| $\Delta Slope_3$ | | 0.024 | | 0.471 | | 0.147 | | 0.564 | | 0.190 | | 1.109 |
| | | (1.01) | | (1.54) | | (3.06)$^{C}$ | | (1.18) | | (2.35)$^{B}$ | | (3.47)$^{C}$ |
| $R^2$ | 0.18 | 0.19 | 0.16 | 0.16 | 0.27 | 0.30 | 0.40 | 0.41 | 0.34 | 0.36 | 0.41 | 0.45 |
| Prob > F | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

A $p<0.10$; B $p<0.05$; C $p<0.01$

## 6.5. Compliance with Previous Research

To begin with, the negative relation between the risk-free rate variable, Δriskfree, and the credit spread exhibit a similar pattern in table 4 as in table 5. The relation holds in the two-factor model and in its expanded version and is negative for both investment grade and grows more extreme in the high yield regressions. With the exception of the insignificant coefficient in the second period, the relationship is also in line with the findings of Longstaff & Schwartz (1995), Duffe (1998), Collin-Dufrense et al. (2001), Boss and Scheicher (2002) and Lin and Curtillet (2007).

Quite surprisingly, however, is the fact that the slope coefficient in model 2c remains positive throughout the time periods in which we run our regressions. These findings are inconsistent with our expectations and the findings of Duffee (1998), Collins-Dufresne et al, (2001) and Boss and Scheicher (2002) who find a negative relationship. There is little to suggest that the positive coefficient make economic sense. A steeper curve should reflect a more optimistic economic outlook with improved funding and liquidity conditions for corporations. In such a scenario the credit spreads should intuitively narrow. Conversely, a flatter curve should indicate a dry up of sources of funds in the capital markets and an overall more bearish economic outlook which implies widened credit spreads. This intuition is, however, not confirmed by the findings in our regression models.

Simultaneously, in model 2c, the negative relationship between the level of the yield curve, Δriskfree, and credit spread grows stronger when expanding the two-factor model with the slope variable. This pattern is true for all regression outputs in table 5. The reason for this occurrence probably lies in the construction of the level and slope variables. The risk-free rates used to construct $Slope_3$, which are ΔGECU10YR and ΔGECU2YR, correlate strongly with each other. Furthermore, both variables have a correlation with the ΔOAS, for both rating classes, of around -0.3. Moreover, when we create $Slope_3$ by subtracting the short term interest rate from the long term [ΔGECU10YR - ΔGECU2YR = $\Delta Slope_3$] we are left with a coefficient which shows a very low and positive correlation with the dependent variable. We therefore suspect that the properties of the two-year and ten-year risk-free interest rate indices are such that they allow the $Slope_3$ variable to be ripped of its negative relationship with credit spreads.

Boss and Scheicher (2002) constructed a slope variable using ten and two-year interest rates which they subsequently used in their regression model. Their slope coefficient, in contrast, show a reasonable negative correlation with the independent variable. However, not only do

Boss and Scheicher use indices with longer maturity corporate bonds, they also collect data from 1998-2001. Therefore, it is likely that their slope coefficient behaves differently in relation to credit spreads compared to our estimator. Notwithstanding that when we apply model 2c to our first period, which most resembles the period which Boss and Scheicher examines, the slope coefficient is rendered insignificant. One should also note that Boss and Scheicher did not present the correlation between their two-year interest rate that they subtracted from the ten year when constructing their slope variable. This restrains us from creating a slope variable that resembles that of Boss and Scheicher.

Despite the slope coefficient being difficult to interpret the Δriskfree and $R^{SXXE}$ coefficients are of economic importance. The explanatory power of our models for spreads of the BofA indices we use is lower than in the research of Longstaff and Schwartz (1995) who used Moody's indices and for Collin-Dufresne et al. (2001) who used individual bonds. Still, an increase of 100 basis points in Δriskfree implies a decrease of 10.2 basis points for $OAS_{IG}$ and 60.8 basis points for $OAS_{HY}$ according to our model 1b. The consequence is that it makes the duration of a high yield bond smaller which is of importance for investors (Longstaff & Schwartz, 1995). High yield bonds also fluctuate more with price changes on risky assets which is in line with previous research. Should our proxy for asset returns move one standard deviation, $OAS_{IG}$ respond with an inverse move of 1.2 basis points and $OAS_{HY}$ with 18.5 basis points.

Similar to the research of Collin-Dufresne et al. (2001) and Boss and Scheicher (2002), who extended their models much more exhaustively than in this paper, we too are unable to explain a majority of the variance in credit spreads. The mentioned authors were surprised by the high correlations between the residuals of their regressions as they thought their set of variables should adjust for the common factors. The correlation between the residuals of our different regressions for the 1999-2017 period are presented in table 6 below. The correlation is noticeably high and could perhaps be a result from omitting important variables from our models. This would in turn be a possible source of an endogeneity problem. One key factor which is not taking into account is the risk of the market. Variables account for risk aversion among investors of corporate debt, the liquidity risk and volatility of the bond and stock markets are examples of what we could have included to lower the risk of such issues. This could in turn also lower the correlation between the residuals of our different regression outputs. Nevertheless, the research of Collin-Dufresne et al. (2001) and Boss and Scheicher (2002) both include a number of these variables and still find a high correlation between their different residuals. Indeed, our findings show a higher correlation than in the research of Collin-Dufresne et al. and Boss and Scheicher which corresponds with what one could expect from our shorter model. Still, conclusions about this interdependence are to be made with cautiousness. Furthermore, it is likely that credit spreads on European corporate bonds to a large extent are driven by other factors than previous researchers have succeeded to prove and from what economic theory suggests.

**TABLE 6: CORRELATION BETWEEN RESIDUALS.**

*Correlation coefficients between the residuals from the different regression with OAS. $V_x$ corresponds to Model 1b and $W_x$ to Model 2c.*

| | $V_{IG}$ | $V_{HY}$ | $W_{IG}$ | $W_{HY}$ |
|---|---|---|---|---|
| $V_{IG}$ | 1.000 | | | |
| $V_{HY}$ | 0.996 | 1.000 | | |
| $W_{IG}$ | 0.979 | 0.975 | 1.000 | |
| $W_{HY}$ | 0.979 | 0.983 | 0.996 | 1.000 |

The interpretation of these highly correlated residuals and the unexplained part is not straightforward. One argument has been made that bond markets are segmented from equity markets (Collin-Dufresne, Goldstein, & Martin, 2001). This would allow for the respective markets to be driven by separate, or local, shocks in supply or demand. However, the idea of segmented markets is farfetched as it implies equity and bond market will not react to the same macroeconomic factors.

Nevertheless, like Collin-Dufresne et al. (2001) and Boss and Scheicher (2002), we must conclude that there seems to be a significant systematic risk which our regression variable fails to capture.

# 7. Conclusions

## 7.1. Concluding discussion

This thesis has investigated the relationship between changes in interest rates and credit spreads in the European bond market. Using two sets of bond indices, separating bonds of investment grade rating from non-investment grade rated bonds, we use the two-factor model as constructed by Longstaff and Schwartz (1995) and regress changes in credit spreads on two independent variables; the ten-year risk-free rate and return on the stock market respectively. With inspiration from Collin-Dufresne et al. (2001) and Boss and Scheicher (2002) we subsequently expand the two-factor model by adding a third variable which accounts for the slope of the euro area yield curve. We adjust for the potential callability effect by using OAS instead of regular nominal yield credit spreads and find results in line with previous research and our expectations for the two-factor model. That is to say, a negative relationship between the dependent variable credit spread and the independent variables risky asset returns and changes in the risk-free interest rate.

Our dataset consists of weekly time series data collected over the period 1999-2017. It therefore encompasses both a period of rapid growth in the corporate bond market and a period in which the European Central Bank has set interest rates below zero. We break up the dataset into three sub-periods for a comparison of potential changes in the relationship between the variables.

Over the entire period, the regression outputs of our two-factor model are largely in line with that of previous research. Furthermore, we find the interest rate-coefficient decreasing in magnitude for the high yield bond index but the models achieving higher explanatory power, as measured by R-squared, in the later period compared to the earlier. We conclude that this development can partly be attributed to the growth of the overall market since its creation, partly to the growing significance of stock return in the latter parts of our time series. For the expanded model we find a relationship for changes in credit spreads and the level of the yield curve and return on risky assets which are largely in parity to the findings of our peers. As for the slope however, we fail to find a significant variable that complies with previous research and economic sense.

Lastly, we find high correlation in our residuals. This suggests that our model, like its predecessors, fails to capture a large systematic risk component.

## 7.2. Excluded Variables and Suggestions for Future Research

During the design of this study we have experimented with several other variables as well as variations when it comes to interest rates and spreads. That includes restructuring the models to quarterly data to include gross domestic product and real interest rates by incorporating inflation. In line with Collin-Dufresne et al. (2001) and Boss and Scheicher (2002) we have also looked at government bond yield volatility and stock market volatility, among other factors. Most of the experiments have turned out insignificant or difficult to interpret. The purpose of this thesis has never been to find a model explaining all of the variance in credit spreads rather than the effect from interest rates. Thus, we chose to stay with a simpler model in accordance with the foundation of research in this field.

With regards to corporate bond indices, BofA Merrill Lynch provide a diverse index family. Despite this, sub-indices within non-investment grade bonds in the euro area are of rather limited quantity. Comparing bonds of different maturities, different types of issuing firms or breaking up the ratings in several trenches could have added to our research. However, this is a challenge for researchers due to lack of high yield indices and in some cases missing values within those who exist.

As we have found a significant relationship between interest rates and credit spreads in the euro markets we suggest future research should focus on its implications. For example, how investors, corporate managers and policy maker could take advantage, or hedge against disadvantages, of this. Applying the models on baskets of individual bonds or awaiting the publication of new indices will allow for a more comprehensive comparison. Also, if and when interest rates return to a historical average the whole business cycle can be analysed and thus conclusions about its consequences on the corporate bond market can be drawn.

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# Appendix

**TABLE 7: DESCRIPTIVE STATISTICS FOR SUB-SAMPLE 1, 1999-2006**

| Variable | N | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| $\Delta OAS_{IG}$ | 416 | 0.000% | 0.030% | -0.100% | 0.130% |
| $\Delta OAS_{HY}$ | 416 | -0.012% | 0.387% | -2.390% | 2.070% |
| $\Delta EURIBOR_{3M}$ | 416 | 0.001% | 0.057% | -0.470% | 0.436% |
| $\Delta EURIBOR_{12M}$ | 416 | 0.002% | 0.072% | -0.296% | 0.308% |
| ΔGECU2YR | 416 | 0.002% | 0.104% | -0.365% | 0.423% |
| ΔGECU10YR | 416 | 0.000% | 0.092% | -0.240% | 0.306% |
| $R^{SXXE}$ | 416 | 0.088% | 2.666% | -11.151% | 13.369% |
| $\Delta Slope_1$ | 416 | -0.001% | 0.097% | -0.274% | 0.586% |
| $\Delta Slope_2$ | 416 | -0.002% | 0.080% | -0.286% | 0.392% |
| $\Delta Slope_3$ | 416 | -0.002% | 0.067% | -0.234% | 0.314% |

**TABLE 8: DESCRIPTIVE STATISTICS FOR SUB-SAMPLE 2, 2007-2012**

| Variable | N | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| $\Delta OAS_{IG}$ | 313 | 0.003% | 0.086% | -0.240% | 0.610% |
| $\Delta OAS_{HY}$ | 313 | 0.009% | 0.526% | -3.490% | 4.170% |
| $\Delta EURIBOR_{3M}$ | 313 | -0.011% | 0.063% | -0.336% | 0.197% |
| $\Delta EURIBOR_{12M}$ | 313 | -0.011% | 0.063% | -0.287% | 0.321% |
| ΔGECU2YR | 313 | -0.013% | 0.118% | -0.421% | 0.422% |
| ΔGECU10YR | 313 | -0.008% | 0.117% | -0.356% | 0.307% |
| $R^{SXXE}$ | 313 | -0.071% | 3.499% | -21.760% | 11.768% |
| $\Delta Slope_1$ | 313 | 0.003% | 0.127% | -0.437% | 0.561% |
| $\Delta Slope_2$ | 313 | 0.003% | 0.120% | -0.323% | 0.543% |

| | | | | | |
|---|---|---|---|---|---|
| $\Delta Slope_3$ | 313 | 0.004% | 0.098% | -0.322% | 0.356% |

**TABLE 9: DESCRIPTIVE STATISTICS FOR SUB-SAMPLE 3, 2013-2017**

| Variable | N | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| $\Delta OAS_{IG}$ | 222 | -0.001% | 0.037% | -0.120% | 0.110% |
| $\Delta OAS_{HY}$ | 222 | -0.006% | 0.160% | -0.520% | 0.510% |
| $\Delta EURIBOR_{3M}$ | 222 | -0.002% | 0.008% | -0.059% | 0.034% |
| $\Delta EURIBOR_{12M}$ | 222 | -0.003% | 0.011% | -0.060% | 0.037% |
| ΔGECU2YR | 222 | -0.003% | 0.039% | -0.136% | 0.146% |
| ΔGECU10YR | 222 | -0.004% | 0.086% | -0.165% | 0.357% |
| $R^{SXXE}$ | 222 | 0.190% | 2.276% | -6.820% | 5.59572% |
| $\Delta Slope_1$ | 222 | -0.002% | 0.085% | -0.168% | 0.358% |
| $\Delta Slope_2$ | 222 | -0.001% | 0.084% | -0.167% | 0.356% |
| $\Delta Slope_3$ | 222 | -0.001% | 0.068% | -0.150% | 0.310% |

**TABLE 10: CORRELATION BETWEEN OAS AND DIFFERENT INTEREST RATES, 1999-2017.**

| Variable | $\Delta OAS_{IG}$ | $\Delta OAS_{HY}$ |
|---|---|---|
| $\Delta EURIBOR_{3M}$ | 0.046 | -0.072 |
| $\Delta EURIBOR_{6M}$ | 0.017 | -0.125 |
| $\Delta EURIBOR_{12M}$ | -0.029 | -0.167 |
| ΔGECU2YR | -0.334 | -0.339 |
| ΔGECU3YR | -0.325 | -0.341 |
| ΔGECU4YR | -0.325 | -0.330 |
| ΔGECU5YR | -0.320 | -0.316 |

| | | |
|---|---|---|
| ΔGECU6YR | -0.310 | -0.318 |
| ΔGECU7YR | -0.306 | -0.315 |
| ΔGECU8YR | -0.307 | -0.305 |
| ΔGECU9YR | -0.318 | -0.311 |
| ΔGECU10YR | -0.315 | -0.311 |
| ΔGECU20YR | -0.270 | -0.259 |
| ΔGECU30YR | -0.285 | -0.269 |

**TABLE 11: AUTOCORRELATION FOR ALL VARIABLES.**

| Variable | Corr ($Variable_t$ , $Variable_{t-1}$) |
|---|---|
| $\Delta CS_{IG}$ | 0.198 |
| $\Delta OAS_{IG}$ | 0.335 |
| $\Delta CS_{IG}$ | 0.197 |
| $\Delta OAS_{HY}$ | 0.227 |
| $\Delta EURIBOR_{3M}$ | 0.490 |
| $\Delta EURIBOR_{12M}$ | 0.297 |
| ΔGECU2YR | 0.032 |
| ΔGECU10YR | 0.072 |
| $R^{SXXE}$ | 0.009 |
| $\Delta Slope_1$ | 0.041 |
| $\Delta Slope_2$ | 0.067 |
| $\Delta Slope_3$ | 0.064 |

**TABLE 12: P-VALUES FROM F-TEST FOR SEASONALITY.**

*The variables are regressed on quarterly dummies to test for seasonality. The null hypothesis is* $H_0 = \gamma_1 = \gamma_2 = \gamma_3 = 0$ *where* $\gamma_n$ *is the effect from* $Q_n$ *and the P-values are from testing joint significance with a F-test. We cannot reject the null hypothesis even at the 10% level with two exceptions being the Euribor3M and the* $Slope_1$ *which is constructed with Euribor3M. They are however still not significant at the 5% level and hence, we should be unbiased from seasonality.*

| Variable | P-value |
|---|---|
| $\Delta CS_{IG}$ | 0.128 |
| $\Delta OAS_{IG}$ | 0.133 |
| $\Delta CS_{IG}$ | 0.188 |
| $\Delta OAS_{HY}$ | 0.170 |
| $\Delta EURIBOR_{3M}$ | 0.067 |
| $\Delta EURIBOR_{12M}$ | 0.112 |
| ΔGECU2YR | 0.218 |
| ΔGECU10YR | 0.135 |
| $R^{SXXE}$ | 0.288 |
| $\Delta Slope_1$ | 0.075 |
| $\Delta Slope_2$ | 0.174 |
| $\Delta Slope_3$ | 0.5746 |

**TABLE 13: CORRELATION BETWEEN ALL REGRESSION VARIABLES.**

| Variable | $\Delta OAS_{IG}$ | $\Delta OAS_{HY}$ | $\Delta EURIBOR_{3M}$ | $\Delta EURIBOR_{12M}$ | ΔGECU2YR | ΔGECU10YR | $R^{SXXE}$ | $\Delta Slope_1$ | $\Delta Slope_2$ | $\Delta Slope_3$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $\Delta OAS_{IG}$ | 1.000 | | | | | | | | | |
| $\Delta OAS_{HY}$ | 0.628 | 1.000 | | | | | | | | |
| $\Delta EURIBOR_{3M}$ | 0.046 | -0.073 | 1.000 | | | | | | | |
| $\Delta EURIBOR_{12M}$ | -0.029 | -0.168 | 0.785 | 1.000 | | | | | | |
| ΔGECU2YR | -0.334 | -0.340 | 0.336 | 0.613 | 1.000 | | | | | |
| ΔGECU10YR | -0.315 | -0.312 | 0.152 | 0.364 | 0.683 | 1.000 | | | | |
| $R^{SXXE}$ | -0.447 | -0.510 | 0.065 | 0.161 | 0.364 | 0.352 | 1.000 | | | |
| $\Delta Slope_1$ | -0.321 | -0.259 | -0.353 | -0.046 | 0.480 | 0.871 | 0.301 | 1.000 | | |
| $\Delta Slope_2$ | -0.309 | -0.218 | -0.336 | -0.250 | 0.325 | 0.811 | 0.265 | 0.934 | 1.000 | |
| $\Delta Slope_3$ | 0.019 | 0.031 | -0.227 | -0.306 | -0.386 | 0.411 | -0.009 | 0.502 | 0.619 | 1.000 |