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EURIBOR BASIS SWAP SPREAD

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The aim of the study is to investigate the factors affecting Euribor basis swap spreads. Variables are divided into three component; liquidity risk, credit risk, and macroeconomic and monetary policy. The Euribor basis swap was close to zero basis points, but during the early phases of the latest financial crises the spreads jumped.

In empirical part of the study, the stationarity of the variables is tested. In the next step, Phillips-Ouliaris (P-O) co-integration test is tested to get 5 combinations that co-integrates with Euribor basis swap spread 3 month versus 12 month with 5 years to maturity. Thirdly, long-run equilibrium for the Models with Engle-Granger test is applied. Out of the five Models, picked in P-O, only three had long-run equilibrium. From the three long-run equilibrium Models the regression residuals are saved and estimated short-term equilibrium with Error Correction Model. At the end, Ordinary Least Square method with Newey-West corrections with the three co-integrated Models is tested.

The variables for liquidity risk component are Open Market Operations, Aggregate Liquidity Factors, Deposit Facility, and Governing Council Meeting day -dummy. The variables for the credit risk component are Eurobond yield and Bank Credit Default Swap spread. The variables for the macroeconomic and monetary policy component are Euro Overnight-Index Average and exchange rate.

The results show that the biggest determinants for the Euribor basis swap spread 3m vs 12m 5y are Open Market Operations, Meeting day, Eurobond yield 5y, Bank CDS, EONIA, and exchange rate of China.
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1 INTRODUCTION

1.1 Motivation of the study

The latest financial crisis began in 2007 in the United States of America, as borrowers began to default their mortgage loans (Subprime crisis phase was from mid 2007 to September 2008). In the end of July 2007, the subprime mortgage crisis was also seen in Europe. One of the first banks that got hit by the crisis was Deutsche Industriebank IKB. IKB had built a large portfolio of asset backed commercial paper funds, which were mostly invested in residential mortgage backed securities (RMBS), commercial real estate and collateralized loan obligations. Within few days, the European financial markets deteriorated. The European Central Bank (ECB) had to intervene in the beginning of August 2007 with liquidity injection of 95 billion euros and in December 2007, with 300 billion euros. (Liikanen 2012)

The second phase began in September 2008, as Lehman Brothers collapsed. Investors realized that financial institutions would not always be bailed out. As a result, liquidity for banks disappeared and it became impossible for banks to access either short or long-term funding. Even there were liquidity injections by the ECB, some of the banks run out of cash. Liquidity disappeared also from the capital market instruments. (Liikanen 2012)

The third wave of the financial crises is seen as “Economic crisis phase” (as of 2009). Year 2009 seemed to be relative calm year in terms of financial performance. Real economy and public finances were now in trouble. The world trade and real economic growth decreased even there were large stimulus packages to prevent the world economy to slide under depression. (Liikanen 2012)

The fourth phase is seen as “sovereign crisis phase” (2010). Sovereign debt of euro area was around 87% of 2011 Gross domestic product. In November 2009, Greek government revealed the true size of the country’s deficit and debt, discussion of sovereign risk became relevant. Most institutional investors thought European banks held large portfolios of sovereign debt on their balance sheet, trust in the European banking system eroded. (Liikanen 2012)
During the second half of 2007 spreads (quoted price of basis swap) of basis swaps rose from zero basis points till 200 bps, as the financial crises severed, within the primary interest rates. Earlier the spreads had been close to zero for arbitrary reasons. Basis swaps are swaps between two floating rates with different maturities.

Credit risk and liquidity risk are thought to be the main drivers for the Euribor basis swap spread. Bank of international settlements (2010) find that the lending between financial institutions became more difficult due to the uncertainty in the banking sector, especially in the longer maturities. The financial institutions were afraid of the counterparty risk, and because of this, the basis spreads (interbank short-term interest rate, Treasury Bill rates and swap rates) widened. Because of the uncertainty, large banks wanted to revise upward their liquidity needs while being more reluctant to lend to other banks (Michaud & Upper 2008).

Counterparty risk means that banks do not want to lend to other financial institutions because the risk of default on the loans had increased and/or market price on taking such a risk had risen (Taylor & Williams 2009). Decline in housing prices and the sluggish economic growth raised the chances of a weakening of banks’ balance sheets.

According to Acerbi and Scandolo (2007) Liquidity risk can appear in the next three circumstances: Lack of liquidity to cover short term debt obligations (funding liquidity risk), high funding costs makes it more difficult to borrow funds (systematic liquidity risk), high bid-offer spreads makes it more difficult to liquidate assets on the market (market liquidity risk). But the three liquidity elements are not a problem until they appear at the same time. During the latest financial crisis this happened (Morini 2009).

The topic is interesting and significant because the rise in the basis swap spread is seen as an interbank misbehavior that has an effect on financial markets as a whole and there is no precise answer for the question of why the basis spreads widened. It is hot and relevant topic because the basis spreads are still nonzero and the widening of basis spread has deteriorated firms’ balance sheets.
1.2 Literature review

Michaud and Upper (2008) researched the interbank rates (Libor). The paper aims to identify the drivers of the risk premium contained in the interest rates on three-month interbank deposits. The authors came to a conclusion that both credit and liquidity factors were behind the increased risk premium in the interbank money market. They did not find systematic evidence that banks with higher credit risk quoted higher Libor rates. They show that odd liquidity operations contributed to a compression of Libor spreads, while CDS premium for banks did not react in systematic ways.

Beirne (2012) investigated the factors affecting the EONIA spread during the financial crisis of 2007-2009. He regressed EONIA spread (difference between the EONIA rate and the minimum bid rate in open market operations) on liquidity risk, credit risk, interest rate expectations, and the liquidity balance of the Euro system. He finds that in the pre-crisis time, liquidity and credit risk do not significantly affect the EONIA spread. In the phase before the collapse of Lehman Brothers liquidity risk was significant, but after the collapse the credit risk turned to be significant.

Frank and Hesse (2009) decompose the Libor-OIS spread (measure of the premium that banks pay when borrowing funds for a pre-determined period relative to the expected interest cost from repeatedly rolling over funding in the overnight market) into a liquidity and credit risk component. According to expectations hypotheses the spread should be close to zero. The authors argue that credit premium comes from the fact that Libor is an interest rate associated with unsecured lending. They also find that announcement of the LTROs and the TAF seem most effective in reducing the overall Libor-OIS spread. The major finding is that for the early phases of the subprime crisis (July 2007), the rise in the Libor-OIS spread is attributed to funding illiquidity, and the credit risk component becomes more important from mid 2007 until March 2008. The national bank actions can compress the Libor-OIS spread, but it does not end the turbulences of the financial crises.

Poskitt (2011) studies the importance of credit risk versus liquidity premium and how they have evolved during the financial crisis. He divides The LIBOR-OIS spread into credit risk and liquidity components using CDS premium on LIBOR
panel banks as proxy for the credit risk indicator, using the residual as the liquidity indicator. He finds that changes in LIBOR-OIS spread were primarily a liquidity phenomenon. He also finds that variations in the credit risk indicator can be explained by variations in credit risk proxies like bank stock prices, stock price volatility, and risk free rate. For the liquidity side of the investigation, he finds that the liquidity premium can be explained by tightness in the interbank markets. The major finding is that the fluctuation in the liquidity premium is the fundamental driving force of the LIBOR-OIS spread.

Naumann’s (2012) main research question is which one (credit or liquidity risk) is the main driver for the 3m vs 6m Basis swap derived from the Euribor rates in the last four years and possible variations in different time periods. Credit risk component is CDS spread of European banks, liquidity risk indicators are EONIA interest rate swap and recourse to the deposit facility of the ECB by monetary financial institutions.

Naumann (2012) tested the research question empirically using Linear Model, Schwarz Information Criteria, Dickey-Fuller test, Granger causality test, Autoregressive Distributed Lag Model, and a vector autoregressive model. In the Linear Model, he used CDS, EONIA swap spread, and ECB deposit as independent variables against 3m vs 6m Basis spread. The results show that all of the independent variables are positively related to the basis spread. (Naumann 2012)

Hirvelä’s (2012) main research question is what are the main forces behind Euribor basis swap spread, and is it solely liquidity or credit risk that causes such a wide basis spreads. His hypothesis is that European Central Bank’s liquidity providing or absorbing actions together with its key interest rate policy, Euribor panel CDS and Eurobond CDS spreads together with Eurobond yields are the core determinants of Euribor basis swap spread movements. He divided independent variables into three categories: macroeconomic state, liquidity risks, and credit risks. Hirvelä (2012) also had meeting of the Governing council of the ECB as a factor affecting Euribor basis swap spread.
Hirvelä (2012) used multiple empirical methods (Linear regression model, co-integration analysis, Engel-Granger method, and Johansen’s method) to answer his research question. His conclusion is that the foreign exchange rate (USD) will increase the EBSS. It is reasonable because negative macroeconomic news from the euro area will depreciate euro with respect to U.S dollar, which increases uncertainty and increases Euribor basis swap spread. He also find that expected increase in Deposit Facility will lead to increase in EBSS significantly four days beforehand. This is because even the ECB is providing liquidity to the markets, the spread is increasing, markets see this as long as there is excess liquidity in markets and banks keep depositing the funds with national central banks because they refuse to lend each other or their customers. Third major finding is that higher CDS spread will decrease liquidity (increase deposit facility), which will increase EBSS. (Hirvelä 2012)

The aggregate major finding out of the literature review is that the credit and liquidity risk components affect the swap spreads. Liquidity risk is seen as the dominant component determining the spreads. Few studies show that credit risk component attributed more after the Lehman Brothers crashed. The literature review is lacking theoretical arguments about the variables affecting the spreads. Another caveat is that the data used in the studies is not for the whole turbulence. The non-zero spread-phase is still, at this point, continuing.

The empirical methods varied within the articles in the literature review. Some studies used Ordinary Least Square (OLS) method to find out the variables affecting spreads. OLS is not the most suitable for the time series data due to multicollinearity and autocorrelation. Another method used is vector autoregressive model (VAR). This method is used to determine how dependent variable reacts to shocks. Augmented Dickey-Fuller test is used to test the stationary of the data. One of the articles used Markov-Switching approach. It is used because it allows transitions between differing states of the data. Other test used are Granger causality test, Engel-Granger method, and Johansen co-integration tests. Only two of the studies used Euribor basis swap spread as independent variable. I will test with the same methods used in the previous literature review.
There is a need for further investigation of this topic. The time period under investigation should be longer to get better inside. The earlier empirical results indicate that all the determinants of Euribor basis swap spread are not found. Third further investigation need is the exchange rate. Is USD the best choice for the exchange rate variable?

1.3 Research Problem

The research question of this thesis is: What are the main variables affecting Euribor basis swap spread? The empirical methods allow separating the variables into liquidity, credit, and macroeconomic components, to figure out which of the component affects the most for the spread increase.

The time period used in this study is from January 2007 through December 2013. This study uses mostly the same variables as previous studies have used to find out the determinants in the EBSS. I will add a new variable; EONIA (Euro Overnight-Index Average) rate. Reasoning behind adding this variable is that it reveals some macroeconomic conditions as well as liquidity conditions within Euro area. I will also add the exchange rates; GBP (Great-Britain), JPY (Japan) and CNY (China), because the United states of America was suffering from the same basis spread misbehavior as Europe, therefore it does not explain alone the macroeconomic behavior of Europe. Japan and China were not under a financial turmoil during the period. Great-Britain was under sluggish economic growth, but I wanted to test it as well.

The empirical methods used in this thesis are stationarity and co-integration tests and Ordinary least square method. For liquidity component I use variables such as Open Market Operations, Aggregate liquidity factors, and Deposit facility. As credit risk component, I use Eurobond yield and Bank CDS. As macroeconomic variable I chose EONIA, Exchange rates of US dollar (U.S. of America), Pound (Great-Britain), Yuan (China), and Yen (Japan).
I expect Deposit facility, Exchange rate, and bank CDS to be the main determinants of the Euribor basis swap spread due to the earlier findings. I also assume credit risk to be more dominant in the after crisis period.

I find that the determinants of Euribor basis swap spread of 3m versus 12m with 5 years to maturity are Eurobond yield of 5 years to maturity, EONIA, Bank CDS, Open Market Operations, and CNY. Credit component seem to be more significant than liquidity component.

This thesis proceeds as follows. Chapter 2 covers monetary policy of European Central Bank and money market derivatives. In chapter 3 the variables, used in this study, are introduced. In chapter 4 the data is explained and in chapter 5 the empirical methods are presented. Chapter 6 present the results for the empirical testing, and in the last chapter 7 the thesis is concluded.
2 EUROPEAN MONETARY POLICY AND MONEY MARKET DERIVATIVES

2.1 European Central Bank

The monetary policy of the European Central Bank (ECB) is based on a collective decision making body. The Governing Council and the Executive Board are responsible for the preparation, conducting and implementation of the single monetary policy. The tasks for the Governing Council are to adopt the guidelines and make decisions to ensure the performance of the Eurosystem and to formulate monetary policy for the Eurozone. The responsibilities of the Executive Board are to prepare the meetings of the Governing Council, and to implement monetary policy in accordance with the guidelines and decisions made by the Governing Council. It is also responsible for the current business of the ECB. There is a third decision-making body also: The General Council. The General Council has no effect on monetary policy decisions, but it strengthens the coordination of the monetary policies of the European Union (EU) member states whose currency is not the euro, with the aim of ensuring price stability. (ECB 2011a)

Fiscal discipline is important for a smoothly functioning monetary union. In the Eurozone fiscal developments in a country also impact the other countries in it. The European Union tries to limit the risks concerning the price stability that arises from bad national fiscal policies. It is necessary to ensure member states that the state level macroeconomic and financial stability is important for the whole Eurozone. Member states obligation is to avoid unnecessary deficits and maintain a healthy medium-term budgetary position. (ECB 2011a)

Government expenditure has been higher than government revenue in the euro area as a whole after 1970. At the national level, government deficit and debt ratios in most countries are too high, mostly due to the ageing population. In the beginning of the latest financial crisis the euro area deficit ratio reached to 6.3% of gross domestic product (GDP) in 2009. The euro area also had a sharp increase in 2009 in the general government gross debt ratio. Ten countries had a debt ratio of over 60% of GDP threshold. (ECB 2011a)
The European Central bank can influence only short-term money market rates through decisions on key interest rates and by managing the liquidity situation. The central bank is the sole issuer of banknotes and bank reserves (monopoly supplier of the monetary base is the European Monetary Union). (ECB 2011a)

The ECB began injecting additional liquidity into interbank money markets through long-term refinancing operations (LTROs) and short-term operations (MROs) between August 9 and August 14, 2007. The basis swap spread began to increase already in July 2007. (Frank & Hesse 2009)

In October 2008, high negative basis spread appeared because of the large surplus of liquidity. This happened after the breakdown of interbank market activity when ECB implemented non-standard monetary policy in response to the crisis. During so called normal times the spread is low but in crisis times the spread increases in both level and volatility because of the uncertainty of the future (Beirne 2012). The European Central bank reorganized its operational framework in hope to overcome the volatility issue. The ECB shortened the maturity of its MRO and synchronized the timing of the reserve maintenance periods with the Governing Council’s interest rate decisions. The spread between the EONIA rate and the ECB’s key policy rate increased after the reorganization, which was the opposite of intended (Nautz & Offermanns 2008).

The money market has an important role in the transmission of monetary policy decisions because the changes in the monetary policy affect the money market first. An integrated money market is needed for a well working monetary policy, because it ensures an even distribution of central bank liquidity and a uniform level of short-term interest rates across the Eurozone. During the latest financial crisis the functioning of the money market was challenged, since the liquidity and counterparty credit risk increased. The unsecured transactions are usually for short maturities, since it is mainly meant for the use of banks that are lacking liquidity. Price stability is important in eliminating inflation risk premium. By eliminating the risk in the real interest rate, monetary policy creditability gets healthier and increases incentives to invest. There are two reference rates for unsecured money markets; EONIA and Euribor. (ECB 2011a)
Euribor rate is the reference rate for the over-the-counter (OTC) transaction in the Euro area. It is the rate at which Euro interbank deposits are being offered within the EMU (European monetary union) zone by one prime bank to another. The rates (15 maturities) are constructed as trimmed average of the rates submitted by a panel banks. The panel banks are the banks with the highest volume of business in the Eurozone money markets. In short, the Euribor rates reflect the average cost of funding of banks in the interbank market. After the crisis had started the solvency and solidity of the financial industry was questioned and the credit and liquidity risk and premium associated to interbank counterparties sharply increased. (Bianchetti & Carlicchi 2012)

The aggregate turnover in the euro money market began to decrease in 2007. The decline can be explained by the ongoing adverse impact of the financial crisis on interbank activities and by the surplus liquidity. The decrease in unsecured money market can be explained by the counterparty credit risk and by the decrease in the demand for liquidity. The decrease in turnover was driven by maturities of up to one month. This was again because of the unwillingness for the counterparty credit risk. The willingness to avoid counterparty credit risk can be an explanation for the increase in the basis swap spread. (ECB 2011a)

Central bank is independent, accountable, and transparent. Maintaining price stability in entrusted to an independent central bank (ECB), which is good because it is outside of political pressures. Accountability is seen as the legal and political obligation of an independent central bank to explain the decisions to citizens. Transparency is seen as an environment where the central bank provides all the relevant information of its strategy, assessments, and policy decisions to the general public. (ECB 2011a)

### 2.2 Plain vanilla swap

A plain vanilla swap (including Euribor basis swap) is traded Over-The-Counter. The euro interest rate swap is a contract between two parties to exchange streams of interest payments. It typically has one stream of payments as a fixed rate of interest rate and the other stream of payment as floating rate. Only the interest rates are paid,
not the notional principals. The euro swap market is growing fast; hedging and positioning activity drove the growth. (Remolona & Wooldridge 2003).

Flavell (2011:8-10) divided the evolution of a swap market into three phases. In the first phase two companies (swap end-users) negotiated directly with each other. They used “advisory” bank to assist them. This was slow processing, with documentation frequently tailored for each transaction. The counterparties were typically high rated, so they were happy dealing directly with each other. In the second phase the commercial banks began to take more role on providing traditional credit guarantees. The two companies would now negotiate with the bank, which structured back-to-back swaps but hold the credit risk. The documentation in this phase was more standardized. In the third and last phase a bank provides swap quotations when requested. The banks are dealing with a range of counterparties simultaneously, and entering into a variety of non-matching swaps.

The yield used for the fixed rate leg represents the expectations about the future path of the floating rate for the life of the contract and the risk related with the volatility of the rate. The floating rate depends on the contract’s maturity; EONIA is used in the short maturities and Euribor is used in the long-term maturities. The pricing of plain vanilla swap depends on the interest rate used for the floating rate leg of the contract. Swap rate tend to be higher than government bond rate because it contains a premium for credit risk. (Remolona & Wooldridge 2003)

The Euro interest rate swap market is one of the most liquid (participants can execute large- volume transactions without any significant change in the price) financial markets in the world. Therefore, the euro interest rate swap curve is the best benchmark yield curve in financial markets of Euro; some government bonds are often compared to it. Liquidity in Euro interest rate swap market is not as sensitive to market stress as the large government securities and futures markets. (Remolona & Wooldridge 2003)

A disadvantage of plain vanilla swap is that the counterparty may default before the expiration date of the contract, and is not able to make the required payments. If counterparty A has a positive net present value (NPV), then counterparty A expects
to receive average future cash flows from counterparty B. Also, since B has a negative NPV, B is expected to pay for A (B has debt with A). Credit Support Annex (CSA) or collateral agreement can ease the credit exposure. The important take away from the CSA, is that the basis swap prices quoted on the interbank market are counterparty risk free OTC transactions. (Bianchetti & Carlicchi 2012)

2.2.1 Euribor basis swap

Euribor basis swap is a plain vanilla swap where two different floating reference rate cash flows are exchanged (Hull 2006a:698). Bianchetti and Carlicchi (2012) clears the Euribor basis swap spread: The quoted Euribor 3m versus Euribor 6m Basis Swap rates is the difference between the fixed rates of a first standard swap with Euribor 3m floating leg (quarterly frequency) versus a fixed leg (annual frequency), and of a second swap with Euribor 6m floating leg (semi-annual frequency) versus a fixed leg (annual frequency). The frequency of the floating legs is the “tenor” of the corresponding Euribor rates.

Basis swaps are locking levels for forward basis risks, and their market quotes (spread) are based on expected future difference between the tenors. The market quotes are thenceforth based on market’s forecast of future credit spreads. As an example Euribor versus German Sovereign bond yield is mostly banking credit versus German Government credit (Sadr 2009:71). In Euribor basis swap it is then banking credit of shorter maturity versus banking credit of longer maturity.

According to Porfirio and Tuckman (2003) a basis swap is an exchange of floating rate payments based on different maturities on over-the-counter market. An example: swapping the three-month Euribor rate to 6-month Euribor rate. Euribor is default free rate; the lender and borrower should be indifferent between the rates. Even the parties are indifferent about the rates; there is a built-in credit premium due to the counterparty default risk of longer maturities. Hicks (1939) argue that the term premium have a positive relationship with time to maturity. This implies that the party who receives the longer maturity rate should earn a higher premium that the one with shorter maturity rate. On the other hand, Hirvelä (2012) argues that basis
swaps in the market are collateralized, which means there is no counterparty default risk.

The sudden increase in the Euribor basis swap spreads, after the 2007, can be explained in terms of the different credit and liquidity risks carried by the underlying Euribor rates with different tenor. After the crisis market participants prefer to receive floating payments with higher frequency (4 times a year) indexed to lower tenor Euribor rates (Euribor 3m) with respect to floating payments with lower frequency (twice a year) indexed to higher tenor Euribor rates (Euribor 6m) and to pay premium for the difference. A positive spread must be added to the 3m floating leg to parallel the value of the 6m floating leg. (Bianchetti & Carlicchi 2012)

Basis swap is used for hedging purposes among financial intermediaries whose assets and liabilities are dependent on different tenors. Consider four different counterparties. Lender, investor, financial institution, and swap counterparty. Lender needs 1 million for 5 years from financial institution, the lender pays interest rate of 6m Euribor plus 90 basis points. The bond investor have 1 million extra cash it wants to invest for five years to the financial institution, and receives 3m Euribor. In the last phase, the financial institution enters into Euribor basis swap with the swap counterparty. The financial institution now receives 3-month flat Euribor, and pays 12m Euribor minus 14 bp (31.12.2013). This happens because financial institution is exposed into basis risk for five years due to the earlier interactions. (Hull 2006b:151-152)

Basis risk arises when a financial institution have different amounts of rates earned and paid on different instruments with otherwise comparable repricing features. When interest rates increase/decrease, there may arise unexpected changes in the cash flows and earnings spread between liabilities, assets, and OBS instruments of similar maturities or repricing frequencies. (Basel Committee on Banking Supervision 2011)
2.2.2 Valuation of Euribor basis swap

The compounded short-term rate must equal the longer-term rate, and the arbitrage-free spread should be zero. It seems weird that there even exist spreads between basis swaps. As an example, the periodic payoff of a 3m versus 6m with a spread (S) for each calculation period (T, T+6m) is the net payment at T+6m (3m compounded twice) (Sadr 2009:73-75)

\[
\left\{ \left(1 + \frac{E_{3m}(T)}{4}\right)\left(1 + \frac{E_{3m}(T+3m)}{4}\right) + \frac{S}{2} \right\} - 1 
\]

(1)

Versus the six month

\[
\left(1 + \frac{E_{6m}(T)}{2}\right) - 1
\]

(2)

Or equivalently

\[
\left\{ \frac{E_{3m}(T)}{4}\left(1 + \frac{E_{3m}(T+3m)}{4}\right) + \frac{E_{3m}(T+3m)}{4} + \frac{S}{2} \right\} - \frac{E_{6m}(T)}{2}
\]

(3)

Where \(E_{3m}\) is the Euribor rate for 3 months, T is time. Four divides the \(E_{3m}\), because it is the frequency within a year. Arbitrage arguments suggest that the spread should equal zero. This argument only holds for risk-free interest rates. It there is no potential counterparty risk then any disequilibrium of quoted forward rates from their arbitrage-free values can be arbitraged away by entering into offsetting loans. For example, consider a risk-free interest rates quoted by default-free banks for 3m and 6m at \(E_{3m}(0), E_{6m}(0)\). Then one can buy a 3x6 FRA (forward rate agreement) at X,
borrow at $E_{3m}(0)$ for the first 3 months. Pay the principal and interest $(1 + E_{3m}(0)/4)$ in 3 months with a new loan at the prevalent 3-month rate $E_{3m}(3m)$. In 6 months, one must to pay

$$1 + E_{3m}(0)/4 \times (1 + E_{3m}(3m)/4)$$

While receiving

$$(E_{3m}(3m) - X)/4$$

as the reinvested payoff of the FRA, one also receives $1 + E_{6m}(0)/2$ as the 6 month loan matures. It cost nothing to enter the basis swap, no-arbitrage requires the final money in 6m be the same and $X$ to satisfy: (Sadr 2009:73-75)

$$(1 + E_{3m}(0)/4) \times (1 + X/4) = 1 + E_{6m}/2$$

If one is dealing with counterparties of the same credit worthiness, the riskiest transaction is the longest loan as it has the longest default exposure window. Therefore, whoever is going to lend for 6m will require a rate higher than what is implied by shorter-term rates.

$$(1 + E_{3m}(0)/4) \times (1 + X/4) = 1 + (E_{6m} + S)/2$$

This is why Euribor 6m versus Euribor 3m trades at a positive spread. (Sadr 2009:73-75)
3 COMPONENTS OF THE EURIBOR BASIS SWAP SPREAD

3.1 Liquidity risk component

3.1.1 Open Market Operations

The most important operations of monetary policy implementation is the Open Market Operation (OMO). Open Market Operations are conducted on the advantage of the ECB, mostly in the money market. Money market is usually referred to the market in which the maturity of transactions is less than a year. OMO includes main refinancing operations (MROs), longer-term refinancing operations (LTROs), fine tuning operations (FTOs), and structural operations. These four operations play a vital role in signaling the stance of monetary policy, steering key interest rates and managing the liquidity conditions. (ECB 2011)

According to Benito, Leon, and Nave (2007) the main OMO is the main refinancing operations (MRO), which is the liquidity-providing transaction. The operations are executed by the national central banks on the basis of standard tenders and play a vital role in the OMO. MRO provide the bulk of refinancing to the financial sector. Nautz and Offermanns (2007) clarify the role of MRO: determine the liquidity of the European banking sector. Since June 2000, the MRO minimum bid rate is the ECB’s key interest rate. The ECB’s key policy rate has always been the midpoint of the corridor because the opportunity cost of holding positive and negative balances at the central banks should equal at the central bank’s target rate.

Lending through OMO usually is operated in the form of reserve transactions. This means that the central bank buys assets under a repurchase agreement or grants a loan against assets pledged as collateral. Therefore, reserve transactions are temporary Open Market Operations, which provide liquidity for a pre-specified period only. (ECB 2011a)

The hypothesis is that Open Market Operation has a negative relationship with EBSS, since when the OMO increase, liquidity increase (because OMO is liquidity providing), which lowers the EBSS.
3.1.2 Autonomous Liquidity Factors (ALF)

The Autonomous Liquidity Factors are the sum of banknotes in circulation plus government deposits minus net foreign assets plus other factors. These factors have an effect on the liquidity of the banking system. They are not the result of the use of monetary policy instrument because for example banknotes in circulation are not controlled by the ECB. Government deposits with the ECB and banknotes in circulation generate the liquidity absorbing effect of autonomous factors because the notes are obtained from central banks, and financial institutions borrow funds from the central banks. On the other hand, the monetary authorities can control net foreign assets but the transactions are not related to monetary policy operation. The net foreign asset position of a country can be calculated as: the value of the sum of foreign assets held by monetary authorities and commercial banks, less their foreign liabilities. (ECB 2011a)

When sum of ALF liability side of a balance sheet exceeds the sum of ALF asset side of the balance sheet, there exist liquidity deficit in the banking sector. The hypothesis is that when ALF increases, liquidity lowers (because ALF is liquidity absorbing), and EBSS increases; there is a positive relationship between the two variables.

3.1.3 Deposit Facility

Counterparties can use the Deposit Facility to make overnight deposits with the National Central Banks. The deposits are repaid at an interest rate that is pre-specified. Usually, the interest rate on the Deposit Facility provides a floor for the overnight market interest rate. No collateral is given to the counterparty in exchange for the deposits. Institutions fulfilling the general counterparty eligibility criteria can access the Deposit Facility and it may deposit any amount it wishes. (ECB 2012)

The use of Deposit Facility increased during the financial crisis as banks wanted to possess more central bank reserves than required and to deposit the extra reserves in the deposit facility instead of lending them out to other financial institutions. Reasoning behind holding extra reserves is uncertainty and perceived counterparty
risk. The scale of use of the Deposit Facility reflects very high amounts of excess liquidity indicating that the markets are not working well. (ECB 2011a)

The hypothesis is that Deposit Facility and EBSS are positively correlated because deposit is increased due to uncertainty, lowering extra liquidity in the interbank market, which increases EBSS.

3.1.4 Governing Council meeting day dummy

According to ECB (2011a), the Governing Council is the main decision-making voice of the European Central bank. It consist of the governors of the national central banks (17 countries) plus six members of the Executive Board. The Governing Council meets twice a month in Frankfurt, Germany. The agenda of the first meeting of a month includes economic and monetary developments (intermediate monetary objectives, key interest rates and the supply of reserves). The agenda of the second meeting of a month includes the other tasks and responsibilities of the ECB and the Euro system. The monetary policy decision is explained in detail at a press conference right after the first meeting of each month.

Hartmann, Manna, and Manzanares (2001) argue that trading activity (quoting and volatility) increases right after 13.45 as the market gets the news from Council decisions and agents rebalance positions. The average volume during the post-announcement period is 2.5 times larger than on non-council Thursdays.

The hypothesis is that Meeting day dummy is negatively correlated with EBSS, since meeting day increases volume, which decreases EBSS.

3.2 Credit risk component

3.2.1 Eurobond yield

There are no Eurobonds (referred to combined sovereign bond of European Monetary Union countries) available in the market at the moment, but the European Commission is currently discussing whether to implement Eurobonds. The idea is
that Euro-area countries should divide their sovereign debt into two parts: “Blue” bonds (60% of GDP) with senior status, would be jointly and severally guaranteed by participating countries, and the rest as “Red” bonds with junior status. Blue bonds would be extremely liquid and safe asset (should never default), enabling the Euro-area borrow part of the sovereign debt at interest rates comparable to the benchmark German bond. The Red bonds would help to enforce fiscal discipline. The borrowing would be more expensive at the margin and it would strengthen market signals in the absence of a credible fiscal stance. Red bonds should be kept away from the banking system. (Delpla & Weizsäcker 2011)

Term structure of interest rates represents the window at which people are willing to trade consumption today for consumption tomorrow (Harvey 1989). Treasury bill (maturity in less than a year) makes a payment, face value, at some specified date in the future. Treasury notes and bonds have maturities over a year from the issue date. Notes and bonds promise to make coupon payments until the bond matures; the face value is also paid at the maturity. A bond can be divided into pieces and sold as separate zero-coupon bonds. Zero-coupon bond makes a known payment of face value, an investor knows the return over the life of the bond: a measure of this return is yield to maturity. (Campbell 1995)

A steeper slope of the yield curve implies higher future economic growth. Normally yield curve changes across the business cycles. During the financial crisis the yield was upward sloping because premia on long-term bonds is high and yield on short-term bonds is low. The premia on long-term bonds is negatively correlated to the overall state of economy because investors are not willing to take risk during economic bursts. Thus, short-term bonds are positively correlated to the overall state of economy because central bank lowers short yields during recession to stimulate consumption. (Estrella & Hardouvelis 1991)

Hirvelä (2012) categorize Eurobond yield to be a factor of credit risk component even it effects liquidity as well. The reasoning behind the twofold interpretation is that when European central bank sells government bonds in order to increase government bond yield it affects liquidity also.
Eurobond yield should be positively correlated to EBSS, since uncertainty increases both, the Eurobond and EBSS. On the other hand during the economic slowdown, governments try to decrease bond yields.

3.2.2 Bank CDS spread

Credit default swaps are Over-The-Counter derivatives introduced in the 1990s. CDSs can be thought as an insurance which transfers default risk of a certain individual entity from the buyer of protection to the seller of the protection. CDSs represent the cost of assuming pure credit risk. On the other hand, bonds represent several risks such as interest rate, credit risk, and foreign exchange risk. Before CDSs were available, a bond investor adjusted credit risk by buying or selling bonds, which would effect the investor’s position on all risks. CDSs provide the ability for investors to independently manage the credit risk (Beinstein & Scott, 2006).

The payoff from CDS depends on what happens to a company (including banks), or country, say Finland (reference entity). There are two sides to the contract: the buyer and the seller of protection. There is a payoff from the seller to the buyer of protection if Finland defaults on its obligations. The buyer of the insurance obtains the right to sell bonds, issued by Finland, for their face value (as an example $100 million) if Finland defaults. The seller of the insurance agrees to buy the bonds for their face value if Finland defaults. Suppose bond is worth $25 per $100 of face value, the cash payoff would be $75 million. The total face value of the bonds that is being sold is known as the credit default swap’s notional principal. The buyer of the CDS makes periodic payments (as an example 90 basis points annually) to the seller until the end of the life of the CDS or until a credit event (default) occurs. In case Finland does not default the buyer of the CDS pays (in this example) $900,000 per year to the seller of the CDS. (Hull 2006b:517-519)

A spread is the insurance premium that is paid for protection against default and is quoted in basis points (bps) per year as a fraction of the underlying notional. The notional amount represents the amount of insurance coverage. These protection-triggering events are defined by the International Swaps and Derivatives Association (ISDA), bankruptcy, failure to pay coupons on bonds, delay of payment of debt or
rejection of debt, restructuring of debt, and acceleration (e.g. downgrade of credit rating). (Beinstein & Scott 2006)

The CDS spread is the total amount paid as a percent of the notional principal per year to buy protection. Few big banks are market makers in the CDS market. A market maker might bid 200 basis points and offer 250 basis points. This means that the bank is prepared to buy protection by paying 2 percent per year and sell protection for 2.5% per year. CDS contracts with 5-year maturities are the most popular. (Hull 2006b:519)

According to Michaud and Upper (2008), banks’ risk of default can be measured by the premium paid on the credit default swaps referencing the debt of the borrowing banks. CDS premia refer to a combination of the risk of default and the compensation demanded by investors for bearing this risk. Credit default swaps are used to enable market participants to protect against credit risk or to enable market participants to transfer credit risk. (Naumann 2012)

Euribor panel bank CDS mid spread is regarded as a factor of credit risk component. Hirvelä (2012) assume that countries that belong to the Euribor panel jointly represent the current credit default risk of the representative euro area credit financial institutions and credit risk component in Euribor rates. The hypothesis is that Bank CDS and EBSS are positively correlated, since Bank CDS arises from uncertainty.

### 3.3 Macroeconomic component

#### 3.3.1 EONIA rate

The EONIA (Euro Overnight-Index Average) rate is the reference rate for overnight Over-the-counter transactions in the Euro zone. It is constructed as the weighted average rate of the overnight transactions executed during a given business day by a panel banks on the interbank money market. The EONIA rate includes information on the short run liquidity expectations of banks in the Euro zone. It is the best proxy available for the risk free rate. Beirne (2012) simplifies the EONIA rate: it is a
weighted average of all overnight lending transaction between credit institutions in the Euro. (Bianchetti & Carlicchi 2012)

Most popular trading maturities of EONIA are three months or less. EONIA swap rates are thought to be the pre-eminent benchmark at the short end of the euro yield curve. EONIA swaps are used to hedge and speculate on the short-term interest rate movements by banks, pension funds, insurance companies, hedge funds, and money market mutual funds. Overnight index swaps (OISs) have become popular in hedging and positioning vehicles in euro financial markets. An OIS is a fixed-for-floating interest rate swap with a floating rate leg tied to an index of daily interbank rates. OISs are referenced to the EONIA rate (Remolona & Wooldridge 2003).

According to Benito, Leon, and Nave (2007) marginal lending facility and deposit facility determine the fluctuation band of the EONIA rate with the aim to reduce volatility. Nautz and Offermanss (2008) add that interest rates of the two standing facilities (deposit and marginal lending facility), where banks can lend and deposit overnight liquidity at short notice define an interest rate corridor than bounds the volatility of the EONIA. According to ECB (2011b), both facilities have an overnight maturity and are available to counterparties on their own initiative.

The European Central Bank controls the EONIA rate. EONIA acts to influence the longer-term interest rates. Monetary policy in the Eurozone is executed through EONIA rate. It anchors the term structure of interest rates. Volatility of the EONIA rate is bad for the economy because it confuses financial market participants about the policy-intended interest rate level. Also the volatility at the short rates might be transmitted along the yield curve to long-term rates (Nautz & Offermanns 2008). The Effective steering of the overnight rate by the European Central Bank (ECB) would imply a low spread between the ECB policy rate (the key policy rate is set by the Governing council via its weekly MROs) and the EONIA rate (Beirne 2012).

The EONIA rate is selected to the study because it reflects the expectations about liquidity and also, monetary policy is executed through EONIA. From literature it is argues that EONIA has positive relationship with EBSS because EONIA increases, when excess liquidity decreases, uncertainty then increases the EBSS. In the
beginning of the period EONIA was around 4% but then suddenly decreased to around one where it has stayed since. This happened because monetary policy is executed through EONIA. The hypothesis is that EONIA is rather a monetary policy instrument than corresponder of liquidity expectations, as a result EBSS and EONIA should have a positive relationship.

3.3.2 Exchange rate

Floating nominal exchange rate is market price of a currency (USD) converted into another currency (Euro). Shocks to interest rate parity relationship makes central bank to react making exchange rate correlated negatively with interest rates differentials. Central banks can control only short-term interest rates, the effect is mostly seen at short horizons. Macroeconomic variables are included quickly into exchange rates, although the relative importance of individual macroeconomic variables shifts over time. Economic fundamentals appear to be more important in the long run, because a short run deviation of exchange rates from their fundamentals is attributed to speculation and hedging purposes. Chinn (2003)

The hypothesis is that exchange rates are negatively correlated to EBSS, because depreciation in Euro, increases uncertainty, which increases EBSS.
4 DATA

4.1 Euribor basis swap spread (EBSS)

The data for the Euribor basis swap spreads are retrieved from Bloomberg. The time series daily data is supposed to be from the period of January 1, 2007 through December 31, 2013. Due to missing data, the period is less than mentioned. Table 1 reports summary of descriptive statistics of Euribor basis swap spread of two different maturities (two and five years). The means of the basis swap spreads vary greatly among the swaps. The highest EBSS was close to 80 basis points for 3 month versus 12 month with maturity of 2 years. The lowest is 0.3 basis points for 3 versus 6 month with 5-year maturity basis swap spread. The Table 1 reports that the means of the spreads for the 5-year maturities are less than for the 2-year maturities. This implies inverted slope curve for the Euribor basis swap spread over maturities.

Standard deviation ranges from 3.51 (1m versus 3m with 5 years maturity) to 15.73 (3m versus 12m with 2 years maturity). Skewness measures the symmetry of the variable with respect to its mean. According to the Table 1 the variables are skewed close to the center. The kurtosis of the basis swap spreads are mostly negative. Normally distributed time series has a kurtosis of 3. If a kurtosis is close to 3 the distribution has short tails, and less extreme values. (Tsay 2005:34). Jarque and Bera (1987) combine the skewness and kurtosis test to figure out whether the variable is normally distributed. A hypothesis of normality is rejected if the p-value of the JB statistics is more than the significance level (in this case with the 5% level of significance the critical value is 5.99). From the Table 1, one can see that normality is rejected for each variable (JB is higher than 5.99). The last row in the Table 1 (ADF) is Augmented Dickey-Fuller p-values. Augmented Dickey-Fuller is a test of stationary. All spreads, but EBSS 1vs3y5, are nonstationary in 5% significance level.
Table 1. Descriptive statistics of Euribor basis swap spreads.

<table>
<thead>
<tr>
<th>EBSS</th>
<th>EBSS</th>
<th>EBSS</th>
<th>EBSS</th>
<th>EBSS</th>
<th>EBSS</th>
<th>EBSS</th>
<th>EBSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1467.00</td>
<td>1463.00</td>
<td>897.00</td>
<td>1669.00</td>
<td>1464.00</td>
<td>1560.00</td>
<td>1419.00</td>
</tr>
<tr>
<td>Min</td>
<td>8.60</td>
<td>7.70</td>
<td>10.70</td>
<td>0.30</td>
<td>2.55</td>
<td>6.20</td>
<td>0.05</td>
</tr>
<tr>
<td>Max</td>
<td>34.50</td>
<td>23.00</td>
<td>30.50</td>
<td>22.35</td>
<td>77.20</td>
<td>49.40</td>
<td>65.00</td>
</tr>
<tr>
<td>Mean</td>
<td>19.09</td>
<td>15.60</td>
<td>18.10</td>
<td>11.60</td>
<td>36.28</td>
<td>26.04</td>
<td>19.13</td>
</tr>
<tr>
<td>Median</td>
<td>19.70</td>
<td>15.40</td>
<td>15.80</td>
<td>13.15</td>
<td>30.90</td>
<td>26.90</td>
<td>16.18</td>
</tr>
<tr>
<td>Std.Dev</td>
<td>5.80</td>
<td>3.51</td>
<td>5.78</td>
<td>5.91</td>
<td>15.73</td>
<td>10.94</td>
<td>11.53</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.03</td>
<td>0.07</td>
<td>0.68</td>
<td>-0.32</td>
<td>0.91</td>
<td>0.03</td>
<td>0.84</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.84</td>
<td>-0.96</td>
<td>-1.10</td>
<td>-0.73</td>
<td>-0.29</td>
<td>-0.68</td>
<td>0.09</td>
</tr>
<tr>
<td>JB</td>
<td>43.27</td>
<td>57.45</td>
<td>112.00</td>
<td>65.00</td>
<td>208.80</td>
<td>49.52</td>
<td>169.70</td>
</tr>
<tr>
<td>ADF</td>
<td>0.10</td>
<td>0.02</td>
<td>0.70</td>
<td>0.33</td>
<td>0.12</td>
<td>0.34</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Where N=number of datapoints, Std.dev=standard deviation, JB= Jarque-Bera value, ADF= Augmented Dickey-Fuller p-value. EBSS1v3y2 refers to 1m vs 3m with 2 years to maturity. Time period: January 1, 2007 through December 31, 2013 (time period varies among the EBSS’s). Source: BLOOMBERG

4.2 Liquidity risk component

4.2.1 Open Market Operations

The daily data for the Open Market Operations are retrieved from the Datastream. It consists of a time period of January 1, 2007 through December 31, 2013, and is denoted as million euros. The Table 2 show that the mean of the daily Open Market Operation is 639 831 million euros. It has a negative kurtosis and it is skewed to the right. JB confirms that the normality is rejected and it is nonstationary. Correlation measures the strength or degree of linear association between the two variables (Gujarati 2003: 23). Since the variable is nonstationary I apply logarithmic first differences in correlation. The correlation between the EBSS and OMO is 0.03. It is statistically insignificant (function cor.test in R), therefore I will not make further analysis of the sign of the correlation at this point. Figure 1 illustrates the plot between the logdifferenced variables of liquidity component and the spread.
4.2.2 Autonomous Liquidity Factors

Table 2 illustrates the Autonomous Liquity factor (ALF) values in million euros for the period of January 1, 2007 through December 31, 2013. The data are retrieved from the Datastream. The mean ALF is 261 196 million euros. Kurtosis is positive and it is skewed to the left. ALF is not normally distributed (JB value of 141) and is nonstationary. There is a huge difference between the minimum value and the maximum value (1808 million euros versus 417217 million euros). Since the variable is nonstationary I apply logarithmic first differences in correlation. The correlation between the EBSS and Autonomous liquidity factor is negative 0.01. Since the correlation is statistically insignificant, I will not make further analysis of the sign of the correlation at this point.

4.2.3 Deposit Facility

Deposit Facility is retrieved from Datastream for the period of January 1, 2007 through December 31, 2013. The values are in millions. There is a huge difference between the highest and lowest value, for the Deposit Facility, of over 800 000 millions as seen in Table 2. The deposit facility is not normally distributed with 2.15 skewness and 4.7 kurtosis, and JB of over 3000 and Deposit is nonstationary. The logarithmic first difference correlation between the Deposit Facility and the EBSS is -0.05, it is also statistically insignificant. I will not make further analysis of the sign at this point.

4.2.4 Governing Council meeting day dummy

Governing Council meeting day dummy variable is qualitative or nominal scale variable. The Governing Council meeting day is artificial variable that take value of one if the first meeting of a month occurs and 0 otherwise.

Table 2. Descriptive statistics of variables of liquidity component.

<table>
<thead>
<tr>
<th></th>
<th>OMO</th>
<th>ALF</th>
<th>Deposit</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1827.00</td>
<td>1827.00</td>
<td>1827.00</td>
</tr>
<tr>
<td>Min</td>
<td>180 433.00</td>
<td>1808.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Max</td>
<td>1 119 374.00</td>
<td>417 217.00</td>
<td>820819.00</td>
</tr>
<tr>
<td>Mean</td>
<td>639 831.00</td>
<td>261 196.00</td>
<td>135980.00</td>
</tr>
<tr>
<td>Median</td>
<td>626 125.00</td>
<td>259 192.00</td>
<td>68261.00</td>
</tr>
<tr>
<td>Std.dev</td>
<td>198 6238.00</td>
<td>89 762.00</td>
<td>185418.00</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.65</td>
<td>-0.67</td>
<td>2.15</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.59</td>
<td>0.24</td>
<td>4.65</td>
</tr>
<tr>
<td>JB</td>
<td>153.36</td>
<td>141.11</td>
<td>3063.00</td>
</tr>
<tr>
<td>corr</td>
<td>0.03</td>
<td>-0.01</td>
<td>-0.05</td>
</tr>
<tr>
<td>ADF</td>
<td>0.36</td>
<td>0.61</td>
<td>0.37</td>
</tr>
</tbody>
</table>

The table includes descriptive statistics of Open Market Operations, aggregate liquidity factors, and Deposit facility. Where N=number of datapoints, Std.dev=standard deviation, JB= Jarque-Bera value, ADF=Augmented Dickey-Fuller p-value. Correlation is measured for logdifferenced values. Values are in million euros. Time-period is from January 1, 2007 through December 31, 2013. Source: DATASTREAM.
Figure 1. Plot: Logdifferenced EBSS3vs12y5 versus logdifferenced variables of liquidity component

4.3 Credit risk component

4.3.1 Eurobond yield

The data for the sovereign bond yields are from the Bloomberg for the period of January 1, 2007 through December 31, 2013. The quarterly data for the gross domestic product are from the OECD (http://www.oecd.org/statistics/) as an average over the period of 12 years.

Hirvelä (2012) constructed Eurobond yield from government bond market quotations of 11 different EMU-countries. Each country has a weight (GDP country panel/
combined GDP). The weight and the financial state (sovereign bond yield) of the 10 countries reflect the constructed Eurobond yield. This study follows the same method in constructing Eurobond yields. The countries in this study are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal, and Spain. The weights are in the Table 3.

Table 3. Weights for the Eurobond yields.

<table>
<thead>
<tr>
<th></th>
<th>Aus</th>
<th>Bel</th>
<th>Fin</th>
<th>Fra</th>
<th>Ger</th>
<th>Ire</th>
<th>Ita</th>
<th>Net</th>
<th>Por</th>
<th>Spa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>3.2 %</td>
<td>4.0 %</td>
<td>2.1 %</td>
<td>22.0 %</td>
<td>28.8 %</td>
<td>1.9 %</td>
<td>17.9 %</td>
<td>6.6 %</td>
<td>1.9 %</td>
<td>11.6 %</td>
</tr>
</tbody>
</table>

The table shows the weights for each country as GDP country panel/combined GDP. Countries: Austria, Belgium, Finland, Germany, Ireland, Italy, Netherlands, Portugal, Spain. Time period: from 2002 through 2013. Source: (http://www.oecd.org/statistics/)

The Table 4 illustrates the summary of descriptive statistics of Eurobond of 5-year and 10-year maturities. The mean for 5 year Eurobond is 2.7% and for the 10-year Eurobond the yield is 3.8%. This can be interpreted as upward sloping yield curve. The standard deviations for the Eurobonds are between 0.5 and 1 and kurtoses are negative for both maturities. The 5-year Eurobond is skewed to the right, but the 10-year Eurobond is skewed to the left (negative). JB statistics confirms that the Eurobonds are not normally distributed (Critical value of 5.99 is lower than JB) and Eurobonds are nonstationary. Due to the nonstationarity, correlation is taken from logdifferenced values. The correlation for both maturities with the EBSS is negative and statistically significant. The sign is different from my hypothesis. Central banks can decrease sovereign bond yields by buying sovereign bonds in OMO (more on this in ECB 2011b). This implies that the ECB succeeded in lowering the sovereign bond yields.

The Figure 2 show a negative relationship between the differenced values of the spread and the Eurobond yields of 5-years to maturity and 10-years to maturity. Eurobond yield of 5-years to maturity is more correlated than 10-years to maturity, therefore 10-years to maturity is omitted from further analysis.
4.3.2 Bank CDS

Euribor panel bank CDS are not available in the markets, which is why the EU Banking 5y CDS index midspread is used as a proxy for the Euribor panel bank CDS. The EU Banking 5y CDS index midspread is retrieved from the Datastream. Table 6 contains descriptive statistics of Bank CDS. The mean value is 221 basis points. It has a kurtosis of -0.7 and skewed to the right. JB statistics confirm that the bank CDS midspread is not normally distributed and the variable is nonstationary. The correlation of logdifferenced values of EBSS and BankCDS is statistically significant and positive as my hypothesis in section 3.2.

Table 4. Descriptive statistics of variables of credit risk component.

<table>
<thead>
<tr>
<th></th>
<th>Eurobond 5y</th>
<th>Eurobond 10y</th>
<th>BankCDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1826.00</td>
<td>1826.00</td>
<td>1827.00</td>
</tr>
<tr>
<td>Min</td>
<td>1.17</td>
<td>2.43</td>
<td>7.38</td>
</tr>
<tr>
<td>Max</td>
<td>4.57</td>
<td>5.02</td>
<td>606.36</td>
</tr>
<tr>
<td>Mean</td>
<td>2.72</td>
<td>3.83</td>
<td>221.09</td>
</tr>
<tr>
<td>Median</td>
<td>2.58</td>
<td>3.87</td>
<td>217.77</td>
</tr>
<tr>
<td>Std.Dev</td>
<td>0.83</td>
<td>0.54</td>
<td>137.42</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.25</td>
<td>-0.38</td>
<td>0.31</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.97</td>
<td>-0.65</td>
<td>-0.69</td>
</tr>
<tr>
<td>JB</td>
<td>90.61</td>
<td>76.45</td>
<td>64.52</td>
</tr>
<tr>
<td>corr</td>
<td>-0.38</td>
<td>-0.34</td>
<td>0.23</td>
</tr>
<tr>
<td>ADF</td>
<td>0.50</td>
<td>0.50</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Table illustrates descriptive statistics of Eurobond yield 5 years to maturity, Eurobond yield 10 years to maturity, and the EU Banking 5y CDS index midspread. Where N=number of datapoints, Std.dev=standard deviation, JB=Jarque-Bera value, ADF=Augmented Dickey-Fuller p-value. Correlation is measured for logdifferenced values. Time-period is from January 1, 2007 through December 31, 2013. Source: DATASTREM and BLOOMBERG.
4.4 **Macroeconomic component**

4.4.1 **EONIA rate**

The data of EONIA rate are retrieved from the Datastream. Descriptive statistics of EONIA percentage rate is seen from Table 5. The mean EONIA is 1.44%. It has negative kurtosis, and skewed to the right. It has a JB value of over 300 indicating that the variable is not normally distributed and EONIA is nonstationary. Since EONIA is interest rate I will not take logarithmic values. The correlation between the differenced EBSS and differenced EONIA rate is 0.01. Since, the correlation is insignificant (cor.test in R), I will not consider the sign at this point.
Since the variable is nonstationary I apply first differences in Figure 3. It shows the relationship between the EONIA rate and the spread. The EBSS and EONIA do not have a linear relationship, they move independently.

4.4.2 Exchange rate

The exchange rate of U.S, Japan, Great Britain, and China are retrieved from European Central Banks Statistical Data Warehouse for the period of January 1, 2007 through December 31, 2013. Descriptive statistics for the Exchange rates are seen from Table 5. Mean values for the exchange rates are 1.4 U.S Dollar (USD) per euro, 130 Yen (JPY) per Euro, 0.8 pound (GBP) per Euro, and 9.2 Yuan (CNY) per Euro. None of the rates are normally distributed as seen from the skewness, kurtosis, and JB and all variables, but GBP, are nonstationary. The correlations with logdifferenced values of the EBSS and the exchange rates are negative (as in my hypothesis) and statistically significant for all variables but GBP.

Table 5. Descriptive statistics of variables of macroeconomic component.

<table>
<thead>
<tr>
<th></th>
<th>EONIA</th>
<th>USD</th>
<th>JPY</th>
<th>GBP</th>
<th>CNY</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1827.00</td>
<td>1793.00</td>
<td>1793.00</td>
<td>1793.00</td>
<td>1793.00</td>
</tr>
<tr>
<td>Min</td>
<td>0.06</td>
<td>1.19</td>
<td>94.63</td>
<td>0.66</td>
<td>7.71</td>
</tr>
<tr>
<td>Max</td>
<td>4.60</td>
<td>1.60</td>
<td>169.75</td>
<td>0.98</td>
<td>11.17</td>
</tr>
<tr>
<td>Mean</td>
<td>1.44</td>
<td>1.37</td>
<td>129.01</td>
<td>0.82</td>
<td>9.20</td>
</tr>
<tr>
<td>Median</td>
<td>0.57</td>
<td>1.35</td>
<td>126.18</td>
<td>0.84</td>
<td>9.09</td>
</tr>
<tr>
<td>St.Dev</td>
<td>1.59</td>
<td>0.08</td>
<td>21.46</td>
<td>0.07</td>
<td>0.95</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.87</td>
<td>0.68</td>
<td>0.43</td>
<td>-0.93</td>
<td>0.35</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-1.05</td>
<td>0.01</td>
<td>-1.05</td>
<td>0.10</td>
<td>-1.15</td>
</tr>
<tr>
<td>JB</td>
<td>313.29</td>
<td>138.06</td>
<td>137.60</td>
<td>259.17</td>
<td>134.18</td>
</tr>
<tr>
<td>corr</td>
<td>0.01</td>
<td>-0.14</td>
<td>-0.22</td>
<td>-0.01</td>
<td>-0.14</td>
</tr>
<tr>
<td>ADF</td>
<td>0.24</td>
<td>0.20</td>
<td>0.40</td>
<td>0.03</td>
<td>0.31</td>
</tr>
</tbody>
</table>

The table includes descriptive statistics of EONIA, and Exchange rates. Where N=number of datapoints, Std.dev=standard deviation, JB= Jarque-Bera value, ADF= Augmented Dickey-Fuller p-value. Correlation is measured for logdifference values (EONIA is first difference). Values are in million Euros. Time-period is from January 1, 2007 through December 31, 2013. Source: DATASTREAM and EUROPEAN CENTRAL BANK’S STATISTICAL DATA WAREHOUSE.
Figure 3 plots the differenced values of the nominal exchange rates of the four rates and the Euribor basis swap spread of 3m vs 12m 5y. The spread and the exchange rates have negative relationship, meaning when an exchange rate increases, the spread decreases. GBP does not have a clear relationship as seen the correlation in Table 5 Column 4. The correlations give me a reason to omit GBP. USD is omitted from further analysis because I believe it is not the best estimator of Euro-area macroeconomic news, since the United States was suffering from the financial crisis and from the same spread issues as Europe. Therefore, I will continue with two exchange rate variables: JPY and CNY.

Figure 3. Plot: logdifferenced EBSS3vs12y5 versus logdifferenced variables of macroeconomic component.
5 EMPIRICAL METHODS

5.1 Tests of stationarity

Augmented Dickey-Fuller test is used in chapter 4 in descriptive statistics, since most financial time series data is nonstationary, which means its mean and variance vary over time. This gives headache for researchers, because of the problems it brings in the empirical research. It is often said that asset prices follow a random walk (nonstationary). (Gujarati 2003:797-803)

If a time series is stationary to begin with (does not need any differentiation) it is said to be integrated of order zero (stationary time series). Most financial time series are I(1), that is they generally become stationary after taking their first difference. (Gujarati 2003:808)

There are two types of random walks, one with a drift (intercept) and one without (no intercept). A random walk without a drift can be expressed as (Gujarati 2003:797-803):

\[ Y_t = Y_{t-1} + u_i \]  

(8)

Where \( u_i \) is a white noise error term with mean 0 and variance \( \sigma^2 \). The value \( Y_t \) is equal to its lagged value (t-1) plus a random shock \( u_i \) (this is AR(1) model). If \( Y_t \) is nonstationary, its first difference of a random walk time series is stationary because \( \Delta Y_t = (Y_t - Y_{t-1}) = u_i \).

A random walk with a drift can be expressed as:

\[ Y_t = \delta + Y_{t-1} + u_i \]  

(9)
Where, $\delta$ is the drift parameter. $Y_t$ drifts upward or downward depending on the drift parameter. Gross domestic has a positive drift, since it is growing. (Gujarati 2003:800) A time series has a unit root, if the first difference of such is stationary.

The following properties of integrated time series may be noted: let $X_t$, $Y_t$, and $Z$ be three time series (Gujarati 2003:805):

1) If $X_t \sim I(1)$ and $Y_t \sim I(1)$, then $Z_t = X_t + Y_t \sim I(1)$; a linear combination or sum of stationary and nonstationary time series is nonstationary.

2) If $X_t \sim I(0)$, then $Z_t = (a + bX_t) \sim I(0)$, where $a$ and $b$ are constants. A linear combination of an I(0) series is also I(0).

3) If $X_t \sim I(d_1)$ and $Y_t \sim I(d_2)$, then $Z_t = (aX_t + bY_t) \sim I(d_2)$, where $d_1 < d_2$

4) If $X_t \sim I(d)$ and $Y_t \sim I(d)$, then $Z_t = (aX_t + bY_t) \sim I(d^*)$; $d^*$ is generally equal to $d$, but in some cases $d^* < d$ (co-integration)

Dickey-Fuller (DF) test of unitroot assumes that the error term $\mu_t$ is uncorrelated. The Dickey-Fuller test is estimated in three different forms (Gujarati 2003:815-817)

\[
\Delta Y_t = \delta Y_{t-1} + u_t
\] (10)

where $\Delta Y_t$ is a random walk, $\delta = \rho_1 - 1$, where $\rho_1$ is autocorrelation of lag 1 and $Y_{t-1}$ is lagged value of $Y_t$. In case of a unitroot $\rho_1 = 1$ and $\delta = 0$.

\[
\Delta Y_t = \beta_1 + \delta Y_{t-1} + u_t
\] (11)

where $\Delta Y_t$ is a random walk with a drift,
\[ \Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + u_t \]  

(12)

where \( \Delta Y_t \) is a random walk with a drift around a stochastic trend. \( t \) is time or trend variable. In each of the three situations, the null hypothesis is that \( (\delta = 0) \) time series is nonstationary.

Augmented Dickey-Fuller (ADF) test is done by “augmenting” the three equations above by adding the lagged values of the dependent variable \( \Delta Y_t \). ADF test estimates the following equation: (Gujarati 2003:817)

\[ \Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} a_i \Delta Y_{t-i} + \varepsilon_t \]  

(13)

Where \( \varepsilon_t \) is noise error term. The idea is to include enough terms so that the error term is uncorrelated. ADF tests also whether \( \delta = 0 \) and it follows the same asymptotic distribution as the Dickey-Fuller statistics.

5.2 Co-integration tests

5.2.1 Phillips-Ouliaris co-integration tests

Phillips-Ouliaris test is a residual based co-integration tests. It tests whether residuals of a regression are stationary with Augmented Dickey-Fuller test. Critical values for the test are obtained from Phillips and Ouliaris (1990). The null is no co-integration.

The same mechanism is used in Phillips and Ouliaris co-integration test as in Engle and Granger co-integration test excluding Error Correction Model. The only difference is the critical values. Number of parameters is the amount of independent variables.
5.2.2 Engle and Granger test and Error Correction Model

The two-step procedure for co-integration analysis, recommended by Engle and Granger (1987), consist of Engle-Granger test and Error Correction Method. At first unit roots in the data should be tested and then the long-rung equation:

\[ Y_t = \delta_1 x_t + u_i \]

Where \( \delta_1 \) is a drift parameter and \( u_i \) is error term. If the variables are cointegrated, the OLS residuals in equation 14 are long-run equilibrium errors. That is: Equation 14 is the long-run equilibrium relation between the dependent and independent variables.

\[ \hat{u}_i = y_t - \hat{\delta}_1 x_1 \]

If the estimated error term (\( \hat{u}_t \)) is stationary, there is co-integration among variables. This test of stationarity is conducted using Augmented Dickey-Fuller tests on the residuals, using MacKinnon (2010) critical values adjusted for the number of data points.

Error correction model corrects for disequilibrium which happens in the short run. The error can be thought as equilibrium error, the equilibrium error can be used to tie the short-run behavior of EBSS to its long-run value. The ECM corrects the disequilibrium. The Granger representation theorem argues that if two variables \( Y \) and \( X \) are co-integrated, then the relationship between the two can be expressed as ECM. The error correction model for the Bank CDS is in the form of (Gujarati 2003:825):
\[ \Delta EBSS_t = \alpha_0 + \alpha_1 u_{t-1} + \alpha_2 \Delta BankCDS_{t-1} + \alpha_3 \Delta EBSS_{t-1} + \varepsilon_t \]  \hspace{1cm} (16)

Where \( \alpha_0 \) is the intercept, \( \Delta \) denotes the first difference, \( \varepsilon_t \) is a random error term, and \( u_{t-1} = (EBSS_{t-1} - \beta_1 - \beta_2 BankCDS_{t-1}) \), which is one-period lagged value of the error from the co-integrating OLS regression. This equation states that difference of EBSS depends on the difference of Bank CDS and on the equilibrium error term. If the equilibrium error term is nonzero, then the equilibrium is not in place. In case, the \( \Delta BankCDS \) is zero and \( u_{t-1} \) is positive, the \( EBSS_{t-1} \) is too high to be in equilibrium. This means that if \( EBSS_t \) is above its equilibrium value, it will start falling in the next period to correct the equilibrium value. The absolute value of \( \alpha_1 \) decides how fast the long-run equilibrium is restored. (Gujarati 2003:825)

5.3 Ordinary Least Square Method with Newey-West corrections

Regression analysis is the study of dependence of a dependent variable on one or more explanatory (independent) variables, with a view to estimate the (population) mean or average value of the dependent variable in terms of the known values of the explanatory variables (Gujarati 2003:18).

For Ordinary Least Square (OLS) method the assumptions are vital, because the estimate should be the best linear unbiased estimator (BLUE). There are few assumptions to check first before interpreting the OLS regression (autocorrelation, homoskedasticity, and covariance). (Gujarati 2003: 66-75).

The assumption of homoscedasticity, or equal variance of \( u_t \), is tested with Breusch-Pagan in R-code. The variance of the dependent population is supposed to be constant as shown in equation 17. The heteroscedasticity of the model can arise from the skewness of the regressors. The null hypothesis is constant variance.
\[ \text{var}(u_i | X_i) = \sigma^2 \]  

\[ (17) \]

The assumption is no autocorrelation between the error terms (equation 18) can be tested using Ljung-Box (LB) test in R-code. The null hypothesis is independency between the error terms.

\[ \text{cov}(u_i u_j | X_i X_j) = 0 \]

\[ (18) \]

Ljung-Box statistics (LB) of autocorrelation is a joint hypothesis that all the \( \rho_k \) up to certain lags is simultaneously equal to zero can be tested using LB statistics.

\[ \text{LB} = n(n + 2) \sum_{k=1}^{m} \left( \frac{\hat{\rho}_k^2}{n - k} \right) \sim \chi^2 m \]

\[ (19) \]

Where \( n \) is sample size, \( k \) is lag length, \( m \) is the number of lags being tested, and \( \hat{\rho}_k \) is estimated autocorrelation function. Ljung-Box test follows Chi Square distribution. If the \( \chi^2 \) value is higher than the critical value: reject the null hypotheses.

The assumption of zero covariance between the error term and independent variables, as seen in the equation 11, is tested in R-code. The error term and independent variables are assumed to be uncorrelated (i.e. have separate influence on the dependent variable). If they are correlated it is impossible to get their individual effects on the dependent variable because when error term increases, the independent variable increases aswell.
\begin{equation}
\text{cov} \left( u_i, X_{2i} \right) = \text{cov} \left( u_i, X_{3i} \right) = 0
\end{equation}

Lastly the assumption of no perfect multicollinearity is tested using VIF –test in R-code. If the VIF values are above 10, there is multicollinearity problem.

Newey-west correction overcomes autocorrelation and heteroskedasticity problems in a regression.
6  EMPIRICAL RESULTS

6.1  Tests of Stationary

The correlograms for the level stage variables of Autocorrelation Function is in the appendix Figures 4 and 5. They give a reasonable doubt to expect that the variables are nonstationary, since autocorrelations with lag one are close to 1. The Correlogram does not show whether they are nonstationary in mean or variance or both.

Augmented Dickey-fuller test results for all the level stage variables show that most variables are nonstationary (Test results of Descriptive Statistics are in the Tables 1,2,4, and 5). With 5% significance level, p-values should be less than 0.05 to be stationary.

6.2  Co-Integration tests

6.2.1  Phillips-Ouliaris test

I chose the level stage combinations, that co-integrates in Phillips-Ouliaris test (po.test in R) with try and error method. I find 5 combinations that are significant. The combinations are seen in Table 6.

None of the components (Liquidity, Credit, and Macroeconomic) co-integrates with EBSS 3vs12y5, but Credit component is closest being co-integrated. I conducted the test also for each independent variable. Bank CDS is the only variable that co-integrates with EBSS 3vs12y5 according to Phillips-Ouliaris test.

6.2.2  Engle-Granger test and Error Correction Method

I regressed five models that co-integrated with EBSS 3vs12y5 in Phillips-Ouliaris test (Table 6) and saved the level stage residuals. Then I conducted the Augmented Dickey-Fuller unitroot test with MacKinnon (2010) critical values. I did the same for each component: Liquidity component (OMO, ALF, and Deposit), credit component
(Eurobond 5y, Eurobond 10y Bank CDS), and macroeconomic component (EONIA, CNY, JPY). I also regressed each of the variable independently.

Table 6. Results of Phillips-Ouliaris and Engle-Granger co-integration tests.

<table>
<thead>
<tr>
<th>Model 1: EBSS3s12y5 ~ OMO + Deposit + Eurobond5 + EONIA + CNY</th>
<th>PANEL A: Phillips-Ouliaris</th>
<th>PANEL B: Engle-Granger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate</td>
<td>p-value</td>
<td>CV 5%</td>
</tr>
<tr>
<td>-63.700</td>
<td>0.010</td>
<td>-41.940</td>
</tr>
<tr>
<td>Model 2: EBSS3s12y5 ~ OMO + Deposit + Eurobond5 + BankCDS + CNY</td>
<td>-46.010</td>
<td>0.030</td>
</tr>
<tr>
<td>Model 3: EBSS3s12y5 ~ OMO + Deposit + BankCDS + CNY</td>
<td>-45.910</td>
<td>0.010</td>
</tr>
<tr>
<td>Model 4: EBSS3s12y5 ~ OMO + Deposit + Eurobond5 + CNY</td>
<td>-62.690</td>
<td>0.010</td>
</tr>
<tr>
<td>Model 5: EBSS3s12y5 ~ OMO + ALF + Deposit + CNY</td>
<td>-46.617</td>
<td>0.0123</td>
</tr>
</tbody>
</table>

EBSS ~ Liquidity -19.643 0.150 -25.524 -3.502(4) 0.000 -4.104
EBSS ~ Credit -23.347 0.150 -25.524 -3.347(4) 0.001 -4.104
EBSS ~ Macro -22.057 0.150 -25.524 -3.049(4) 0.002 -4.104
EBSS ~ OMO -5.750 0.150 -20.500 -1.978(2) 0.048 -3.340
EBSS ~ ALF -13.890 0.150 -20.500 -2.925(2) 0.004 -3.340
EBSS ~ Deposit -12.400 0.150 -20.500 -2.856(2) 0.004 -3.340
EBSS ~ Eurobond5 -4.400 0.150 -20.500 -1.54(2) 0.123 -3.340
EBSS ~ BankCDS -25.917 0.018 -20.500 -3.423(2) 0.001 -3.340
EBSS ~ EONIA -5.550 0.150 -20.500 -1.75(2) 0.081 -3.340
EBSS ~ JPY -9.370 0.150 -20.500 -1.83(2) 0.068 -3.340
EBSS ~ CNY -10.830 0.150 -20.500 -2.196(2) 0.028 -3.340

The critical values for Phillips-Ouliaris test are from Table 1a in Phillips and Ouliaris (1990). The number of variables is counted from the independent variables. The critical values for Engle-Granger test are calculated from Table 2 in Mackinnon (2010:13) with N:1478. Number of variables in parentheses.

Out of the five models, found in Phillips-Ouliaris test, three co-integrates according to Engle-Granger test. The liquidity component is not co-integrated with the Euribor Basis swap spread. The credit and macroeconomic components do not co-integrate either in any of the significance levels. The results are seen in the Table 6.
The basis spread of 3m vs 12m 5y and Bank CDS are co-integrated, which means there is a long-term, or equilibrium, relationship between the two variables. Credit component is closer being co-integrated than liquidity component. As mentioned in the literature review, the credit component becomes more important after the Lehman Brothers collapse. The results from the co-integration can be explained by the data set. The data for the EG model starts from the end of 2007 till the end of 2013. Most of the data points are from after the collapse in mid-September of 2008.

The results for the Error Correction Method are seen in Table 7. Bank CDS is the only variable that co-integrates with Euribor basis swap spread, so Error Correction Model can be used to check the misequilibrium. The error parameter \( a_1 \) is from a level stage regression, lagged parameters \( a_2 \) and \( a_3 \) are logdifference level variables.

The error parameters (parameter \( a_1 \) in equation 16) are insignificants in the Models 1 and 4. This imply that there is no short term effects in the prior period on dependent variable in the current period. In the Model 5, the error parameter is significant. This means that the Error Correction Model corrects the misequilibrium 0.01 percent per day. Table 7 show the Error Correction Model results for the model 1, 4, and 5.

The regression model EBSS3vs12y5~BankCDS gives interesting results. T-ratio of \( a_1 \) parameter rejects the null hypothesis in 5% significance level. This means that Error Correction Model is significant and corrects the misequilibrium less than 0.01% per day. Parameter \( a_2 \) (in the equation 16, Lag ldBankCDS in Table 7 Column 5) is negative and insignificant. It means Bank CDS does not lead the basis swap spread market in the short-term. Parameter \( a_3 \) (lag EBSS for Column 5) is significant in 5% level.

In the regression model BankCDS~EBSS3vs12y5, the parameter \( a_1 \) (Lag Error) rejects the null hypothesis in 10% significance level, meaning that error correction model is significant. Misequilibrium is corrected less than 0.01% per day. Parameter \( a_2 \) (lag EBSS in Column 6) is positive and insignificant. It means that EBSS does not lead the Bank CDS. Parameter \( a_3 \) of lagged bank CDS is significant.
Table 7. Error Correction Model.

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Estimate</th>
<th>Estimate</th>
<th>Estimate</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.000</td>
</tr>
<tr>
<td>Model 4</td>
<td>0.001</td>
<td>0.000</td>
<td>-0.001</td>
<td>0.000</td>
<td>-0.000</td>
</tr>
<tr>
<td>Model 5</td>
<td>0.000</td>
<td>0.000</td>
<td>-0.002</td>
<td>0.000</td>
<td>-0.000</td>
</tr>
<tr>
<td>EBSS 3vs12y5~BankCDS</td>
<td>-1.473</td>
<td>-1.483</td>
<td>-2.044</td>
<td>-2.006</td>
<td>-2.686</td>
</tr>
<tr>
<td>BankCDS~EBSS 3vs12y5</td>
<td>0.006</td>
<td>-0.003</td>
<td>-0.002</td>
<td>0.000</td>
<td>-0.000</td>
</tr>
<tr>
<td>Lag ldOMO</td>
<td>0.066</td>
<td>-0.003</td>
<td>-0.002</td>
<td>0.000</td>
<td>-0.000</td>
</tr>
<tr>
<td>Lag ldALF</td>
<td>-0.002</td>
<td>(-0.233)</td>
<td>(-0.164)</td>
<td>(-0.948)</td>
<td></td>
</tr>
<tr>
<td>Lag ldDeposit</td>
<td>-0.003</td>
<td>-0.003</td>
<td>-0.003</td>
<td>(-0.926)</td>
<td></td>
</tr>
<tr>
<td>Lag ldEurobond5</td>
<td>-0.071</td>
<td>-0.067</td>
<td>(-1.121)</td>
<td>(-1.068)</td>
<td></td>
</tr>
<tr>
<td>Lag ldBankCDS</td>
<td>0.019</td>
<td>0.065</td>
<td>(0.654)</td>
<td>(2.419)</td>
<td></td>
</tr>
<tr>
<td>Lag ldEONIA</td>
<td>0.017</td>
<td>(1.311)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lag ldCNY</td>
<td>0.029</td>
<td>0.028</td>
<td>(0.185)</td>
<td>(0.174)</td>
<td></td>
</tr>
<tr>
<td>Lag ldEBSS</td>
<td>-0.073</td>
<td>0.071</td>
<td>-0.062</td>
<td>-0.065</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>(-2.558)</td>
<td>(-2.514)</td>
<td>(-2.346)</td>
<td>(-2.421)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.795)</td>
</tr>
</tbody>
</table>

Model 1, 4, and 5 from Table 6.
Lag ldOMO corresponds to lagged logdifference value of OMO.
Column 5: ECM EBSS3vs12y5~Bank CDS.
Column 6: ECM Bank CDS~ EBSS3vs12y5.
t-values in parenthesis.

To conclude, the co-integrated models 1, 4, and 5 have no short-run effect on EBSS 3vs12y5. Even EBSS 3m versus 12m with 5 years to maturity and Bank CDS are co-integrated, the error correction model does not bring light to figuring out the research question about the parameters that determine the EBSS 3m versus 12m with 5 years to Maturity.
6.3 Ordinary Least Square Method with Newey-West corrections

I run a regression for four models with Newey-West corrections. The variables are in first difference form. The Models 1, 4, and 5 are from Table 7, and the variables for the model 6 are chosen by using step-wise function in R. The residuals of the models are autocorrelated and heteroskedastic. Therefore I use the Newey-West corrections to modify the standard errors and t-values to get proper results.

R² measures the percentage of the total variation in EBSS 3vs12y5 explained by the regression model. F-Statistics measures the overall significance of the estimated regression. The Model 6 has the best goodness of fit with 25.5%. It gives a signal that all the variables affecting EBSS are not found yet.

The most interesting finding of the OLS regression is the signs of the variables. OMO has a negative relationship with EBSS, ALF and Deposit Facility have a positive relationship with the EBSS. My hypothesis is that the EBSS and Eurobond has a positive sign, but correlation and OLS regression result confirm that the relationship is negative. ECB succeed in lowering the sovereign bond yields of the member countries. BankCDS and EONIA has positive relationship as expected. CNY has a negative sign as expected. I find Open Market Operations, Eurobond 5-years to maturity, BankCDS, and CNY to be statistically significant determining variables affecting EBSS.
### Table 8. Ordinary Least Square Method.

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.003</td>
<td>0.001</td>
<td>0.012</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td>(0.126)</td>
<td>(0.072)</td>
<td>(0.580)</td>
<td>(0.545)</td>
</tr>
<tr>
<td>OMO</td>
<td>1.25E-06</td>
<td>7.23E-07</td>
<td>8.26E-07</td>
<td>1.31E-06</td>
</tr>
<tr>
<td></td>
<td>(2.187)</td>
<td>(1.563)</td>
<td>(1.746)</td>
<td>(2.408)</td>
</tr>
<tr>
<td>ALF</td>
<td></td>
<td></td>
<td>-2.98E-06</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(-1.379)</td>
<td></td>
</tr>
<tr>
<td>Deposit</td>
<td>7.19E-07</td>
<td>6.92E-07</td>
<td>4.00E-07</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.215)</td>
<td>(1.161)</td>
<td>(0.650)</td>
<td></td>
</tr>
<tr>
<td>Meeting</td>
<td></td>
<td></td>
<td>-0.176</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(-1.970)</td>
<td></td>
</tr>
<tr>
<td>EurobondS</td>
<td>-6.520</td>
<td>-6.500</td>
<td>-6.689</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-11.711)</td>
<td>(-11.661)</td>
<td>(-13.063)</td>
<td></td>
</tr>
<tr>
<td>BankCDS</td>
<td></td>
<td></td>
<td>0.010</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3.321)</td>
<td></td>
</tr>
<tr>
<td>EONIA</td>
<td>0.438</td>
<td></td>
<td>0.470</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.082)</td>
<td></td>
<td>(2.372)</td>
<td></td>
</tr>
<tr>
<td>CNY</td>
<td>-1.844</td>
<td>-1.853</td>
<td>-1.959</td>
<td>-1.382</td>
</tr>
<tr>
<td></td>
<td>(-4.360)</td>
<td>(-4.231)</td>
<td>(-3.471)</td>
<td>(-3.591)</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.232</td>
<td>0.229</td>
<td>0.032</td>
<td>0.255</td>
</tr>
<tr>
<td>F-statistics</td>
<td>89.906</td>
<td>110.800</td>
<td>13.260</td>
<td>85.130</td>
</tr>
</tbody>
</table>

T-values in parenthesis. Models 1, 4, and 5 from Table 6.
7 CONCLUSION

In this study, determinants of Euribor basis swap spread is being studied, especially 3m versus 12m with 5 years to maturity. The increase in EBSS in the beginning of the latest financial crisis is seen as deteriorated interbank activity. The main reasons for the sudden increase is seen as liquidity deficit and increased uncertainty.

The hypothesis is based on earlier empirical results. The aim of the study is to provide factors that affects EBBS and find out which one, liquidity or credit, effect more on the EBBS movements.

In empirical part of the study, I first checked the stationarity of the variables. Then I applied Phillips-Ouliaris (P-O) co-integration test to get 5 combinations that co-integrates with Euribor basis swap spread 3 month versus 12 month with 5 years to maturity. Then I estimated long-run equilibrium for the Models with Engle-Granger test. Out of the five Models, picked in P-O, only three had long-run equilibrium. From the three long-run equilibrium Models I saved the regression residuals and estimated short-term equilibrium with Error Correction Model. At the end, I tested Ordinary Least Square method with Newey-West corrections with the three co-integrated Models. I also used Step-wise to choose another Model.

Engel-Granger and Error correction model is applied to find out if there exist long- and short -term equilibrium. Of course, to conduct Engel-Granger and ECM, stationary tests must be done. For stationary tests Autocorrelation function and Augmented Dickey-Fuller tests are used.

I considered OMO, ALF, Deposit Facility, and Governing Council Meeting -dummy as liquidity components due to the hypothesis. As credit risk components I considered Eurobond yield 5y, Eurobond yield 10y and Bank CDS. As macroeconomic and monetary policy component I chose EONIA and exchange rates.

The stationary test indicates that all the variables (besides GBP) are integrated of order 1. Co-integration test results for liquidity, credit, macroeconomic reveals that
none of them co-integrates with Euribor basis swap spread 3m vs 12m 5y. Credit component is closest though. When considering Engel-Granger co-integration test for each independent variable and EBSS, the results show that there exist co-integration between and Bank CDS and EBSS.

OLS regression implies that OMO has positive impact on EBSS. Earlier studies (Beirne 2012, Frank and Hesse 2009) find that liquidity did not have significant impact on EBSS after August 2008. Is the Covered Bond Purchases Programme affecting this too? Autonomous liquidity factor is not a determinant of EBSS even there is high negative correlation. Governing Day meeting dummy explain some of the variation in EBSS (in 10% significance level). It is reasonable to think so, because volume in money market increases after news from Council decisions in pronounced. EBSS decreases because of lower liquidity risk. Deposit facility got cut during the stepwise selection for being determinant of EBSS 3m vs 12m 5y. But it is co-integrated with EBSS 3m vs 6m 5y. This gives mixed signals on Deposit facility being determinant of Euribor basis swap spread. The Governing Council Meeting day –dummy decreases EBSS.

Eurobond yield has the biggest impact on EBSS 3m v 12m 5y. When considering Creek, the bond yields went up because of the very high liquidity and credit risks, consequently would be reasonable think, that bond yield is positively correlated with EBSS. This is not the case here though; ECB began purchasing covered bonds with the aim of lowering yield curves and stabilizing financial market. The OLS results show that the sign of the two variables is negative. Bank CDS impact EBSS 3m v 12m 5y with 1% significance level. This is reasonable, because CDS is nothing but risk factor; higher risk implies higher EBSS.

EONIA is not the biggest influencer of EBSS 3m v 12m 5y but it is significant. The sign of EONIA is positive. I believe there is no strong connection between EONIA and EBSS during the period of end of 2007 and end of 2013. CNY (Chinese Yuan) has the biggest impact (from exchange rates) to the EBSS. The impact is negative as it is reasonable to think. During economic busts it is normal, that a domestic currency depreciates, thus the domestic products become more desirable for the foreign
countries. Depreciating currency signals markets about worsening macroeconomy, therefore increasing uncertainty, which then again increases EBSS.

To answer briefly to the research question, biggest determinants for the Euribor basis swap spread 3m vs 12m 5y are Open Market Operations, Eurobond yield 5y, Bank CDS, EONIA, and exchange rate of China. Credit component seem to be more significant than liquidity component, since only OMO from liquidity components is a determinant of EBSS.

For further research I suggest adding more variables, because clearly all variables are not found yet. Also, I would suggest to use Minor Refinancing Operations (MRO) instead of OMO since it determines liquidity in banking sector.
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Figure 4. ACF and PACF part 1.
Figure 5. ACF and PACF part 2.