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THE EURIBOR-EONIA SWAP SPREAD AS AN INDICATOR OF A FINANCIAL CRISIS IN THE EUROZONE

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Abstract

The aim of this Master's Thesis is to evaluate if the spread between the 3-month Euribor and the 3-month EONIA Swap was a valid indicator of a financial crisis in the Eurozone during 2005-2014. The method is to measure the degree of correlation to certain events during the financial crisis, to the equity markets and the stock market volatility. The indices used in this research are the Euro STOXX 50 stock index and the Euro STOXX 50 volatility index.

The correlation is evaluated through OLS-based regression analysis with an autoregressive model with an exogenous predictor variable. The results indicate that an increase in the spread indicates a financial crisis by correlating with negative returns in the stock market and increases in the stock market implied volatility. The spread could thus be used as an indicator of a financial crisis in the Eurozone during 2005-2014, but its validity is challenged by the omitted variable bias of various variables that might affect to the stock market returns and the stock market volatility during a financial crisis and during an economic recession. Correlation exists with the stock market returns, stock market volatility and the development of the spread, but any conclusions cannot be made on the causality or the predictive force of the spread to a financial crisis.

Keywords Financial crisis, sovereign debt crisis, interest rates, equity markets

Additional information

CONTENTS

1 INTRODUCTION 6

2 THE EUROPEAN INTERBANK MARKET 8

2.1 INTEREST RATE 11

2.2 EURIBOR 13

2.3 EONIA & EONIA SWAP 14

2.3.1 EONIA 14

2.3.2 Interest rate swap 15

2.3.3 EONIA Swap 16

2.4 THE EURIBOR-EONIA SWAP SPREAD 18

3 THE EUROPEAN STOCK MARKETS 21

3.1 EURO STOXX 50 22

3.2 IMPLIED VOLATILITY 24

4 EVIDENCE FROM EARLIER RESEARCH 27

4.1 MONEY MARKETS 27

4.2 THE STOCK MARKET AND VOLATILITY 28

4.3 EVIDENCE FROM LIBOR-OIS 30

5 METHOD 32

6 RESULTS 35

6.1 EURIBOR-EONIA SPREAD AND EURO STOXX 50 INDEX 35

6.2 EURIBOR-EONIA SPREAD AND THE EURO STOXX 50 VOLATILITY 38

6.3 EURIBOR-EONIA SPREAD AND SHOCKS 40

7 DISCUSSION 43

7.1 THE EURIBOR-EONIA SPREAD AND THE EURO STOXX 50 44

7.2 THE SPREAD AFFECTED EURO STOXX 50 VOLATILITY 46

7.3 THE SPREAD DURING THE STAGES OF THE FINANCIAL CRISIS..... 48

8 SUMMARY 51

REFERENCES..... 54

FIGURES

Figure 1. The supply and demand for money (adapted from Pilbeam, 2010, p. 83). 12

Figure 2. The development of the 3-month Euribor 2005-2014 14

Figure 3. A plain vanilla interest rate swap 15

Figure 4. The development of the 3-month EONIA Swap 2005-2014..... 18

Figure 5. The development of the Euribor-EONIA Swap-spread during 2005-2014..... 20

Figure 6. The development of the opening values of the Euro STOXX 50-index during 2005-2014. 24

Figure 7. The development of the opening values of the Euro STOXX 50 Volatility index during 2005-2014..... 26

Figure 8. Returns of the Euro STOXX 50, Euribor-EONIA Swap-spread and the regression residuals. 35

Figure 9. Returns of the Euro STOXX 50 Volatility, Euribor-EONIA Swap-spread and the regression residuals..... 38

TABLES

Table 1. Regression results of the Euro STOXX 50 and the Euribor-EONIA Swap spread.36

Table 2. Regression results of the Euro STOXX 50 Volatility and the Euribor-EONIA Swap spread 39

Table 4. The change in the spread during the stages of the financial crisis. 40

1 INTRODUCTION

During 2007-2010 the financial markets in the Eurozone faced turmoil and turbulence due to a financial crisis. The origins of the crisis came from the liquidity crisis originated from subprime mortgages in the United States in 2007. The crisis lead eventually to the collapse of high-grade investment bank Lehman Brothers, which contributed heavily to the financial crisis in Europe and introduced a sovereign debt crisis. The financial crisis affected the government bond market heavily and caused problems for example for the economies of Greece and Ireland (Moisescu & Giurescu, 2016).

The spreads between LIBOR (London Interbank Offered Rate) and OIS (Overnight Indexed Swap) have been shown to be a barometer of financial distress in previous research. For example, before the crisis in the credit markets began in 2007, the LIBOR-OIS spread was around 10 basis points, but on the collapse of Lehman Brothers the spread increased rapidly to nearly 365 basis points (Sengupta & Man Tam, 2008).

The European equivalents for LIBOR and OIS are the Euribor and the EONIA Swap. The Euro Interbank Offered Rate (Euribor) is a rate of the averaged interest rates at which banks in the Eurozone offer to lend funds to other banks in the euro money market and the EONIA Swap is a derivative reference for the Euro Overnight Index Average (EONIA). (European Money Market Institute, 2018.)

The aim of this thesis is to evaluate the spread between the 3-month Euribor and the 3-month EONIA Swap rates in the Eurozone during the years 2005 and 2014. With the help of an autoregressive model with an exogenous predictor, the aim is to see if there exists any dependency with the returns of a specific stock index. The Euro STOXX 50 index is the stock index of interest. The purpose is to evaluate how valid indicator the Euribor-EONIA Swap spread was of a financial distress and financial crisis in the Eurozone during the time. The main research question is:

"Was the Euribor-EONIA Swap spread a valid indicator of a financial crisis in the Eurozone?"

Secondly, the correlation with the Euro STOXX 50 volatility index is assessed, which is designed to measure market expectations of near-term up to long-term volatility. This is calculated by measuring the square root of the implied variance across all options of a given time to expiration. (STOXX, 2018.)

Finally, the correlation with specific macroeconomic shocks and the spread is evaluated. The effects of the sovereign debt crisis and the subprime crisis for example are among the macroeconomic shocks that are examined in this thesis.

The research expects some dependency with the Euribor-EONIA Swap spread with the stock indices, the volatility index and macroeconomic shocks. If the Euribor-EONIA Swap spread is a valid barometer on financial distress and could be used to forecast financial crises, there should be a correlation with significant decreases of the stock indices, market volatility and certain macroeconomic events that affect the financial markets.

The public official data is retrieved from internet-resources and existing research on LIBOR-OIS spreads is used as a reference. To calculate the correlation, an OLS-based regression analysis is conducted to the given time-period with statistical software for the data. After that, some specific macroeconomic events are determined, and the spreads are examined manually on the specific dates in time.

LIBOR-OIS spread is generally regarded as how expensive or cheap it is for banks to borrow in relative to a risk-free rate, which can be considered as a government bond, for instance. The spread represents a difference between a rate that has some credit risk and a risk-free rate and thus is an indicator of credit risk. Increase in the interbank market spread implies that banks might not be able to pay their short-term debt.

Euribor-EONIA Swap spread should thus depict the same situation in the Eurozone. Similar observations are expected for the data of spreads between the 3-month Euribor and EONIA Swap rates from the same period of time as for those as the LIBOR-OIS spreads.

2 THE EUROPEAN INTERBANK MARKET

Whenever examining the financial markets, the first distinction should be made between the money markets and the capital markets. The difference between the two markets comes from the maturity of the securities traded in each market. In the money market short-term debt-instruments with terms of maturity is less than one year are traded, whereas longer-term debt-instruments with terms of maturity of one year or greater are traded in the capital markets. (Mishkin, 2016, p. 73.)

Instruments in the money market tend to be more liquid than the instruments in the capital market, since they are more widely traded. They also tend to have smaller fluctuations in prices and are thus considered as safer investments compared to the instruments traded in the capital markets. Money market instruments are commonly used by banks and corporations to earn returns on their short-term funds. (Mishkin, 2016, p. 73.)

The different kinds of money markets can be further distinguished in terms of instruments traded in the market. Money market instruments can be traded in the so-called discount market, where treasury bills and commercial bills are traded, and the market for commercial papers which are quoted on a discount basis. Alternatively, the certificate of deposit market, money market deposits, repurchase agreements and the interbank market are type of money markets quoted on a yield basis. (Howells & Bain, 2008, p. 304.)

In this research the focus is on the interbank market. The interbank market is a market for non-negotiable deposits which can be disposed only by withdrawals and the maturities of these deposits can range from overnight to one year. The market is commonly used by banks to adjust their liquidity positions, for instance. (Howells & Bain, 2008, p. 308.)

The interest paid to the deposits in the interbank market represents a marginal cost of funding for the banks, and this rate is commonly known as the Interbank Offered Rate. These rates are closely related to the official rate of interest set by the central bank, since both the interbank market and the central bank are similar sources of

liquidity for the banks. Some examples of these rates are the London Interbank Offer Rate and the European Interbank Offered Rate, and they are calculated daily for different maturities. (Howells & Bain, 2008, p. 308.)

The money market in Europe is considered as somewhat extraordinary due to the existence of a monetary union and a single currency. In the Eurozone, the Euribor Interbank Offered Rate is used to measure the rates of deposits for various maturities and the Euro Overnight Index Average for overnight deposits. The official interest rate is set by the European Central Bank, and it is common for the entire money market in the Eurozone. (European Central Bank, 2018.)

The integration of the financial markets is important to the Eurozone as to any other monetary union, since it offers some protection against asymmetrical shocks due to risk-sharing of banks. For example, if the banking sector is fully integrated, banks operating in country A and country B should be identical. Country A holds a large portfolio of loans of country B and vice versa. A shock in country B makes part of its loans non-performing and this introduces decreasing revenue for the bank in country A. However, the bank in country A can compensate its losses due to the shock by boosting the revenues attained from the rising values of loans in country A. (Grauwe, 2013 p. 233–234.)

Banks tend to form long-term relationships with other banks and engage in peer monitoring to decrease the credit-risk uncertainty in their activities. Different kinds of shocks in the financial markets can create a lack of trust in the interbank market and it can hinder the lending activities. (Blasques et al, 2018.)

Research suggests that from 1999 to 2010 the European money markets were fully integrated. The European Central Bank applied the same interest rate of lending for all the banks and the banks applied the same rate for lending for other banks. However, after the 2010 sovereign debt crisis the interbank market in the Eurozone has been relatively less integrated, since the banks do not trust each other anymore as much. (Grauwe, 2013 p. 229.)

The sovereign debt crisis in Greece, Ireland, Portugal and Spain during 2010 raised worries in the interbank market of the Eurozone. The banks owned large proportions of government debt from these countries and experienced large losses. The crisis raised the interest rates of the government bonds and in the same time the interest rates that the banks were using to fund themselves. This made the borrowing costs to rise more than the rates in lending, which lead to increased losses of the banks. This created distrust among the banks in the Eurozone. The banks in the countries where the sovereign debt crisis hit the most lost their access to the interbank market. (Lakdawala et al, 2018.)

Similarly, the subprime crisis in 2008 had also its effect on the European interbank market at the time. Blasques et al. (2018) found out that shocks in credit-risk uncertainty lead to extended periods of low market activity and reduced peer monitoring in the European interbank market during 2008-2011 in the Netherlands. Affinito and Franco Pozzlo (2017) made similar observations in Italy: The liquidity crisis in 2007 and the collapse of Lehman Brothers were associated with a remarkable reduction of the relative integration in the Italian banking sector. The situation was the same with the research from Iyer et al. (2014) in Portugal.

On the other hand, the entire interbank market didn't suffer from the losses. For instance, the Euro Interbank Repo market has been observed to be more resilient in the case of a shock and repo loans acted as shock absorbers in the interbank market. A repo is essentially a collateralized loan that is sold in the same time as the forward agreement is been made to repurchase securities at a certain maturity date between banks in the interbank market. (Mancini et al, 2016.)

The issues in the European interbank market are current, since investors have been worried about Italy's sovereign debt after the general election in 2018 (Financial Times, 8th of October 2018). If the Eurozone faces another sovereign debt crisis, it might have significant effects on the interbank market.

2.1 INTEREST RATE

The rate of interest is generally defined as cost of money over time (Gibson, 2003, p. 248). Basically, the interest rate is the price a borrower pays for the use of money as a loan. For the lender the interest rate is the amount of compensation received for the risk exposure taken in the agreement.

From the definition it can be identified that the risk structure is one of the main determinants to the level of the interest rate. The rate of interest is influenced by the degree of risk taken by the lender. Higher rates of interest are charged from the relatively riskier borrowers than from the more reliable borrowers that are evaluated to have a good degree of solvency and smaller probability to default. Also, the lender might demand a liquidity premium that is charged on the decrease of the liquidity of the lender. The risk structure of the interest rate thus depends on the default risk and on the liquidity risk on the agreement. (Mishkin, 2016, p. 113–119.)

Similarly, loan agreements for longer periods of time have higher rates of interest than short-term loan agreements due to the increased uncertainty over time. This can be seen in the bond-market as well, where a “term premium” is the excess yield that investors require for bonds with identical risks of default and liquidity, but with a longer time to maturity due to its uncertainty compared to short-term bonds (Mishkin, 2016, p. 119–121).

Another way to interpret the interest rates comes from the money demand. The demand for money in general influences the interest rates through the law of demand and supply (Pilbeam, 2010, p. 82). The relationship between the money demand, money supply and the rate of interest is illustrated in the figure below:

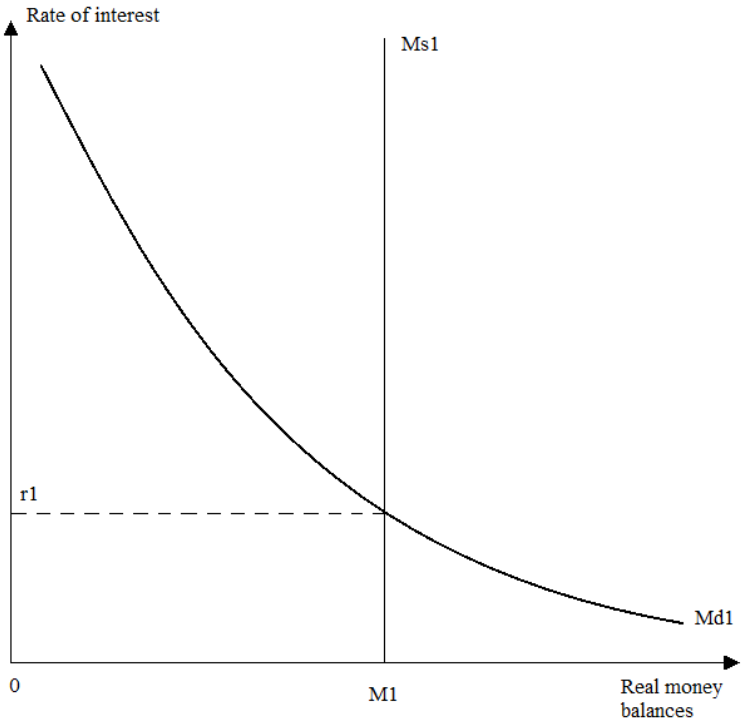

Figure 1. The supply and demand for money (adapted from Pilbeam, 2010, p. 83).

The rate of interest $r1$ is defined in the equilibrium where the money demand $Md1$ equals the money supply $Ms1$. Changes either in the money demand or in the money supply would change the equilibrium rate of interest.

If the demand for money increases because of fast economic growth, the country's central bank can decrease the demand by raising the interest rates and increasing the cost of money (Gibson, 2003, p. 248). For example, the European Central Bank can change the money supply or the money demand through monetary policy and interest rate changes to meet specific interest rate targets (Schabert, 2009).

These interest rate targets are implemented mostly to adjust price stability and to keep the rate of inflation under control. The inflation usually acts as a floor for the cost of money and only in rare cases the rate of interest can fall below the economy's rate of inflation (Gibson, 2003, p. 248). A fall below the rate of inflation would imply a decrease in the purchasing power parity for the lenders, which explains the inflation premium on the rate of interest.

Many kinds of interest rates exist on the financial markets due to their different risk structures. One of the most important interest rates used in the Eurozone as benchmark interest rates are the Euribor and EONIA which are closely linked to each other, since the longer-term interest rates like the Euribor are determined by the market expectation of short-term rates (Tamakoshi & Hamori, 2014). In the next chapter these rates and their role on the interbank market and the EONIA Swap are discussed.

2.2 EURIBOR

The Euro Interbank Offered Rate (Euribor) is the rate at which interbank deposits in the Eurozone are being offered by a one prime bank to another for a specific period of time. Euribor is a common benchmark used by money markets throughout the Eurozone and anywhere that euros are traded. (Gibson, 2003, p. 129.)

Euribor is quoted daily for spot value (T+2) by the European Money Market Institute. The rate is calculated by averaging the inputs of the panel data of European prime banks, excluding the highest and the lowest 15% of the data. Maturities of the rates range from one week to one year. (European Money Market Institute, 2018.)

The introduction of the single currency to the Eurozone in 1999 made the European banks to think that it would be necessary to establish a new interbank rate to the monetary union. The first quotation of the Euribor was quoted on the 30th of December 1998 for value 4th of January 1999, a maturity of one week. After that the number of maturities were increased, and they included the maturities of one week and 1-12 months. From November 1st 2013 onwards, the number of maturities were decreased and currently only maturities of one week, two weeks, one month, two months, three months, six months, nine months and one year are quoted. (European Money Market Institute, 2018.)

Euribor has taken a significant role in monetary policy decisions over the years, since it is commonly used as a reference rate for household loans, corporate loans and other loans with variable rates of interest in the Eurozone. Even the financial institutions themselves tend to use the Interbank Offered rate as a reference rate of

interest instead of the central bank interest rates or the Treasury bill rates. (Pilbeam, 2010, p. 114.)

The figure below illustrates the development of the 3-month Euribor rate during 2005-2014. The graph indicates the increases in the value during the subprime crisis in 2008 and during the sovereign debt crisis in 2010. This tells us that financial crises impose turbulence on the interbank market.

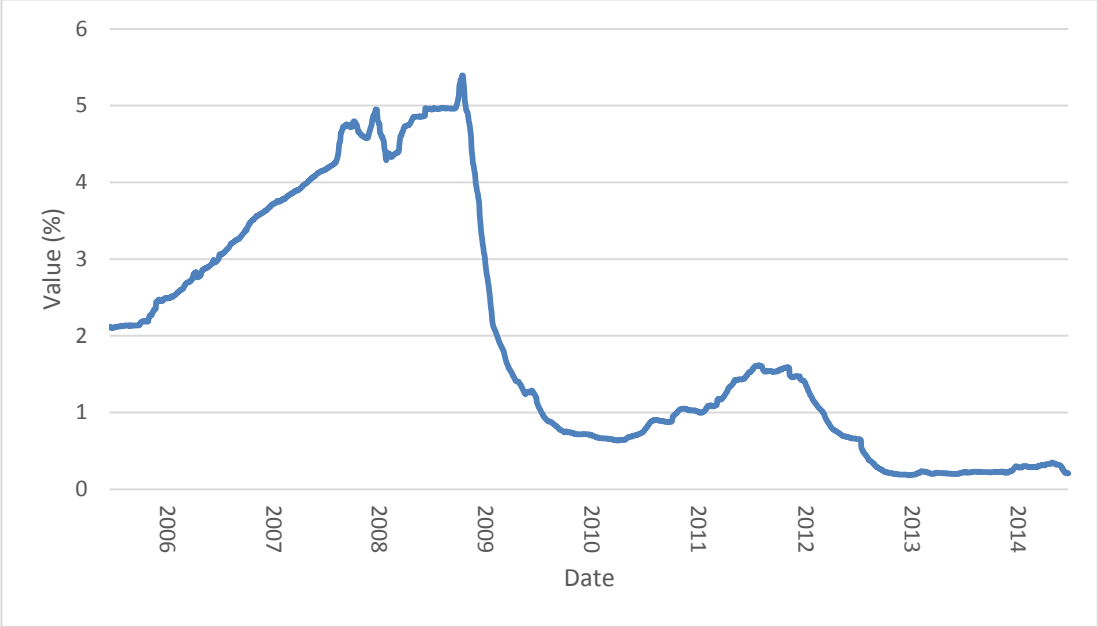

Figure 2. The development of the 3-month Euribor 2005-2014

2.3 EONIA & EONIA SWAP

2.3.1 EONIA

The Euro Overnight Index Average (EONIA) measures all overnight unsecured lending transactions in the interbank market. EONIA is commonly used as a benchmark for pricing transactions in the capital markets in the Eurozone and anywhere that euro-based derivatives are traded. It was introduced at the same time as the Euribor. (Gibson, 2003, p. 127.)

Overnight means a day from the TARGET-system (Trans-European Automated Real-Time Gross-Settlement Express Transfer system) for which the benchmark is calculated to the next TARGET day. EONIA is computed as a weighted average of the contributing panel banks in the European Union (EU) and European Free Trade Association (EFTA) countries. It was first quoted in 4th of January 1999 based on 4th of January 1999 overnight deposit. (European Money Market Institute, 2018.)

2.3.2 Interest rate swap

Interest rate swap is a derivative instrument, which is an agreement between two parties to exchange interest rate payments. In a typical interest rate swap one participant pays the other participant fixed rate payments at specific periods of time, while the counterpart agrees to pay a floating rate of interest to the other participant. One example of a floating rate is the Euro Interbank Offered Rate. A simple agreement in which fixed rate payments are swapped for a floating rate payment with another party is often referred as "plain vanilla interest rate swap". (Pilbeam 2010, p. 398.)

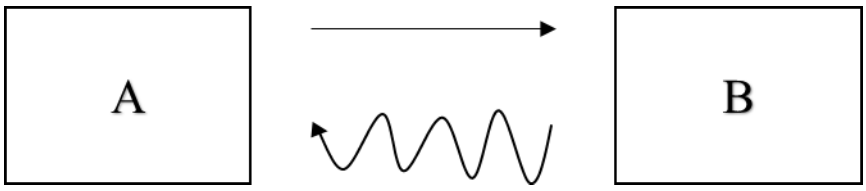

Figure 3. A plain vanilla interest rate swap

The figure above illustrates how a plain vanilla interest swap works. The bank A originally borrows with a floating rate of interest (Euribor, for instance) and bank B borrows with a fixed rate of interest. Let us consider next that both banks are borrowing 100 million euros from the financial markets and bank A wants to borrow with a fixed rate of interest and bank B wants to borrow with a floating rate of interest. If the banks want to engage themselves in an interest rate swap, bank A is obligated to pay bank B the fixed rate of interest to finance its debt and bank B is obligated to pay the floating rate of interest to bank A to finance its debt. There

would be no need for exchanging the principal, since both banks are borrowing the same amount of 100 million euros.

The receiving and the payment of the interest rate happen simultaneously without any change in the principal amount, and only the net cash flows are paid after maturity. In the typical case where the swap is arranged by a bank, the price of the swap depends on the bank´s estimate on the amount of default risk, the easiness of finding a counterpart and on the term structure of interest rates in the bond market. (Howells & Bain p. 449–451.)

2.3.3 EONIA Swap

The EONIA Swap is a form of plain vanilla interest rate swap involving the EONIA-rate being exchanged for a fixed interest rate. The EONIA Swap was initially introduced to increase the range of money market benchmark rates from a derivative perspective. Implemented maturities were 1, 2 and 3 weeks as well as 1 to 12 months since June 2005 and 15, 18, 21, 24 months since May 2007. (European Central Bank, 2008.)

Overnight Index Swaps like the EONIA Swap work as any other plain vanilla interest rate swap where a fixed rate of interest cash flow is exchanged for a variable rate of interest cash flow and vice-versa. The relation between EONIA and EONIA Swap can be illustrated with the formula (1) below, which shows us how the EONIA Swap is determined.

$$r = \frac{360}{n}\left[\prod_{i=t_s}^{t_e-1}\left(1+\frac{r_i \times d_i}{360}\right)-1\right] \qquad (1)$$

Here r describes the floating rate in the interest rate swap, which takes the compounding interest into account and *n* is the maturity of the swap in days. t_s is the

start date of the EONIA Swap and t_e is the end date. r_i is the EONIA fixing rate on the day i and d_i is the maturity in days that the EONIA fixing rate r_i is applied. (European Money Market Institute, 2018.)

The EONIA Swap was introduced in 3th of June in 2005. On July 2014 the European Money Market Institute announced the discontinuation of the EONIA Swap Index due to the lack of contributing panel banks (European Money Market Institute, 2018).

What information do the EONIA Swap rates contain? Hernandis and Torró (2013) investigated the information content of the EONIA Swap rates before and during a financial crisis. From the definition of the swap introduced in equation (1) it is known that the EONIA Swap should reflect the future path of the EONIA rate. This indeed was the case in the period before the financial crisis in 2007, but during the crisis the linkage was not observed to be as clear. In the research it was also conducted that the EONIA Swap rates can be used as exact indicators of the interest expectations of the money market agents.

Statistics of the European Money Market Institute indicated tight bid-ask spreads and strong daily volume of trade during 2000-2007. During the same time, the volume of EONIA Swaps doubled. The significant increase in volume and liquidity of the swaps in the euro money market reflect the importance that the EONIA Swap had during its time. Trenca et al. (2012) observed that EONIA Swaps were the most used instruments in speculation and interest rate hedging, and thus were the most liquid market in the Eurozone interbank markets. It was also concluded that the liquidity problems in the international financial markets caused an increase in the volatility of the European swap rates.

Statistics below illustrate the development of the 3-month EONIA Swap from 2009 to 2014. The graph clearly indicates the values of EONIA Swap rates rose significantly during the financial crisis in 2008 and during sovereign debt crisis in Europe. This indicates again that the subprime-crisis and the sovereign debt crisis created disturbance to the interbank market. The path of the 3-month EONIA swap is

also observed to follow closely the path of the 3-month Euribor introduced previously.

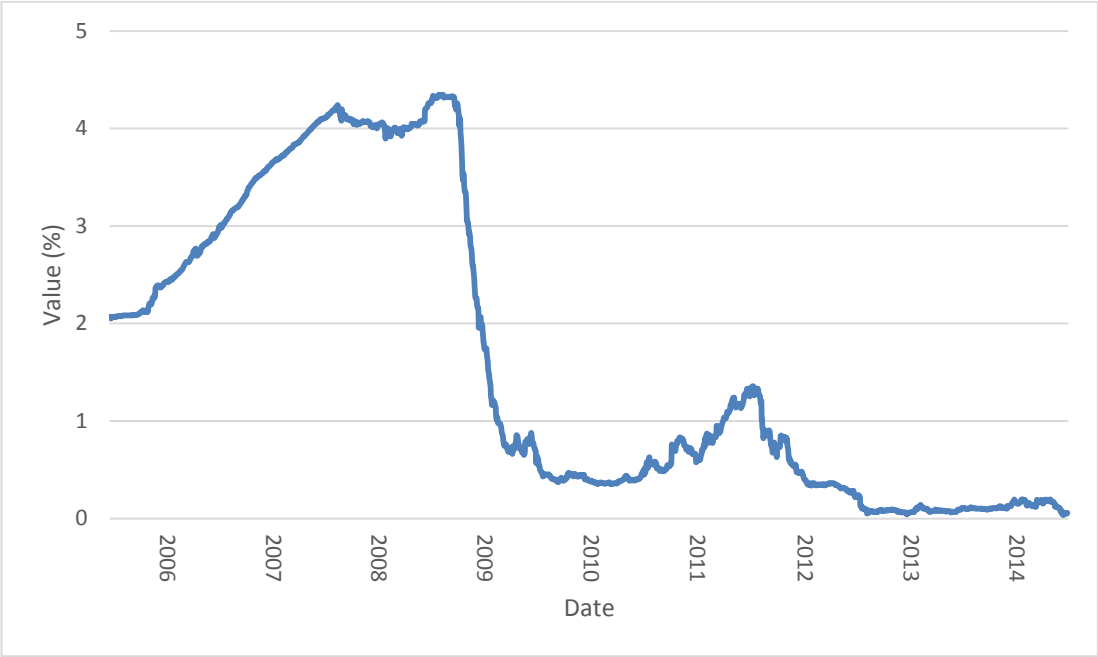

Figure 4. The development of the 3-month EONIA Swap 2005-2014.

2.4 THE EURIBOR-EONIA SWAP SPREAD

A lot of research has been conducted on the spread between an Interbank Offered Rate and an Overnight Indexed Swap, especially between OIS and the London Interbank Offered Rate, often referred as LIBOR. The equivalent benchmark rates in the Eurozone interbank market are the Euro Interbank Offered Rate and the EONIA Swap. In addition to existing research on the two types of interest rates, the main reason to exclude other interest rates for example from the bond market, is the focus exclusively on the interbank market.

In this research the spread between the two rates is evaluated, since their spread should indicate the credit risk in the interbank market in the most efficient way. In addition to the risk premium, the Interbank Offered Rate should reflect the expected path of the monetary policy. The Overnight Indexed Swap should reflect the expectations of the development of the rates used in overnight lending and the expectations of the monetary policy rates in a given currency. Thus, the spread of the

two rates offers a measure of the stress and the health in the interbank market, excluding the effects of policy rate expectations from the model. (Cui et al, 2016.)

The spread should always have a positive value due to the nature of the two benchmark rates. The spread represents a difference between an Interbank Offered Rate that includes some credit risk and a risk-free rate such as the EONIA Swap, which makes the spread an indicator of credit risk in the interbank market. For example, the Euro Interbank Offered Rate measures the interest rate on which the banks offer to lend unsecured funds to other banks in the Eurozone. Since this includes the exchange of a principal, there always exists risks in liquidity and default. However, in the EONIA Swap the interest rates are swapped without any change in the principal amount. The principal isn't exchanged and thus the EONIA Swap is relatively more risk-free for the banks. The difference between the Euribor and the EONIA Swap should thus always be positive in the basic setup.

The spread is important since it involves two commonly used benchmark rates which have a huge impact on the economy and the capital markets. The Interbank Offered rates are commonly used as benchmark interest rates on various financial products. Disruptions in the interbank market would thus have a significant effect on the banking system, the transmission of monetary policy and the financial markets. (Cui et al, 2016.)

The graph below illustrates the development of the spread between the 3-month Euribor and the 3-month EONIA Swap during 2005-2014 in basis points. The peaks in the spread have occurred during the financial crisis in 2007-2008 and the sovereign debt crisis in 2012 where the spread broke through the value of 100 basis points. The first significant increase in the spread occurred during the announcement of BNP Paribas in 2007 to cease three of its funds, that were exposed to subprime mortgages. After that, the spread increased during the further stages in the financial crisis.

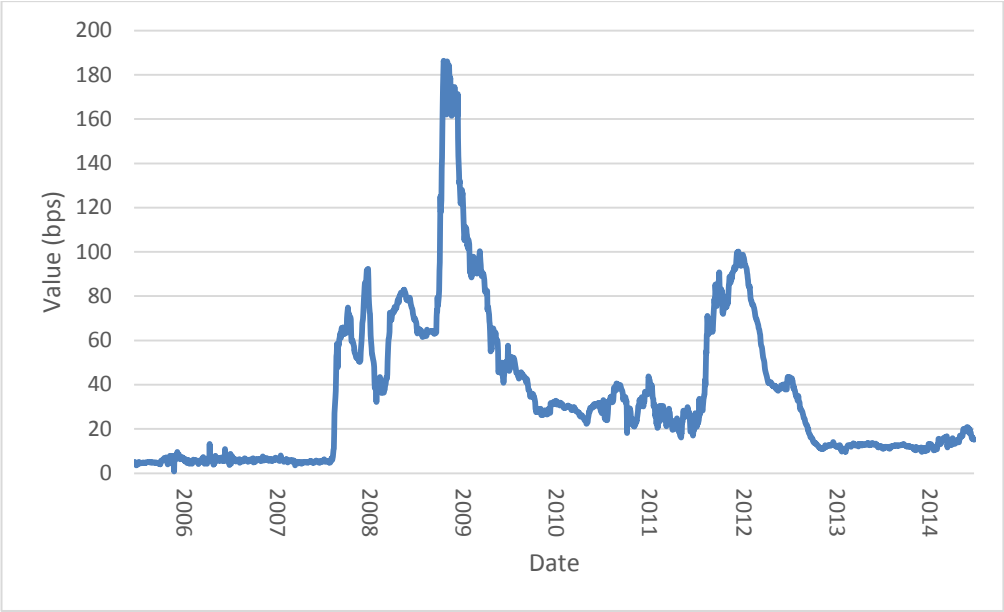

Figure 5. The development of the Euribor-EONIA Swap-spread during 2005-2014.

3 THE EUROPEAN STOCK MARKETS

Capital markets include instruments with the maturity of one year or more. The capital markets can be further divided into debt markets which consist of government bonds and other debt instruments, and to equity markets where equities like stocks and other similar assets are traded. (Pilbeam 2010, p. 6–7.)

In this research the focus is entirely in the stock markets and the equity side of the capital markets. Stock markets, equities and stock indices are commonly seen in the media and they are followed by hundreds of millions of private and institutional investors daily and they are nowadays an important part of the international financial markets.

Statistically the biggest stock markets are located currently in the United States, but European stock markets have also a major contribution to the global financial markets. The major stock markets in Europe are the London Stock Exchange, NYSE Euronext (Europe), Deutsche Borse and BME Spanish Exchange with a combined share of 18% of the global stock market. (Pilbeam, 2020, p. 206.)

The stock markets are commonly illustrated in the form of stock indices, which are measurements of different sections of the stock markets. Stock market indices are calculated as weighted averages of the stocks that are selected to the index with various criteria of selection. Stock indices are a common tool used by investors and financial institutions to interpret the market and compare the returns of various investments. Some of the most significant stock indices around the world are the S&P 500-index, Dow Jones Industrial Average, Nasdaq Composite, Nikkei 225-index and the FTSE 100-index. (Lo, 2016.)

The equity markets in the Eurozone are very closely integrated, and one explanation is offered by the existence of the common currency. Investors from different countries in the Eurozone can invest into foreign markets without currency risk. Currency risk has been observed to be one explanation for “home bias” in the equity

markets, which discourages investors from a foreign country to invest into equities expressed in foreign currency. (Grauwe 2013, p. 229–230.)

However, closely integrated equity markets expressed in the common currency make also the transmittance of country-specific risks and asymmetric shocks more rapid (Grauwe, 2013, p. 10). Even though the currency risk is eliminated in the monetary union, the existence and the transmittance of country risks hinders the further integration of the equity markets in the Eurozone. Also, the regulatory differences between countries in corporate taxation and accounting principles makes it harder to compare the values of different equities across the Eurozone. (Grauwe, 2013, p. 230.)

The sovereign debt crisis, the liquidity crisis in 2008 have had a considerable effect also on the equity markets. During the 2008 liquidity crisis starting from the United States, the shock to the US equity markets spread rapidly also to the equity markets in the Eurozone and was one effect to the birth of the sovereign debt crisis. (Mollah et al, 2016.)

Aizenman et al. (2016) observed that especially the sovereign debt crisis imposed decreasing returns for the equity markets in the Eurozone during the shock. This was mainly due to the interdependence of the financial markets in the Eurozone and the negative spillovers in the financial markets. It was also observed that good news affect positively to the equity market return and bad news negatively to the returns.

In this research a stock index and the implied volatility of a stock index are used as dependent variables. The decreases in the stock market returns and the increase in the implied volatility have been proven to exist during a financial crisis (Nyberg, 2012).

3.1 EURO STOXX 50

Euro STOXX 50 is a stock index that describes the returns of the 50 largest and most liquid stocks of the biggest companies in Eurozone, and it contains the data from companies from over 11 European countries. It is quoted by STOXX, an index provider of the Deutsche Borse and the index serves many international financial institutions as a benchmark of many investment products, such as exchange-traded

funds and options that are sold to the investors. The index was first introduced on the 26th of February 1998. (STOXX, 2018.)

The returns of price, net return and gross return are calculated every 15 seconds from its opening in 09:00 CET to its closing in 18:00 CET expressed both in euros and US dollars. The index is available in several other currencies as well, but the returns in other currencies are available only on the end-of-day of the index at 18:00 CET. The calculation of the daily indices is calculated with the Laspeyres formula illustrated below. The formula measures price changes against a fixed base quantity weight for the time t for n number of companies.

$$Index_t = \frac{\sum_{i=1}^{n}(p_{it} \times s_{it} \times ff_{it} \times cf_{it} \times x_{it})}{D_t} = \frac{M_t}{D_t} \quad (2)$$

Here p_{it} represents the price of the stock i in time t and s_{it} the number of stocks of the company i in time t. ff_{it} is the so called free-float factor of the company i in time t, cf_{it} is the weighting cap of the company i at time t and x_{it} represents the exchange rate from local currency into index currency for company i at time t. By multiplication the M_t, the free-float market capitalization of the index at time t is acquired to the numerator. D_t in the denominator represents the divisor of the index at time t. (STOXX, 2018.)

Due to its liquidity and the usage as a common benchmark, the Euro STOXX 50 is used as a benchmark in this research to describe the development of the equity markets during 2005-2014 in the Eurozone. The development of the Euro STOXX 50 is illustrated in the figure below. The effects of the sovereign debt crisis and the liquidity crisis on the index can be clearly distinguished. The Euro STOXX 50 stock index decreased by over 2500 points during the 2008 liquidity crisis. During the start of the sovereign debt crisis, the index faced another considerable drop and negative returns during the end of 2011.

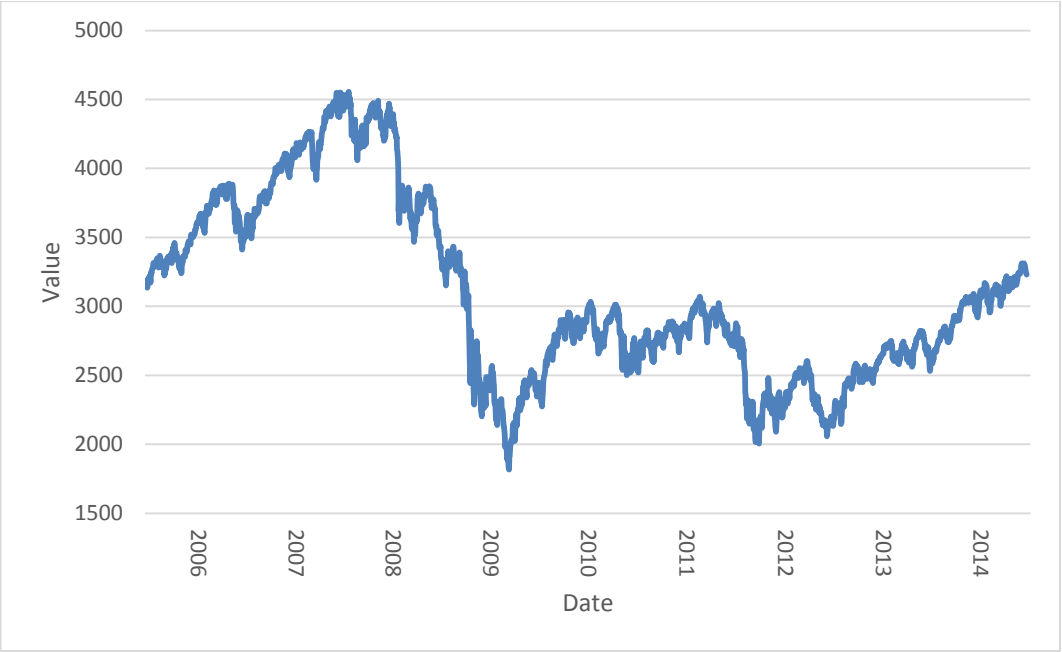

Figure 6. The development of the opening values of the Euro STOXX 50-index during 2005-2014.

3.2 IMPLIED VOLATILITY

Another measurement of stock market activity in addition to the stock indices is the volatility in the given stock market. Volatility is used as a measure of uncertainty in the financial markets by measuring the frequency and magnitude of different kinds of price movements in a given market. It can be calculated either by calculating the historical volatility or the implied volatility. When calculating the historical volatility, actual realized historical price changes are used, whereas the implied volatility uses the option prices of the stock market. One of the most known indices of implied volatility is the VIX-index designed by the Chicago Board Options Exchange in 1993 to measure the implied volatility of the S&P 500-index. (Chicago Board Options Exchange, 2018.)

The Euro STOXX 50 Volatility-index is constructed to measure the intraday volatility in the Euro STOXX 50 stock index. It is based on the Euro STOXX 50 options prices and is designed to reflect the market expectations of near-term up to long-term volatility. The Euro STOXX 50 Volatility-index measures not only the implied volatility, but the implied variance of the options of a given time to maturity. (STOXX, 2018).

The Euro STOXX 50 Volatility-indices are calculated for 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 and 360 days to expire from which the focus is on the 30-day Euro STOXX 50 volatility. In addition to the main indices, 8 sub-indices are also calculated based on the Euro STOXX 50 option expiries ranging from one month to one year. The main indices are calculated with linear interpolation of specific sub-indices, which make the main indices independent of a specific time to expiration. (STOXX, 2018.)

The index is calculated by taking the square root of the implied variances of all the options of a given time to maturity. The main indices are calculated as a time-weighted average (interpolation) of two sub-indices which include the same time to expire as the main index. The formula for calculation for determining the main index MI_{tm} with fixed time to maturity of *tm* days is illustrated below.

$$MI_{tm} = 100 \times \sqrt{[\frac{T_{st}}{T_{365}} \times (\frac{SI_{st}}{199})^2 \times \frac{T_{lt} - T_{tm}}{T_{lt} - T_{st}} + \frac{T_{lt}}{T_{365}} \times (\frac{SI_{lt}}{100})^2 \times \frac{T_{tm} - T_{st}}{T_{lt} - T_{st}}] \times \frac{T_{365}}{T_m}} \quad (3)$$

Here SI_{st} represents the sub-index with shorter maturity and SI_{lt} the sub-index with longer maturity used in the interpolation. T_{st} indicates the time to expiry of SI_{st} in seconds and T_{lt} the time to expiry of SI_{lt} in seconds. T_{tm} is the amount of seconds in one day (86,400 seconds) and T_{365} the amount seconds in one year (31 536 000 seconds). (STOXX, 2018.)

The determination of the sub-indices with shorter and longer maturities is expressed as the square root of the implied variance σ_i^2 for the i^{th} Euro STOXX 50 option expiry date and the sub-index:

$$\sqrt{\sigma_i^2} = \sqrt{\frac{2}{T_i/T_{365}} \times \sum_j \frac{\Delta K_{ij}}{K_{ij}^2} \times R_i \times M_{K_{ij}} - \frac{1}{T_i/T_{365}} \times \left(\frac{F_i}{K_{i,0}} - 1\right)^2} \quad (4)$$

Here T_i measures the time to the i^{th} option expiry date in seconds, R_i is the refinancing factor with the interpolated risk-free rate and $M_{K_{ij}}$ is the inclusion price of the option with strike price K_{ij} for the j^{th} option. $K_{i,0}$ represents the maximum strike price that doesn't exceed the value of F_i, which is the price of the forward contract for the i^{th} option expiry date. ΔK_{ij} measures the average difference between the strike prices of the options slightly above and below K_{ij}. (STOXX, 2018.)

The development of the Euro STOXX 50 Volatility-index is illustrated in the figure below. From the graph it is easy to identify how the implied volatility quadrupled during the 2008 liquidity crisis. Two other significant peaks have occurred during the sovereign debt crisis in 2010 and in the end of 2011.

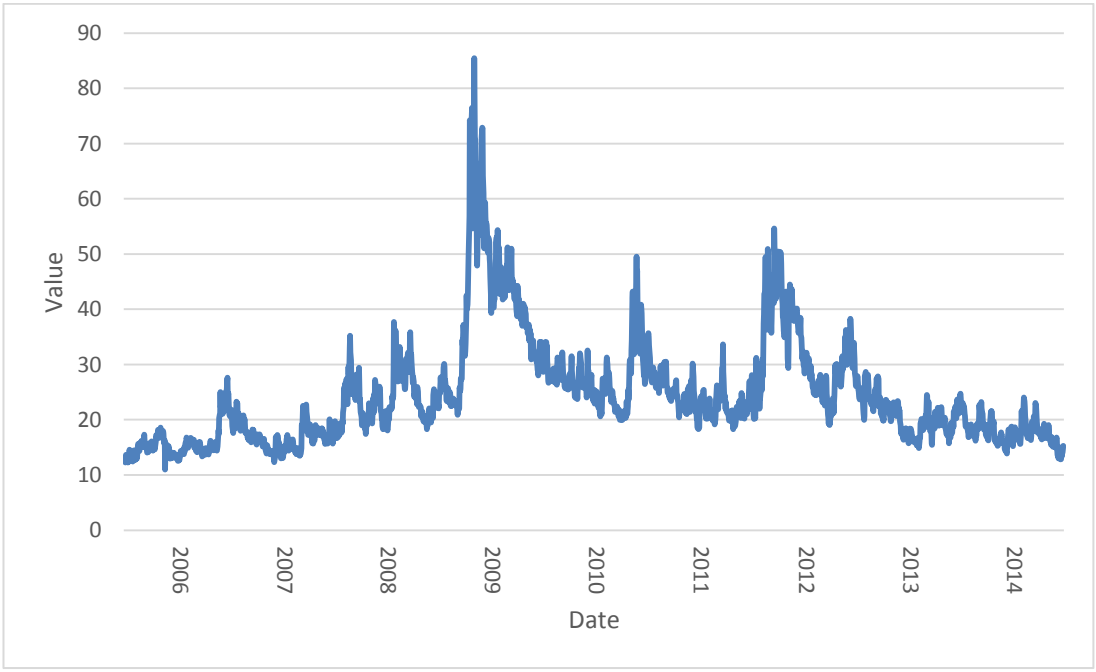

Figure 7. The development of the opening values of the Euro STOXX 50 Volatility index during 2005-2014.

4 EVIDENCE FROM EARLIER RESEARCH

4.1 MONEY MARKETS

As already stated, the liquidity crisis and the sovereign debt crisis have been observed to reduce the integration of banks in the interbank market. The potential effects in the money markets during a financial crisis are evaluated further, since the interbank market can correlate with a financial crisis in many ways.

Perera and Wickramanayake (2016) observed that macroeconomic factors in government policies and banking were major determinants of changes and adjustments in commercial bank interest rates. The transparency and the financial stability of the central bank policies were also key factors identified in a research conducted with a panel data from 122 different countries inside and outside the Eurozone.

The interbank market itself is a major determinant in the economy and it itself cause fluctuations in the business cycle. Giri (2018) examined an explicit interbank market, where banks invest their excess liquidity either into the interbank market or to government bonds. The study indicated that an increase in the default risk in the interbank market can freeze the money market. This freeze would create a flow of funds from the relatively riskier interbank assets to safer assets like government bonds. The credit supply in the money market would decrease, which would lead eventually into a recession caused by the reduction in investment and household consumption.

Iyer et al. (2014) faced similar empirical observations of a credit crunch during the 2007 liquidity crisis. The interbank market faced a liquidity shock, which made firms' access to credit more difficult in the frozen financial markets. Especially small entrepreneurial firms couldn't obtain finance from other banks in the market to compensate their situation. The firms' decreased access to credit lead to decreased investment activity.

Cassola and Moriana (2012) on the other hand conducted a research on the correlation of the financial crisis and the money market turbulence in the Eurozone. Increased spreads between Euribor and OIS during the 2007 liquidity crisis were observed, reflecting increased counterparty risks, credit risks and liquidity risks in the interbank market. Two breaking points in the spread were observed in the same instant of time across all maturities. The first point was the day when the French bank BNP Paribas announced that it would be impossible to determine the value of its structured products for two of its funds that have been exposed to the subprime mortgages. The spread reached its maximum in 16th of September 2008, when Lehman Brothers filed for bankruptcy.

The effect of the change in monetary policy was also imminent. When the European Central Bank reduced its interest rate by 75 basis points on December 2008, the rising trend of Euribor-OIS spreads was broken and the spreads begun to decrease. This caused a radical reduction in the credit risk and liquidity risk in the interbank market.

Taboga (2014) also observed the increase in the levels and volatility of the Euribor-OIS spreads during the financial crisis in 2007. One explanation on this was found from the empirical evidence of the panel survey when the Euribor is calculated. Before the crisis many European banks had high credit ratings and were considered as “prime” banks, which made almost all of the participating pane banks to seem creditworthy. However, after the financial crisis increased uncertainty in the interbank market and banks experienced sharp decreases in their credit ratings, the definition of a credit-worthy prime bank became more subjective.

4.2 THE STOCK MARKET AND VOLATILITY

The 2007 liquidity crisis that originated from the United States, spread quickly all over the world and caused significant decreases in the stock markets around the globe. The crisis had a significant contribution to the equity markets in the Eurozone as studied by Mollah et al. (2016). The United States was the major determinant to the drop in the equity markets in the Eurozone at that time, and it was observed that

the equity markets in the United States affected the European equity markets also in several cases during the time period of 2003 to 2013.

Nyberg (2012) researched the risk-return tradeoff in excess stock market returns with a generalized autoregressive conditional heteroskedacity-in-mean model in the stock markets of the United States over business cycles. Nyberg concluded that stock returns vary over business cycles, implying that during recessions the stock market returns are mainly more negative than times when no recession is present in the economy. Recessions have followed financial crises globally and negative stock returns have correlated with financial crises. However, it was still observed that a positive risk-return relationship exists between volatility and expected return with no dependency on the business cycle.

Hamilton and Lin (1996) performed a joint time-series analysis on the stock market volatility and the growth in industrial production. Research indicated that economic recessions have been the main determinant for the fluctuations in the stock market volatility. This introduces the correlation between the stock market volatility, economic recessions and thus financial crises.

Caporale et al. (2016) studied the linkages between the S&P500 and the Euro STOXX 50 stock indices. The results suggested a correlation between the two from 1996 to 2009. After 2009 however, the correlation was observed not to be as significant and the two indices followed quite different recovery paths. It could thus be argued that the endogenous contagion of the financial crisis from the United States to the Europe was mainly due to the high integration of the financial markets between the two.

The development of the situation in the United States was observed to introduce regime changes also in the EONIA swap rate in the Eurozone. Similarly, the daily euro fixed-float OIS has been estimated to be dependent on the implied volatility of the S&P 500-index due to its nature of reflecting market expectations. (Eross et al, 2018.)

Market volatility has been observed to affect the stock returns both directly and indirectly and the negative relationship between the two arises mainly from greater risks and increased liquidity premiums (Chung & Chuwonganant, 2018). This implies that liquidity is a major determinant in stock market volatility and in stock market returns, and a decrease in the market liquidity should increase the implied volatility and decrease the stock market returns. These observations support the data presented in figures 3 and 4, where the 2007 liquidity crisis caused decreased returns in the Euro STOXX 50 index and increased volatility of the index.

Schreiber et al. (2012) observed that the negative relationship between asset prices in the equity markets and the credit spreads hold during the pre-crisis period but didn't hold during the liquidity crisis in 2007. The stock market returns were not observed to be significant predictors of credit spreads during the crisis. However, the credit spreads and the decrease in liquidity were indeed observed to affect the stock market volatility.

4.3 EVIDENCE FROM LIBOR-OIS

Earlier research has been conducted on the significance of the spread outside the Eurozone between the London Interbank Offered Rate (LIBOR) and the Overnight Indexed Swap (OIS) and their indications of a financial crisis. It has been a closely watched indicator and most of the research conducted have utilized the 3-month maturity of the interbank offered rate as their data.

Before the liquidity crisis caused disturbance to the interbank market in 2007, the LIBOR-OIS spread was observed to lie around 10 basis points. The spread rose quickly near to 100 basis points during three events. The first increase occurred when the Bank of England announced to introduce emergency funding on the 14th of September 2007 to bail out Northern Rock, which was one of the biggest mortgage lenders in the United Kingdom. Similarly, during the increased losses of big investment banks like UBS and Lehman Brothers on the 10th of December 2007 and during the collapse of Bear Sterns on 17th of March 2008, the spread rose to higher levels before reaching its peak of 365 basis points on the announcement of the bankruptcy of Lehman Brothers on 10th of October 2008. (Sengupta & Man Tam,

2008.) Thus, the LIBOR-OIS spread can be considered as an indicator of disturbances in the money markets during the time period examined in this thesis.

The main determinants of the LIBOR-OIS spread have been researched in several studies. In line with the results of Eross et al. (2018), Pellizzon and Sartore (2013) also identified the implied volatility of the S&P 500-index as one of the key explanations of the spread. The most significant variable however was the volume of credit default swaps for both Euribor and Libor markets. The index for credit default swaps had an inverse relationship to the spread, which indicates that tensions in the interbank market liquidity causes the increases in the LIBOR-OIS spreads.

Cui et al. (2016) examined the determinants of five major currency LIBOR-OIS spread changes during the period of interbank market distress. In line with the results of earlier studies, it was observed that in addition to the credit risks and counterparty risks, the market liquidity and volatility were the determinants of the spread in the interbank markets. Furthermore, the financial leverage of the commercial banks and the state of the economy affected the spread. These results are in line with the expectations that the spread should correlate highly with certain events during the liquidity crisis and the sovereign debt crisis.

The liquidity shocks affect both the money markets and the equity markets, and they influence the market expectations. Based on earlier empirical research, the hypothesis is that increases should occur also in the Euribor-EONIA Swap spread during the times of a financial crisis and that these spreads should correlate with macroeconomic events, stock market returns and the changes in the implied volatility of the stock markets in some extent.

5 METHOD

The data is gathered for the Euribor and the EONIA Swap from 20th of June 2005 to 30th of June 2014 for all the maturities. The population of the data consists of total 2 290 data points which represent the trading days when both the money market and the capital market instruments have been traded during the time period. Weekends and other bank holidays are thus excluded from the data. In this research the 3-month Euribor and the 3-month EONIA Swap are chosen to determine the spread between the two rates for each day for the same maturity. The main motivation for using the 3-month maturity is the existing empirical research on the effects of a financial crisis to the interbank market.

The spread is first calculated by subtracting the 3-month EONIA Swap from the 3-month Euribor in each period *T* and expressed in basis points:

$$Spread_t = EURIBOR_t - EONIASWAP_t \tag{5}$$

After which the daily logarithmic differences of the spread are used, which are implied with X_t and calculated as:

$$X_t = ln(Spread_t) - \ln(Spread_{t-1}) \tag{6}$$

Logarithmic returns and differences are used to remove any trends in the data. The study includes also the daily logarithmic returns for the Euro STOXX 50 stock index and the daily logarithmic differences in the Euro STOXX 50 Volatility index from the same time period. The daily returns for both indices are calculated by the differences of the opening values of consecutive trading days. The goal is to evaluate

how the change in X_t affects to the returns of the stock market and stock market volatility over time.

The spread is evaluated by a standard OLS-regression. The OLS-method is used for its position of being currently the dominant method used in practice in the field of economics. OLS is also considered as an efficient unbiased estimator. (Stock & Watson, 2012, p. 121–123.)

An autoregressive model with an exogenous predictor is used to represent the random process of the returns in the stock market and the changes in the stock market volatility. An autoregressive model relates the time series variables to their past values. The following autoregressive model of the order p in is used in both cases:

$$Y_t = \beta_0 + \sum_{m=1}^{p} \beta_m Y_{t-m} + \sum_{n=1}^{p} \varphi_n X_{t-n} + \varepsilon_t \quad (7)$$

Here Y_t represents the dependent variable which is the daily return at time t of an index of interest β_0 is the first coefficient in the model and β_m values are the lagged parameters of the dependent variables Y_t. φ_n values are the lagged parameters of the spread X_t. The dependent variable Y_t is represented thus by its lagged parameters and the lagged parameters of the independent variable X_t. ε_t represents the white noise, the residual of the regression, which is minimized by using the method of least squares. The Huber-White heteroskedasticity robust standard errors are used in this regression analysis. The goal is to measure on what degree the changes in the spread affect the returns of the indices. In this analysis 8 degrees of freedom are used for m and n.

In addition, the development of the spread during the crisis is evaluated manually on specific dates. The bankruptcy of Lehman Brothers on the 16th of September 2008, the date of the news release of BNP Paribas and other specific events and dates in the

sovereign debt crisis are examined to determine if the development in the spread could've been used as an indicator of the shocks.

6 RESULTS

6.1 EURIBOR-EONIA SPREAD AND EURO STOXX 50 INDEX

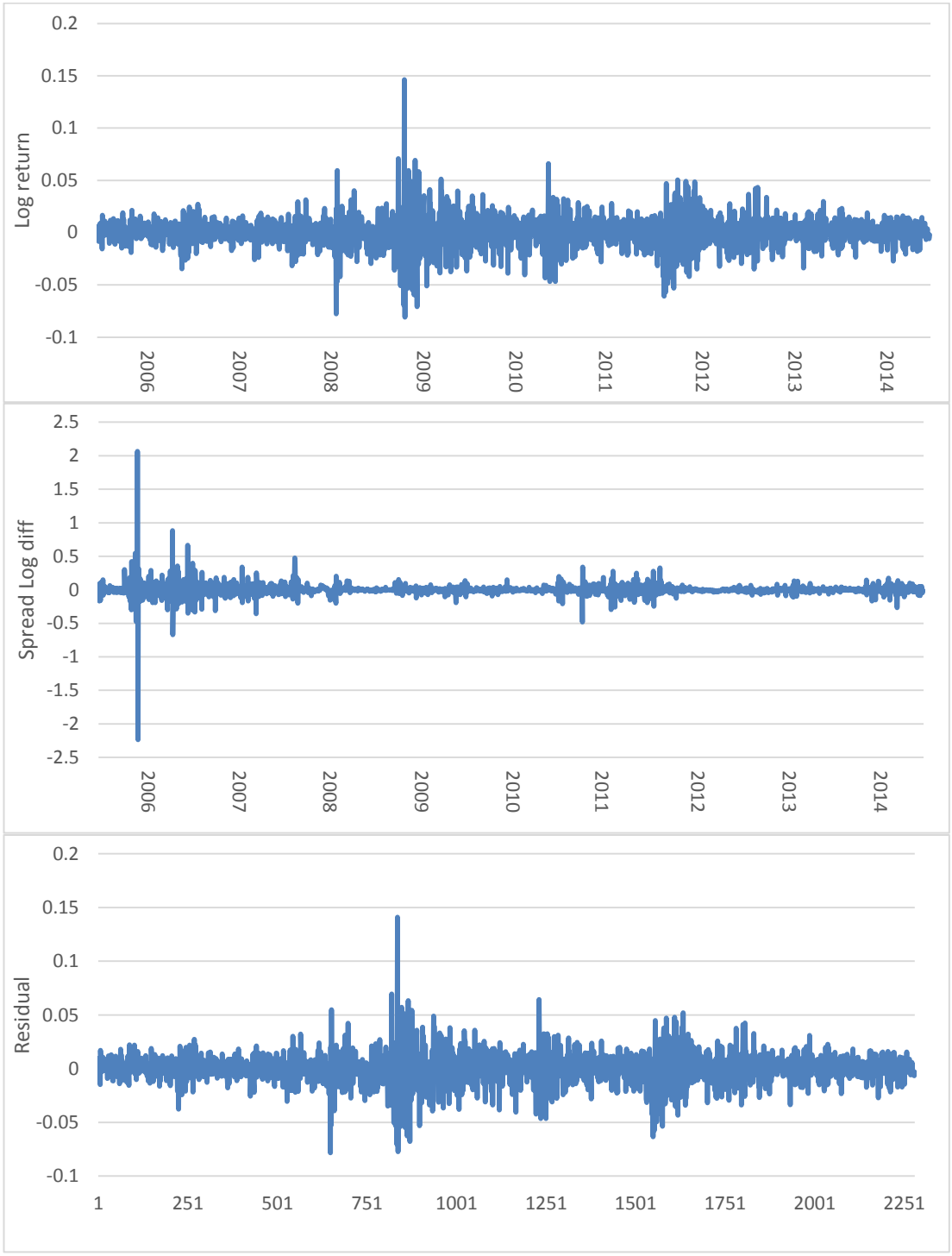

Figure 8. Returns of the Euro STOXX 50, Euribor-EONIA Swap-spread and the regression residuals.

The figure above represents the plot of the daily logarithmic returns of the Euro STOXX 50 index, the daily logarithmic differences of the spread and the residuals from each observation of the regression. There seems to exist increased variance in the residuals during the times of the crisis which implies that the linear autoregressive model doesn't provide a decent fit for the data in times of a crisis. Also, worth noting for is the fact that the logarithmic daily differences of the spread have decreased in magnitude before the crisis, whereas the magnitude of the daily logarithmic returns of the stock index have been in their extremes during the financial crisis in 2008-2009. During the times of the financial crisis, the logarithmic returns in the stock market have been relatively more negative than during times when no crisis has been present in the financial markets.

The table below illustrates the coefficients from the regression with their standard errors and p-values.

Table 1. Regression results of the Euro STOXX 50 and the Euribor-EONIA Swap spread.

	coeff	*std err*	*t stat*	*p-value*	*95% conf. int.*	
Y(t)-1	- 0,0124	0,038	- 0,325	0,745	- 0,087	0,062
Y(t)-2	- 0,0464	0,043	- 1,068	0,285	- 0,132	0,039
Y(t)-3	- 0,0419	0,038	- 1,115	0,265	- 0,116	0,032
Y(t)-4	0,0109	0,036	0,303	0,762	- 0,060	0,082
Y(t)-5	- 0,0383	0,039	- 0,991	0,322	- 0,114	0,038
Y(t)-6	0,0035	0,034	0,102	0,919	- 0,063	0,070
Y(t)-7	0,0180	0,034	0,526	0,599	- 0,049	0,085
Y(t)-8	- 0,0159	0,032	- 0,493	0,622	- 0,079	0,047
x(t)-1	- 0,0086	0,004	- 2,200	0,028	- 0,016	- 0,001
x(t)-2	- 0,0024	0,003	- 0,782	0,434	- 0,008	0,004
x(t)-3	- 0,0024	0,003	- 0,787	0,431	- 0,008	0,004
x(t)-4	- 0,0005	0,003	- 0,141	0,888	- 0,007	0,006
x(t)-5	- 0,0040	0,003	- 1,159	0,247	- 0,011	0,003
x(t)-6	0,0014	0,003	0,424	0,672	- 0,005	0,008
x(t)-7	0,0003	0,003	0,093	0,926	- 0,006	0,007
x(t)-8	- 0,0006	0,002	- 0,260	0,795	- 0,005	0,004
Durbin-Watson		2,001		*Multiple R*		0,099
F-value		1,389		*R^2*		0,010
Significance F		0,137		*Adjusted R Square*		0,003
Observations		2280		*Standard Error*		0,014

The value of R^2 implies how much the independent variable of the model explains the observed variation in the model (Stock & Watson, 2012, p. 123). In the model, the 0,01 value of R^2 implies that the Euribor-EONIA Swap spread explains only 1% of the observed variation of the stock index return. The model has a standard error of 0,014 and the p-value of the 1,389 F-statistic is 0,137. The relatively high p-value for the F-statistic implies that the model would not be statistically significant, but the F-statistic is not accurate in the case of using heteroskedastic robust standard errors and the corresponding p-value should not be heavily relied on this case (Stock & Watson, 2012, p. 228).

The coefficients of the regression are in general considered statistically significant, if their p-value is less than 0,05 (Stock & Watson, 2012, p. 78). From the results the coefficient X_{t-1} is identified as statistically significant with a p-value of 0,028. The negative sign of the coefficient implies that an increase in the spread causes a decrease in the stock market return. According to the results, an 1% increase in the spread should imply an 0,86% decrease in the Euro STOXX 50 index. The Durbin-Watson test indicates that there exists no autocorrelation in the residuals of the data, since the value of the test is close to the value of 2.

6.2 EURIBOR-EONIA SPREAD AND THE EURO STOXX 50 VOLATILITY

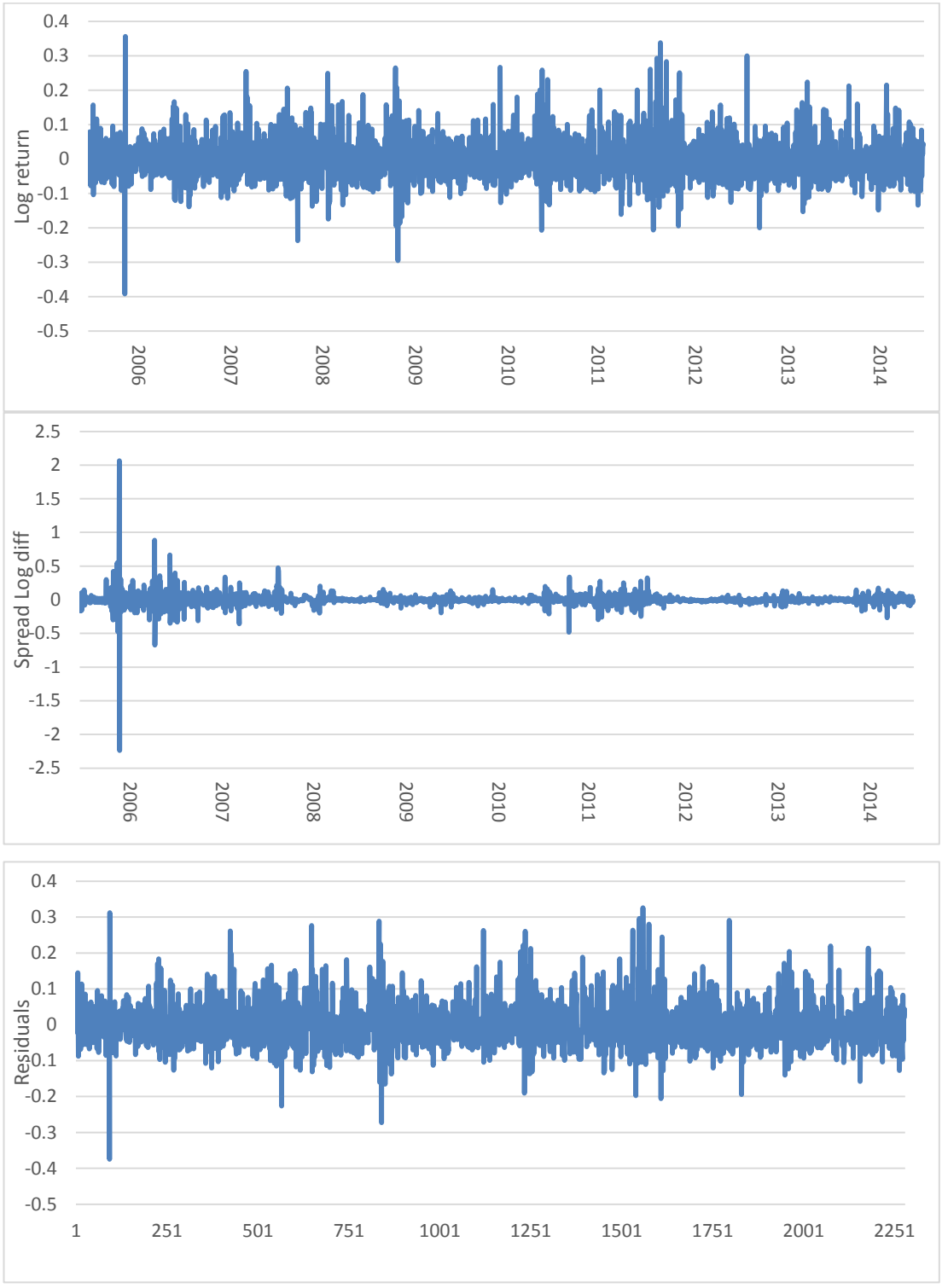

Figure 9. Returns of the Euro STOXX 50 Volatility, Euribor-EONIA Swap-spread and the regression residuals.

The figure above represents the plot of the daily logarithmic returns of the Euro STOXX 50 volatility index, the daily logarithmic differences of the spread and the residuals from the regression. In this case it is again noted that there exist in some extent increased variance in the residuals during the times of the crisis and the data doesn't offer a decent fit into a linear regression model. In the case of volatility, the daily logarithmic returns of the volatility do not seem to follow as clear trend as for example the returns of the stock index but still seem to be the highest during times when a crisis is introduced to the financial markets.

The table below illustrates the coefficients from the regression with their standard errors and p-values.

Table 2. Regression results of the Euro STOXX 50 Volatility and the Euribor-EONIA Swap spread

	coeff	*std err*	*t stat*	*p-value*	*95% conf. int.*	
Y(t)-1	- 0,1123	0,027	- 4,158	0,000	- 0,165	- 0,059
Y(t)-2	- 0,0749	0,025	- 2,976	0,003	- 0,124	- 0,026
Y(t)-3	- 0,0669	0,027	- 2,504	0,012	- 0,119	- 0,015
Y(t)-4	- 0,0676	0,026	- 2,577	0,010	- 0,119	- 0,016
Y(t)-5	- 0,0113	0,024	- 0,460	0,646	- 0,059	0,037
Y(t)-6	- 0,0538	0,024	- 2,222	0,026	- 0,101	- 0,006
Y(t)-7	- 0,0303	0,025	- 1,194	0,233	- 0,080	0,019
Y(t)-8	- 0,0536	0,024	- 2,272	0,023	- 0,100	- 0,007
x(t)-1	0,0571	0,017	3,342	0,001	0,024	0,091
x(t)-2	0,0190	0,014	1,332	0,183	- 0,009	0,047
x(t)-3	0,0086	0,017	0,518	0,605	- 0,024	0,041
x(t)-4	0,0098	0,017	0,574	0,566	- 0,024	0,043
x(t)-5	0,0039	0,018	0,224	0,823	- 0,030	0,038
x(t)-6	- 0,0092	0,016	- 0,557	0,578	- 0,041	0,023
x(t)-7	- 0,0073	0,013	- 0,555	0,579	- 0,033	0,018
x(t)-8	- 0,0136	0,014	- 0,943	0,346	- 0,042	0,015
Durbin-Watson Test		2,004		*Multiple R*		0,176
F-value		4,536		*R^2*		0,031
Significance F		0,000		*Adjusted R Square*		0,024
Observations		2 280		*Standard Error*		0,061

In this model, the 0,031 value of R^2 implies that the Euribor-EONIA Swap spread explains only 3,1% of the observed variation of the return of the stock index volatility. The model has a standard error of 0,061 and the F-statistics of 4,536 is statistically significant with a p-value of 0,000. The low p-value for the F-statistics implies that the model is statistically significant despite the usage of robust standard errors.

From the results it is identified that the coefficient X_{t-1} is statistically significant with a p-value of 0,001. The positive sign of the coefficient implies that an increase in the spread causes an increase in the stock market volatility. According to the results, an 1% increase in the spread should imply a 5,71% increase in the Euro STOXX 50 implied volatility.

The Durbin-Watson test with a value of 2,004 indicates no autocorrelation between the residuals of the regression.

6.3 EURIBOR-EONIA SPREAD AND SHOCKS

The effect of different macroeconomic shocks is to the spread is also evaluated. In the Table 3 below, specific events during the financial crisis in and during the sovereign debt crisis are listed along with the changes in the spread.

Table 3. The change in the spread during the stages of the financial crisis.

Event	Date	Change in spread
BNP Paribas ceases the funds	9th of August 2007	+6,7 bps
Lehman Brothers bankrupcty	16th of September 2008	+7,2 bps
London G20 summit	2nd of April 2009	+1,3 bps
Greek debt crisis	9th of May 2010	+1,6 bps
S&P Downgrades US credit rating	5th of August 2011	+15 bps

The stages of the financial crisis can be distinguished into 5 different stages. On the 9th of August, BNP Paribas announced to cease the activities in its three hedge funds that were associated with the subprime-mortgages in the United States. It was the first instant of time where the existence of problems caused by complex derivatives

was noted for the first time. (The Guardian, 7th of August 2011.) During that day, the spread increased approximately 7 basis points.

On the 16th of September 2008, a year later after the announcement of BNP Paribas, the US government allowed the investment bank Lehman Brothers to go bankrupt. The bankruptcy caused distress and fear in the financial markets when it was evident that the government would not necessarily bail out distressed banks anymore. Previously the government of the United States had organized a buyout for Bear Sterns and the government in United Kingdom for Northern Rock, but now it looked like banks weren't anymore "too big to fail" (The Guardian, 7th of August 2011). The global economy experienced a significant downturn when the credit flows to the private sector were diminished and business confidence collapsed due to the fear of more bankruptcies in the banking sector. The spread increased 7 basis points on this very day as well.

During the aftermaths of the financial crisis, the G20-countries had their summit in London on the 2th of April 2009. During the summit the first measures were taken to cut the interest rates to the bare minimum and to tackle the crisis with the help of fiscal expansion and by providing support to the International Monetary Fund and other global institutions to boost the economy. (The Guardian, 7th of August 2011.) The spread reacted in a modest way and increased by 1,3 basis points.

The crisis shifted from the private sector to the public sector when the Greek debt crisis was assessed for the first time on the 9th of May 2010. The International Monetary Fund and the European Union decided to provide financial help for Greece, which suffered from its high budget deficit (The Guardian, 7th of August 2011). The concern on the public debt and austerity measures reflected on the nervousness of the financial markets and the spread increased 1,6 basis points on that day.

The most significant one-day increase in the spread occurred on the 5th of August 2011, when Standard&Poor's, an international credit agency, downgraded the credit rating of the United States from the top AAA to a lower level of AA+ (The Guardian, 7th of August 2011). Downgrading the most powerful economy in the world raised

concerns on the future development of the global economy and caused the spread to increase over 15 basis points on the 5th of August 2011.

7 DISCUSSION

From the results a conclusion can be made that the most significant changes in the data have happened during the financial crisis of 2008. The stock index was at its highest a year before the start of the financial crisis, whereas the implied volatility and the spread were at their highest during the crisis. During the crisis the stock index faced its greatest drop and its minimum value. The Euribor and the EONIA Swap were also on their all-time highs during the crisis in 2008.

During the sovereign debt crisis a few years after the next significant changes in the data can be observed. These results indicate that financial crisis has had its effect on the data and correlation seems to exist with the changes in the data and the shocks in the financial markets.

Even though during the crisis the significant logarithmic daily returns were observed in the stock index during the 2008-2009 financial crisis, the logarithmic returns of the spread during the same period aren't as significant. In fact, the logarithmic returns of the spread decreased during the financial crisis in 2008 but increased during initial phases of the sovereign debt crisis in 2011. However, it seems that the logarithmic differences have been more positive than negative during the times of the financial crisis. This supports a view that during the times of a crisis there exists more of an increasing trend in the development of the spread than during other specific periods of time, even though the magnitude of these daily differences isn't as significant during the crisis as in the pre-crisis period.

The spread seems to correlate with the financial crisis in some extent, and the correlation is evaluated more thoroughly next. The results from the regression indicate how well does the spread seems to correlate with the stock index and the implied volatility. In addition to the correlation, the purpose is to find out if it is fair to say that the change in the spread is also the causality of the changes in the stock indices and the implied volatility.

In the following section the specific events that took place during the financial crisis are examined and the returns of the indices and the change in the spread on those specific dates are evaluated.

7.1 THE EURIBOR-EONIA SPREAD AND THE EURO STOXX 50

According to the results, an 1% increase in the spread should imply an 0,86% decrease in the Euro STOXX 50 index. The results are in line with the previous research that suggested a negative relationship between asset prices in the equity markets and the credit spreads. Increased credit risks in the European interbank market reflect on the equity markets, which caused in some extent a decrease in the stock indices in Europe during 2005-2014.

As Giri (2018) observed, increased risks in the interbank market would lead the economy eventually into a recession caused by the reduction in investment activity and household consumption. Furthermore, recessions have correlated with financial crises and during this time the stock market returns have mainly been negative when the earnings of different companies decrease (Nyberg, 2012). The results indicate this correlation between credit spreads in the interbank market and the returns of the stock markets during financial crises.

However, the statistical significance of the results and the magnitude of the interdependence seems rather thin and the constructed model might suffer from omitted variable bias. The returns in the stock market might be more dependent on the levels of economic growth and recessions, market liquidity (Chung & Chuwonganant, 2018), dividend yields (Cutler, 1991), general investor sentiment, the valuations of alternative investments or industry-specific outlooks and expectations. Nyberg (2012) provided supporting evidence for the correlation between GDP growth rates and the stock market returns.

During a recession when stock returns have been observed to be negative, the credit risks in the interbank market can maybe remain also unchanged if the recession is caused by factors outside the banking sector. An economic recession and business cycles can be caused by many other determinants: Iyetomi et al. (2011) researched

the Japanese industrial production data and deducted that real demand shocks accompanied by significant inventory adjustments have been the major causes of business cycles. Exogenous shocks to the exports or technology shocks for example can cause real aggregate demand shocks and drive the economy into a recession. These examples point out that increased credit risks in the interbank market aren't the only determinant of a recession, even though their role on the financial crises has been discussed previously. The correlation between financial crisis and recession is evident in many researches especially during the 2008 liquidity crisis, but the causality hasn't been clearly determined. It is also thus determined that a recession and decreasing stock market returns can exist also without a change in the spread.

The internal validity is challenged by the usage of the returns between the opening values of the indices, which is disturbed by excluding weekends and other bank holidays. Also, the data is constructed from the dates when both the equity markets and money markets have been open, and any crossing dates have been excluded from the model. This introduces challenges especially to the internal validity in the independent variable of Euribor-EONIA Swap spread.

As Schreiber et al. (2012) observed, the negative relationship between the asset prices in the equity markets and the credit spreads hold during the pre-crisis period but failed to hold during the liquidity crisis in 2017. It was concluded that the stock market returns were not observed to be a significant predictors of credit spreads during the crisis. By examining the results from the regression, the spread seems to explain the stock market returns in some extent during the whole period of 2005-2014, but further evaluation would be needed to see if there are any exceptions during the 2008 liquidity crisis. The results from the regression support the hypothesis that a negative relationship between the stock market return and the credit spread exists, but it cannot be generalized to hold in all circumstances.

In general, the spread seems to explain the stock market returns but the stock market returns aren't explaining the development of the spread according to earlier research. Thus, simultaneous causality shouldn't exist between the independent variables and the dependent variable in the model. This might be due to the mentioned different factors that have been evaluated to be the main determinants of stock market returns

and affect the returns more than the development of the Euribor-EONIA Swap spread.

Nevertheless, when it comes to the financial crises in the Eurozone, the negative returns in the Euro STOXX 50 stock index and the increases in the Euribor-EONIA Swap spread have both been present. As the negative equity market returns are correlating with a financial crisis, it can be said that the Euribor-EONIA Swap spread was an indicator of decreasing asset returns and thus an indicator of a financial crisis in the Eurozone during 2005-2014 despite the possible omitted variable bias. However, he spread doesn't always correlate with the returns since stock market returns can also be negative during an economic recession without any change in the spread

7.2 THE SPREAD AFFECTED EURO STOXX 50 VOLATILITY

According to the results, an 1% increase in the spread should imply a 5,71% increase in the Euro STOXX 50 implied volatility. The results are in line with the previous research that suggested a positive relationship between stock market volatility in the and the credit spreads. Increased credit risks in the European interbank market reflect on the equity markets, which caused in some extent an increase in the stock market volatility in Europe during 2005-2014.

Increased risks in the interbank market would lead the economy eventually into a recession and during recessions the stock market volatility has been observed to increase (Hamilton & Lin, 1996). The results indicate this correlation between credit spreads in the interbank market and the stock market volatility.

Schreiber et al. (2012) observed that the credit spreads affected the stock market volatility. Similarly, Pellizzon and Sartore (2013) observed that the implied volatility of the S&P 500-index has been correlating with spread between LIBOR and OIS. The regression results of this thesis also suggest that increases in the Euribor EONIA Swap spread introduced increases to the stock market volatility with statistical significance, and thus the results are in line with previous research.

However, the model might again suffer from omitted variable bias. Wang and Deng (2018) determined that the stock market volatility is caused mainly by investors' expectations and behaviour. The investor-expectations were determined to form mainly based on positive signals and negative signals in the information flow. These signals can be in theory almost anything, all the way from the actions of influential investors to political instabilities. Additional variables to the stock market volatility might be needed to include in the model to eliminate the omitted variable bias and to increase the statistical significance of the results.

The credit spread is an indicator of distress in the interbank market and this can affect to the investor sentiment when fears arise on the liquidity of the banking sector. However, it is challenging to distinguish the effect of the credit spread to the market expectations from other factors. For example, decreasing levels of economic growth can be more significant factor for stock market volatility than the credit spread. The determination of the main factors for the investor sentiment and thus for the stock market volatility challenges the significance of the change in the Euribor-EONIA Swap as a significant explanatory variable for the Euro STOXX 50 Volatility-index.

As in the previous case, the internal validity is challenged by the fact that some trading days have been omitted from the time series to include the same trading days for the money markets and the equity markets in the Eurozone during the time period of interest.

It can be identified that the implied volatility of the Euro STOXX 50 increased during financial crises in the Eurozone. According to the results, increases in the Euribor EONIA Swap correlate with the increases in the stock market volatility. The Euribor-EONIA Swap spread was an indicator of increased stock market volatility and thus an indicator of a financial crisis in the Eurozone during 2005-2014 despite the possibility of omitted variable bias. Increases in the credit risks in the interbank market can certainly affect the market expectations in the financial markets and thus affecting the stock market volatility.

7.3 THE SPREAD DURING THE STAGES OF THE FINANCIAL CRISIS

By evaluating the data, it can be concluded that during the specific events during the financial crisis the spread between the two rates has increased relatively more compared to the days when no information or announcements were given in the information flow. For instance, before the announcement of BNP Paribas on the 9th of August 2007 the spread between the two rates had increased by 4 basis points during the past week. In that context, an increase of 6,7 basis points in one day can be considered as relatively significant increase in the spread. On the 9th of August 2007, the spread increased to 18 basis points. Before the announcement, the average size of the spread from 2005 to 2007 was approximately 5,7 basis points but increased in a month to 66 basis points right after the announcement. The announcement introduced clearly an increasing trend to the development of the spread and indicated distress in the banking sector for the first time.

Also, the increase of 7,2 basis points on the date of the bankruptcy of Lehman Brothers was a significant change in the spread that caused the spread to grow rapidly. On the 16th of September 2008, the spread was 73,7 basis points and during the aftermaths of the collapse of Lehman Brothers, the spread reached its maximum value of 186 basis points on the 24th of October in 2008. This supports the view that was obtained from the case of BNP Paribas: After the announcement an increasing trend in the spread was observed and the spread indicates a banking crisis in this case.

The spread reacted the most to the announcement of downgrading the US credit rating with an increase of 15 basis points. Before the downgrading, the spread lied around its levels of 20 to 30 basis points. After the announcement however, the spread again went to an increasing path and reached a value of 100 basis points a few months later. Again, the announcement of negative information in the information flow caused the spread to increase and indicated increased fear and distress in the interbank market.

During the ignition of the Greek debt crisis that introduced the sovereign debt crisis to the Eurozone, the spread didn't react significantly to any specific announcements.

Also, during the aftermaths of the sovereign debt crisis, there weren't any significant increasing trends in the development of the spread. The spread lied around 30 basis points the whole year. It is an interesting fact considering that many European banks possessed great amounts of Greek government debt.

The spread didn't seem to react significantly to the new data presented from the London G20 Summit. After the London G20 summit the spread decreased from its value of 72 basis points to 61 basis points within a month. This might be due to the relieving messages that were presented in the summit. Commitment from the G20 countries to increase employment and growth after the cut of interest rates indicated that the global economy indeed was in a turn, increasing confidence in the financial markets.

By observing the data, it can be identified that specific shocks affected the development of the spread. Distress in the interbank market reflected on the development of the spread when negative information was introduced. Similarly, positive news from the London G20 Summit caused the spread to decrease. There seems to be a correlation between the development of the spread and specific events during the financial crisis. When no information was presented, any significant changes or trends in the development of the spread were not observed.

The theory of an interest states that more the lender takes a risk, the higher is the interest rate required by the lender from the borrower. Since the Euribor-rate represents an interest rate that has in some degree more risk than the EONIA, increased credit risk reflects on the increase in the spread between the Euribor and the EONIA Swap. Specific events during the financial crisis increased uncertainty in the interbank market due to the fears of the liquidity and solvency of the banking system. Especially the bankruptcy of the Lehman Brothers increased risks in the interbank markets and spread fear globally to the financial markets.

However, it seems that the role of the spread seems to be more reactive than predictive. No major increases in the spread were observed on the times before the occurrence of the events. Spread reacted on the new information and was an indicator but was unable to be a valid predictor of different banking crises such as the

collapse of the Lehman Brothers. By looking at the development of the spread, one can see correlation with the specific events during the financial crisis and see that the development of the spread indicates distress in the financial markets but cannot make predictions on the development of the situation.

Also, as observed from the figures 8 and 9, the magnitude for the changes in the spread has varied. Even though the shocks have introduced an increasing trend to the spread during certain times and events, the magnitude of the daily changes hasn't been as significant as it was during 2006-2007, for instance.

8 SUMMARY

The spread between the London Interbank Offered Rate and the Overnight Indexed Swap has been researched in previous research to be an indicator of distress in the financial markets. During financial crisis, the spread between LIBOR and OIS has been observed to increase. The aim of this thesis was to evaluate the similar spread in the Eurozone, by researching the spread between the 3-month Euribor and the 3-month EONIA Swap.

The spread measures the credit and default risks in the interbank market, since it represents the difference between an Interbank Offered Rate that has a credit risk in some degree and the EONIA Swap, which is risk-free since no exchange in principal is required in the swap agreement. The theory of an interest rate states that more the lender takes a risk, the higher is the interest rate required by the lender from the borrower. Since the Euribor-rate represents an interest rate that has in some degree more risk than the EONIA, increased credit risk reflects to the increase in the spread between Euribor and the EONIA Swap.

According to the results, the spread between Euribor and the EONIA Swap explains in some extent the returns in the stock market and the implied volatility of the stock market in the Eurozone. Increases in the spread correlate with negative returns in the stock market and increases in the stock market volatility. The decreasing returns in the stock market and increased stock market volatility have both been evaluated to exist during a financial crisis, but negative stock returns can also occur during an economic recession independent on the credit risk development in the interbank market. The spread explains the stock market volatility better than the stock market returns on the used data.

It is concluded that the spread between Euribor and the EONIA Swap indicates not only distress in the interbank market but also a financial crisis through correlating with the negative stock market returns and the increased implied volatility of the stock market. By observing the development in the spread it is possible to identify the times of a financial crisis, since the spread has been increasing during times of

financial crisis. The Euribor-EONIA Swap works as an indicator, but its validity is challenged by other variables that have been possible been omitted.

The spread also correlates with specific events during the liquidity crisis in 2008 and the sovereign debt crisis in the Eurozone. With new negative information was presented, the spread illustrated an increasing trend by reflecting increased uncertainty in the financial markets. Similarly, positive news caused the spread to decrease. When no information was presented, any significant changes or trends in the development of the spread were observed.

However, the spread doesn't seem to have a predictive force, since the spread is more reactive than predictive for the specific events during financial crisis. No major increases in the spread were observed on the times before the occurrence of the events. Spread reacted on the new information presented and was an indicator but was unable to be a valid predictor of different banking crises such as the collapse of the Lehman Brothers. The spread can be used as an indicator but not as a predictor of financial crisis according to the results of this research. Also it cannot be concluded that the Euribor-EONIA Swap spread would be a causation of a financial crisis, since many alternative determinants exist for the stock market returns, stock market volatility and for a financial crisis.

Further research would require more through determination of different financial crisis with their causations and effects. Also, control variables should be introduced to make the results internally more valid and statistically more significant to eliminate possible omitted variable bias. One might also argue on the order of the autoregressive model to determine the extent on how the spread affects the stock market returns and the implied volatility of the stock market, and to evaluate the statistical significance. Instead of creating the maximum number of lags, further research could contain the determination of the order of the autoregression through minimizing the Bayes information criterion (BIC), for instance (Stock & Watson, 2012, p. 551). Also, the residuals might be researched more with the help of a certain generalized autoregressive conditional heteroskedasticity (GARCH) model.

In July 2014, the European Money Market Institute announced the discontinuation of the EONIA Swap due to the lack of contributing panel banks. Thus, the spread between Euribor and the EONIA Swap cannot be used in the future as an indicator of financial crisis. The usage of the spread would require a reintroduction of the EONIA Swap or an introduction of a similar instrument to the European money markets. However, these kinds of introductions aren't seen probable any near future.

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