Aalto University
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EURIBOR BASIS SWAP SPREADS Estimating driving forces

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Aalto University School of Economics **Abstract**
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EURIBOR BASIS SWAP SPREADS – ESTIMATING DRIVING FORCES

Objective of the study

The objective of the study is to investigate how credit risk, liquidity and news about macroeconomic factors affect to Euribor basis swap spreads. Euribor basis swap spreads should trade in flat in order to no-arbitrage condition to hold. However, during the current financial crisis spreads have increased significantly. I will regard euro countries' and Euribor panel banks' credit default swap spreads as a credit risk component and the actions of the European Central Bank as a factors of liquidity component.

Data and methods

The study is empirical and will be based on linear regression and co-integration analysis. Data consist of time-series data from July 2008 to December 2011. I will first investigate relations between explanatory variables and 3 month versus 12 month Euribor basis swap spreads with 2 and 5 year maturities using descriptive statistics. After that, I will present proper empirical test results. In first phase, I will use unit root tests to see are time-series stationary. After they are stated to be stationary in differences and log-differences I will proceed to conduct short-run linear regression tests using ordinary least squares estimation. Finally, I will conduct Engle-Granger and Johansen co-integration tests in order to find out is there long-run relationship between the explanatory variables and Euribor basis swap spreads.

Results

Results are in some sense twofold. Ordinary least squares provide rather different test results than co-integration tests for the short-run. In the long-run, I found only one robust co-integrating relation when applying both co-integration methods. The relation was between Euribor basis swap spreads and Eurobond yield. In the short-run I found five significant factors that could model the movements of Euribor basis swap spreads. The coefficients of determination were 30 per cent (2 year) and 25 per cent (5 year). Based on OLS results I could accept my initial hypothesis about significant components being credit risk, liquidity and news about macroeconomic variables. On the other hand based on co-integration tests I could accept liquidity component.

Keywords

Euribor basis swap, interest rate swap, European Central Bank, credit default swap, co-integration, linear regression, Engle-Granger, Johansen

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1 INTRODUCTION

The effect of turbulence on money and capital markets started in the second half of 2007 has created a need to explore forces that have caused multiple uncommon phenomena in markets, such as the increase of the basis spreads quoted on the market between interest rate instruments and swaps particularly (Amentrano & Bianchetti, 2009). In the second half of 2007 the deterioration in a relatively limited segment of the U.S. subprime mortgage sector started to spread to other markets as well. Uncertainty in markets caused banks and other financial institutions to increase their liquidity. The markets were uncertain about forthcoming losses which caused financial institutions to be reluctant to lend each other in money markets, especially in longer maturities. Financial institutions were afraid of counterparty risks. As a consequence basis spreads of interbank short-term interest rates, Treasury bill rates and swap rates widened. The situation in money and capital markets became more severe in September 2008 following the collapse of Lehman Brothers in U.S. Reduction in willingness to take on counterparty risk and even more significant increase in demand to hold liquidity among financial institutions froze funding markets temporarily (Bank for International Settlements, 2010).

In the aftermath of the crisis in June 2011 Federal Reserve Chairman Ben Bernanke said “the U.S. economy is recovering at a moderate pace from both the worst financial crisis and the most severe housing bust since the Great Depression” (MacKenzie C., 2011). Meanwhile in euro area, markets are still unreliable. The increased costs of financial support schemes as well as recession induced falls in tax revenues have caused in most advanced economies a dramatic increase in the supply of government paper and raised concerns about the impact of fiscal imbalances on long-term debt financing costs (Caporale, G.M. & Girardi, A., 2011). Understanding the effects of growing levels of public debt on long-term yields is a difficult task. Economic theory suggests that deteriorated fiscal position will lead to higher real interest rates with a harmful effect on private investment and consumption plans (Buiter, 1976). The ongoing debt crisis in Greece and Italy as well as Portugal in spring of 2011, and Ireland in 2010 are effective reminders of liquidity crisis in the euro area.

Focus of this study is not on government bonds and their spreads. Instead I will concentrate on Euribor basis swap spreads, since there is not much evidence on which are the driving forces of Euribor basis swap spreads quoted on the market between two plain vanilla interest rate instruments. The reason for this is that spreads widened not until during the financial crisis. Previous to 2007 basis spreads were substantially low reflecting a normal, healthy state of the economy.

There are several studies focusing on pricing and hedging interest rate derivatives in pre- and post-crisis framework. As indicated in the paper of Amentrano & Bianchetti (2009), they are studying "old traditional style of single curve market practice for pricing and hedging interest rate derivatives and the recent market evolution, triggered by the credit crunch crisis", which have imposed the new post-credit crunch multi-curve approach for pricing and hedging interest rate derivatives. Among several other researchers, Morini (2009) and Amentrano & Bianchetti (2009) have studied more consistent pricing formulas of basis swaps. In chapter 3, I will present basics of different valuation approaches to basis swaps and the pre- and post crisis pricing framework of Euribor basis swaps in order to understand how financial crisis has changed the structure of pricing interest rate derivatives.

With regard to this study, the most significant pressure will be on forces driving basis swap spreads. Previously studies on the basis swap spreads have largely focused on swap counterparty default risk as the main driver of swap spreads. However, due to collateralization, the counterparty risk is very low in Euribor basis swaps but Euribor rates embed a credit risk component as they are quoted on the interbank market. Duffie, D. & Huang, M. (1996), Minton, B. A. (1997) and Cossin, D. & Pirotte, H. (1997) have studied only one factor, default risk, to explain the magnitude and behavior of swap spreads. Fehle, F. (2002) examined in his paper "The Components of Interest Rate Swap Spreads: Theory and International Evidence", the two additional components being Libor spreads and swap market structure effect, which can cause positive swap spreads even in the absence of counterparty default risk which is the case with collateralized swaps. Poskitt, R. (2010) in his paper "Do liquidity or credit effects explain the behavior of the Libor-OIS spread", decomposes spread into credit risk and liquidity risk components using credit default swaps written on Libor panel banks as a proxy for the credit risk component embedded in market rates and bid-ask spreads together with the number of dealers active in the market as a proxy for liquidity premium.

There are not any comprehensive studies conducted on how several factors affect the basis swap markets, especially in the euro zone. In this sense, there exists a niche to empirically investigate what the effects of presumable driving forces on basis spreads are and how they effect on these markets.

1.1 Motivation of the study

The existence of wide basis swap spreads between various underlying rate tenors can be seen as an indicator of impairment in the financial markets. During the financial turmoil basis swap spreads have been significantly different from zero, one of the consequences of liquidity crisis. I will give an overall description of basis swaps and finally clarify the current market state through example.

A money market basis swap is an exchange of floating rate payments based on one rate tenor for floating rate payments based on another rate tenor (Porfirio, P. & Tuckman, B., 2003) on over-the counter market. An imaginary basis swap to exchange the default-free rate of one term for the default-free rate of another term should trade nearly flat as was the case before summer 2007. Intuitively, the definition of the term structure of default-free rates is precisely that borrowers and lenders are indifferent between, for example 3 month money rolled over a quarter and 6 month money. However, observed money market basis swaps trade with a built-in credit premium. Credit premium built into a particular rate tenor differs from that built into another. Consider again 3 month versus 6 month rate tenors, where the credit risk of a 6 month loan is greater than that of rolling over 3 month loan for a 6 month. A probability of counterparty default is greater the longer is a tenor (Porfirio, P. & Tuckman, B., 2003). The famous liquidity preference theory by Hicks (1939) predicts that term premium have a positive relationship with time to maturity. The expected holding period yield on a long-term rate includes a higher premium than that on a medium-term rate, which includes a higher premium than on a short-term rate (Bailey, 2005). Basis swaps in the market are collateralized so that there is zero credit risk in the basis swap. Therefore it is necessary to compensate the party receiving the lower 3 month rate with a premium called basis spread between the 3 month and the 6 month legs. Since August 2008 to December 2011, the basis swap spread to exchange 3 month Euribor with 12 month Euribor over 1 year was averaged +45 basis points.

1.2 Objectives and contribution of the study

Despite the nature of basis swap spreads increase since 2007, there have been only a few studies focusing on forces driving basis swap spreads. In the economics literature, empirical papers have consisted impacts of credit risk on the pricing of swaps and most of them deal with only U.S. dollar interest rate swaps. I will now discuss shortly the results of central previous studies and then link them to contributions of this study. Finally I will present contributing factors and research problems together with the hypothesis.

Duffie, D. & Huang, M. (1996) studied that default risk contributions to swap spreads can be expected to be more irrelevant than the comparable bond credit spreads between the counterparties because the risk in a swap is lower since only net interest payments are being changed. Fehle (2002) extended the study of Duffie, D. & Huang, M. (1996) to two additional components, Libor spreads and swap market structure effect, and performed empirical analysis using a weekly panel dataset of swaps denominated in seven various currencies between 1992 and 2000. Evidence of his analysis is supportive for all the three swap spread components tested. Default risk, Libor spreads, and market structure were found significant across all swap maturities and denominating currencies, and the findings were generally robust over time. Heider et al. (2008) developed a model that could explain high unsecured rates in interbank markets, excessive liquidity needs by banks and the ineffectiveness of central banks liquidity injections in restoring interbank activity. They based their model on adverse selection problem. When the level and spillover of the credit risk is minor, the adverse selection problem is not an issue. Vice versa, when the penalty built into the interbank rate rises highly rated borrowers drop out of the market causing breakdown of the interbank market. Michaud and Upper (2008) studied Libor-OIS spread in several currencies. They found that Libor-OIS spreads moved together with measures of credit risk. In addition, they found that of the ten extraordinary liquidity management operations conducted by central bank in U.S., Libor-OIS spread declined in seven cases, while credit default swap spread on Libor panel banks declined in only five cases. In addition to Michaud and Upper, Frank and Hesse (2009) examined U.S. dollar Libor-OIS spread and effects of Federal Reserve's Term Auction Facility (TAF) on spreads. TAF is a monetary policy program used by the Federal Reserve to help increase liquidity in the U.S. credit markets during the subprime crisis. European Central Bank's long-term refinancing operations (presented in chapter 4) are quite similar than that of Federal Reserve's TAFs. Authors found out that Libor-OIS spread narrowed following the announcement of FED's TAF and the ECB's long-term refinancing operations and announced cuts in federal funds rate and ECB's discount rate.

Basis swap spreads reflect increased liquidity risk and preferences of financial institutions for receiving payments with higher frequency. I will use several variables in order to estimate what the driving forces of basis spreads are. Forces such as the debt to GDP ratio, euro area government budget deficit to GDP ratio, European Central Bank's actions, Eurobond yields, Eurobond and Euribor panel bank credit default swaps (CDS) and euro - U.S. dollar foreign exchange rate will be investigated in testing. I will present these factors in more detail in chapter 4. I will base my hypothesis partially on the results of previously conducted Libor-OIS studies. Thus, my hypothesis are that European Central Bank's liquidity providing or absorbing actions together with its key interest rate policy, Euribor panel CDS or Eurobond CDS spreads together with Eurobond yields are the core determinants of Euribor basis swap spread movements. In addition, I will consider euro – U.S. dollar foreign exchange rate as a factor providing information about current macroeconomic state of euro area. I will specify my hypothesis further in chapter 4, where I present descriptive statistics and compare each variable with respect to 3M vs. 12M Euribor basis swap spread with 2 year and 5 year maturities. Contributions of various regressors will be examined in chapter 6 using linear regression model, and co-integration tests of Engle-Granger and Johansen. First, I studied whether all datasets are stationary or not, using unit root test. Then, I estimated linear regression model for log-differentiated data, using OLS estimation. As a second test procedure I decided to study both long- and short-run relations between dependent and independent variables and conducted co-integration tests of Engle-Granger and

Johansen. Finally, I estimated error correction models. The methods applied in the study, can be found from chapter 5.

Based on the background information presented, the present study addresses the following research questions: Why does the basis spread exist in markets in aftermath of financial crisis? What are the main driving forces behind Euribor basis swap spreads? Is it solely the liquidity or credit risk that causes such wide basis spreads? Does a long-run relation exist between Euribor basis swap spread and any explanatory factors?

2 CHARACTERISTICS OF OVER-THE-COUNTER MARKET AND EURIBOR BASIS SWAPS

This chapter will introduce Euribor basis swap, one of the basic plain vanilla swap instruments in over-the-counter (OTC) market. First, will be explained the functionality and importance of over-the-counter market regarding hedging purposes to banks, other financial institutions and firms. Secondly, the structure of Euribor basis swap will be explained in more detail. Finally, the pre- and post-crisis state of markets and quotations of Euribor basis swaps will be pointed out.

2.1 Over-the-counter markets

The total trading volume measured on over-the-counter market indicates that over-the-counter market has become an important alternative to trading in exchanges (Hull, 2006. 2 – 3) The Bank for International Settlements has collected data from over-the-counter markets since 1998. Reflecting these figures it can be concluded that the outstanding over-the-counter market had grown to approximately twelve times greater than the world gross product, which was approximately USD 65 trillion in first half of 2011. Options on foreign interest rates and foreign exchange are the most popular products of over-the-counter markets (Hull, 2006. 199).

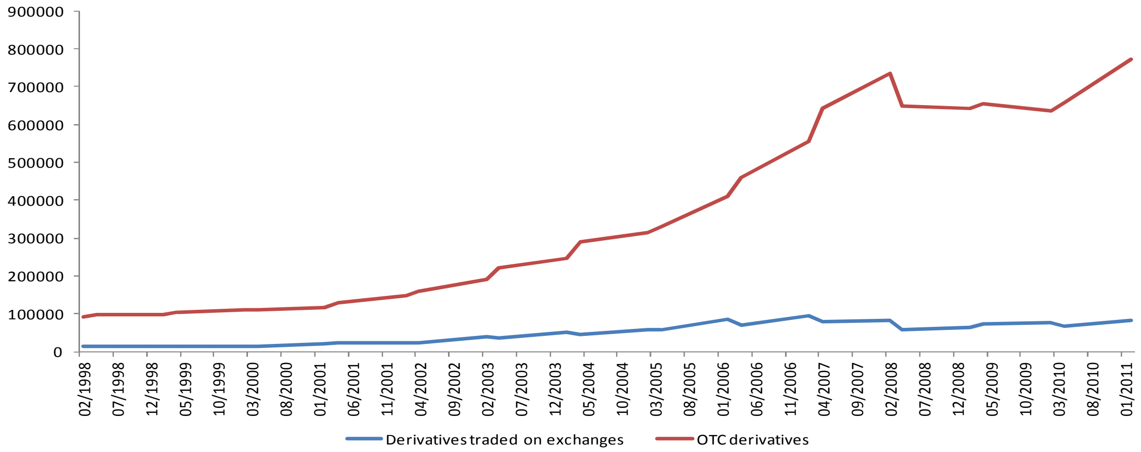

Figure 2.1 Notional amounts of outstanding derivatives in exchange market and over-the-counter market

Over-the-counter market is a telephone- and computer-linked network of dealers. Trades are done through telephone or computer without meeting counterparties face to face. Trades in these markets are usually done between two counterparties, for example between financial institutions or financial institution and one of its clients such as corporate treasurer or fund manager. Financial institutions usually act as market makers in these markets. Thus they should be prepared to quote both bid and ask price anytime. (Hull, 2006. 2 – 3)

Trades in over-the-counter market can be much larger than trades in exchange-traded market. Terms of a contract in over-the-counter market do not have to be those specified by exchange market. The instruments are often structured by financial institutions to meet the needs of their clients. These may involve choosing exercise dates, strikes, barriers or more specific structures than in standard puts and calls. (Hull, 2006, 198 – 199) More complex options are sometimes referred to as exotic options.

Most significant disadvantage of an over-the-counter market is that counterparty may default prior to expiration of the contract and will be not able to make the required payments. For example, counterparty B may default prior to expiration which exposes counterparty A to default and counterparty risk if A has currently a positive net present value (NPV). To cover counterparty risk for example in a basis swap contract, counterparties usually have contracted credit support annex (CSA) which requires counterparties to post collateral. At every margination date, the two counterparties check the value of the portfolio of mutual over-the-counter transactions adding to or subtracting from the collateral account the corresponding mark to market variation with respect to the preceding margination date (Binchetti & Carlicchi, 2011). The posted collateral amount is available to the creditor (positive NPV) while the debtor receives an interest on the collateral amount that it has posted. Credit support annex is a part of an International Swaps and Derivatives Association (ISDA) Master Agreement for transactions in over-the-counter market. ISDA is the drafting of confirmations between two representative swap counterparties that consist of clauses defining terminology used in swap agreements and what happens in the event of default. Actual credit support annex provide many other detailed features that are out of the scope of this study. The recent credit crunch has effected increasingly to number of collateral agreements (Binchetti & Carlicchi, 2011).

As mentioned in previous paragraph, counterparty A is exposed to a counterparty risk if it has currently a positive market value (NPV(A)>0) in a basis swap contract, then counterparty A expects to receive future cash flows from counterparty B. This can be considered like counterparty A has a credit with counterparty B. Mutually if counterparty B has negative market value (NPV(B)<0), then it expects to pay future cash flows to counterparty A. This can be considered like counterparty B has debt with counterparty A. In this case if the counterparty B defaults then the counterparty with positive market value can lose a large proportion of its hedge. Counterparty with positive market value might have to replace its hedge at current market conditions and prices which are less favorable than in the initial hedge. To reduce the counterparty risk associated with the risk of losing positive market value in the basis swap contract can be mitigated through a guarantee, called collateral agreement or credit support annex (CSA). Counterparty with positive market value can call collateral from other counterparty according to credit support annex. (Binchetti & Carlicchi, 2011)

2.2 Euribor basis swap

In a basis swap two different floating reference rate cash flows are exchanged (Hull, 2006. 698). In a case of Euribor basis swap there can be for example cash flow exchanges between 3 month Euribor and 12 month Euribor. A basis swap is widely used for risk management purposes among market participants (Hull, 2006. 698). Basis swap markets are available for financial institutions, banks and their clients (firms). Usually these markets are not available for private customers as notional principal of these hedges can be millions of euros. The principal itself is not exchanged in a single-currency basis swap that is why it is called notional principal (Hull, 2006. 151). Basis swaps are generally only by market professionals such as financial institutions whose assets and liabilities are dependent on different floating rates (Flavell, 2002. 137).

In order to understand how Euribor basis swap can be used to hedge underlying cash flows, Figure 2.2 illustrates the simplified process and reasoning to enter into Euribor basis swap in a case of credit institution, which operates in granting loans to municipalities and non-profit making companies and raises funds by issuing bonds. First consider the credit institution, which issues in a principal of 10 million euros floating rate note (FRN) with five year maturity, which has a variable coupon fixed at the beginning of each coupon period, for example quarterly. On a floating rate bond, interest is fixed at the beginning of the period to which it will apply and is paid at the end of the period (Hull, 2006. 152). In this case the floating rate is 3-month Euribor without margin. In a second stage financial institution grants a 10 million euros loan for five years to a customer that is willing to take the loan in 12-month Euribor + 70 basis points (bps) margin where rate is fixed annually at the beginning of the period to which it will apply and is paid at the end of the period. Margin is the current pricing framework used by financial institution when granting a new credit to a customer. What happens at a third stage, is that a financial institution enters into Euribor basis swap with five year maturity since it is exposed to a basis risk for the next five years.

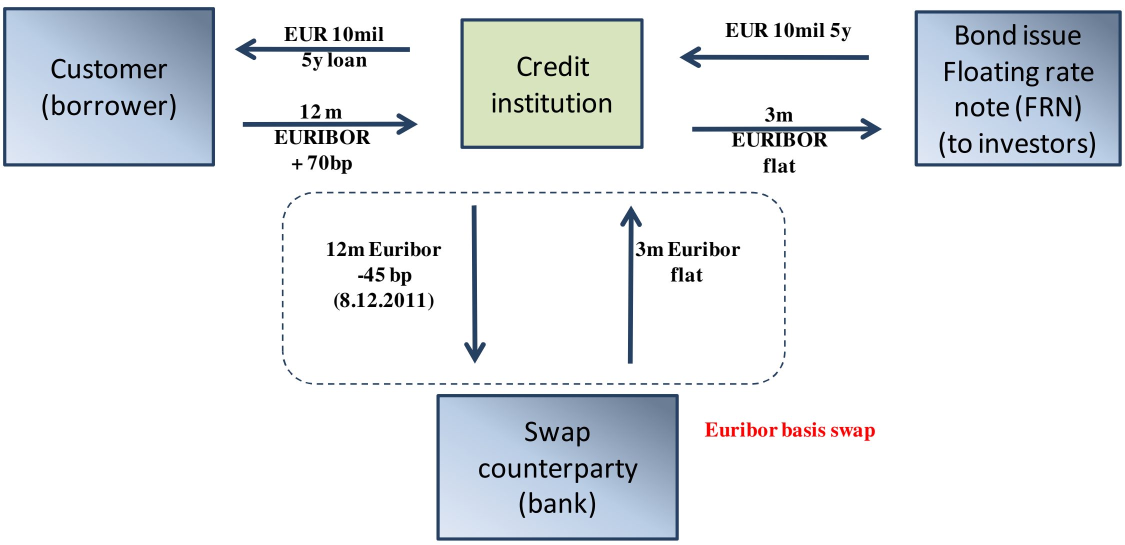

Figure 2.2 Cash flows in a 3m Euribor vs. 12m Euribor basis swap contract

Basis risk is the exposure to change in basis, which is defined as difference between spot and futures prices in the futures market (Saber, 1994. 109). In other words basis risk is the risk that yields on assets and costs on liabilities are based on different rates and different rates will move in different directions. In the worst case scenario, the credit institution is paying higher funding cost and receiving lower interest yield from its lending. To hedge against basis risk, the credit institution decides to net its cash flows and enter into Euribor basis swap. Basis swaps can be seen as locking levels for forward basis risk (Sadr, 2009. 71).

To go back to the third stage and Figure 2.2, in Euribor basis swap, credit institution receives 3 month Euribor without margin from swap counterparty and swap counterparty receives 12 month Euribor minus 43 basis points (spread) from a credit institution. It is worthwhile to notice that actually in the current pricing framework, credit institution is making a profit of +115 basis points as it is receiving 70 basis points margin across the market level from lending and paying 45 basis points funding cost below the market level. This calculation though is based only on current situation, meaning that if underlying rates will shift, then the case is different. The quoted price of basis swap is called spread. Market quotes of basis swaps are based on expected future difference between the two floating rate indexes (Sadr, 2009. 71). As quoted price of basis swap or spread may fluctuate in the markets it is also reasonable to consider perfect timing to enter into a basis swap. That is why it is essential to try to understand factors behind the basis movements.

Usually financial institutions do swaps with several customers like credit institutions or non-financial companies and are basically entering into offsetting swap transactions with two different customers. Financial institutions such as J.P. Morgan and Goldman Sachs have an important role in acting as intermediary since customers like a credit institution or non-financial company, do not get in touch directly to arrange a swap with each other. Neither it is likely that two different customers willing to take offsetting swap transactions are contacting a financial institution at the same time. For this reason financial institution also act as market maker which means that they are prepared to enter into a swap without having offsetting swap with another counterparty. Plain vanilla basis swaps are usually structured so that the financial institution earns about 3 or 4 basis points on a pair of offsetting transactions (Hull, 2006. 153 – 154). In Euribor basis swaps contracted for example with swap counterparty in Figure 2.2 this would mean that credit institution would be paying actually 12 month Euribor minus 43 basis point although it is quoted at 45 basis point at markets.

2.3 Markets and quotations for Euribor basis swaps

Basis swaps are quoted on the euro interbank market in terms of the difference between two swaps with the same fixed legs, for example 12 month tenor, and floating legs paying 3 month Euribor and 6 month Euribor in the case of 3 month versus 6 month Euribor basis swap. The frequency of the floating legs is the tenor of the corresponding Euribor rates. The Euribor rate is the reference rate for over-the-counter transactions in the euro area and is defined as the rate at which euro interbank Deposits are being offered within the European Monetary Union zone by one prime bank belonging to the panel to another bank belonging to the panel at 11:00 a.m. Brussels time. The Panel is composed currently of 42 banks selected among the European Union banks with the highest volume of business in the euro zone money markets. In addition, there are some large international banks from countries that are not members of the European Union with important euro zone operations. Thus Euribor rates are reflecting the average cost of funding of banks in the interbank market. During the crisis, the solvency and solidity of the banking sector was questioned and the credit and liquidity risk and premiums associated with interbank counterparties sharply increased. The Euribor rates immediately reflected these dynamics and raise to their highest values on October 2008. (Binchetti & Carlicchi, 2011)

As we can see from Figure 2.3, the basis swap spreads were actually even not quoted before the crisis. However, they suddenly increased in August 2007 as the first signs of the turmoil to follow appeared in US. mortgage loan markets. This was just a start and basis spreads peaked after 15th September 2008 when Lehman Brothers defaulted. According to Figure 2.3, there is a structural change in markets after Lehman Brothers crashed. Uncertainty started to reach the market already after U.S. the mortgage loan crisis. The basis swap involves a sequence of spot and forward rates carrying the credit and liquidity risk. Differences between different rate tenors and their forward rate agreements are primarily based on market's forecast of future credit spreads fixed by supply and demand dynamics (Sadr, 2009. 71). In times of good financial health basis spreads run around zero but in times of financial turmoil those can easily explode (Sadr, 2009. 71). Thus the basis spread explosion can be interpreted in terms of the different credit and liquidity risk carried by the different underlying Euribor/Libor rate tenors. From Figure 2.3 it can be seen that after the crisis burst market players have had a preference for receiving floating rate payments with higher frequency, for example quarterly indexed to Euribor 3 month, with respect to floating payments with lower frequency, for example annually indexed to Euribor 12 month and pay a premium for the difference (Binchetti & Carlicchi, 2011).

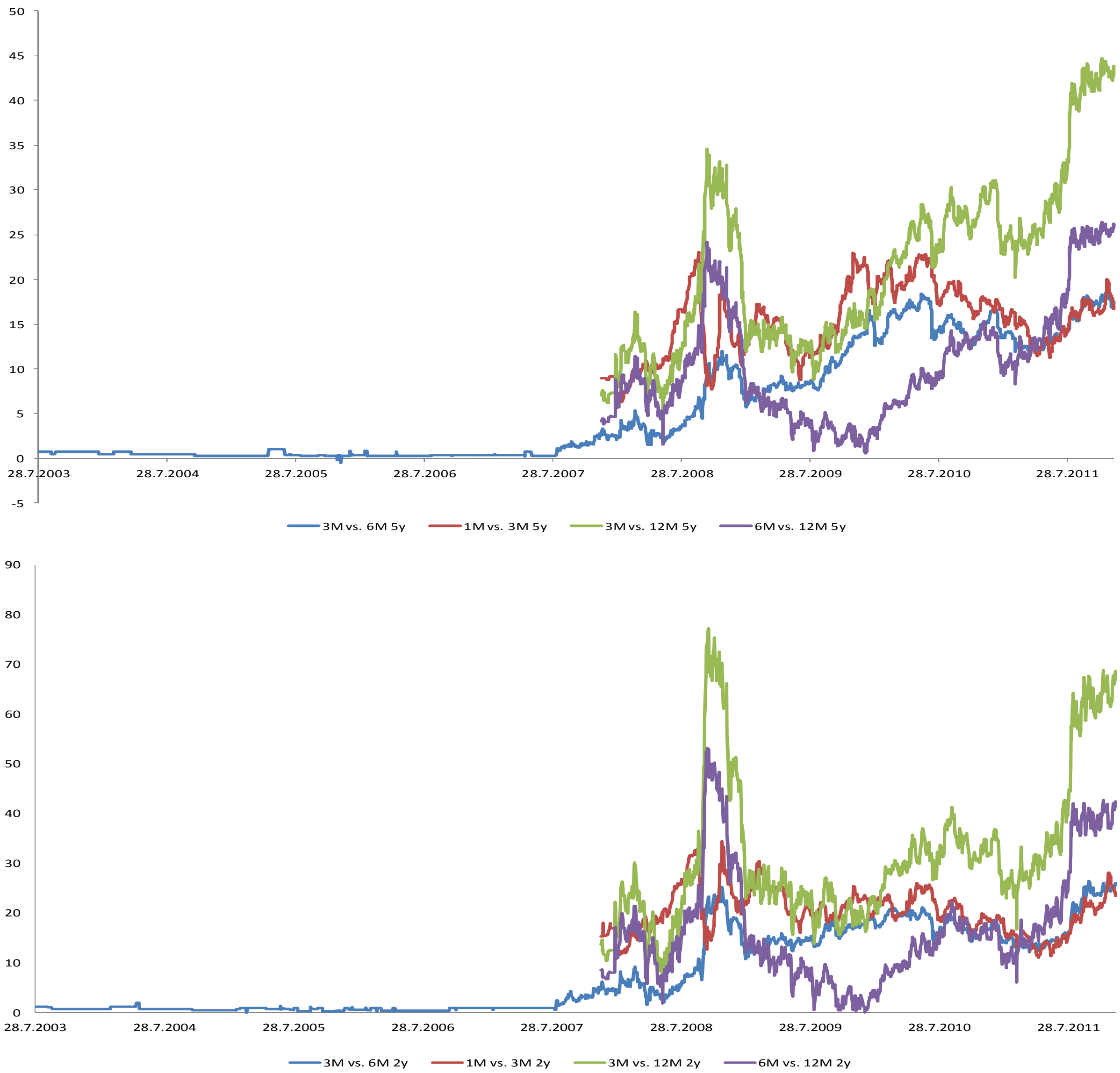

Figure 2.3 Daily observations of Euribor basis swaps with two and five year maturities of different rate tenors from 28th July 2003 to 8th December 2011

In Figure 2.4 is a snapshot of the market quotations as of 8th December, 2011 for the four Euribor basis swap term structures corresponding to the four Euribor tenors 1 month, 3 month, 6 month and 12 month. As one can see, in time interval of 1 year to 30 year the basis spreads are monotonically decreasing from 95 to around 8 basis points.

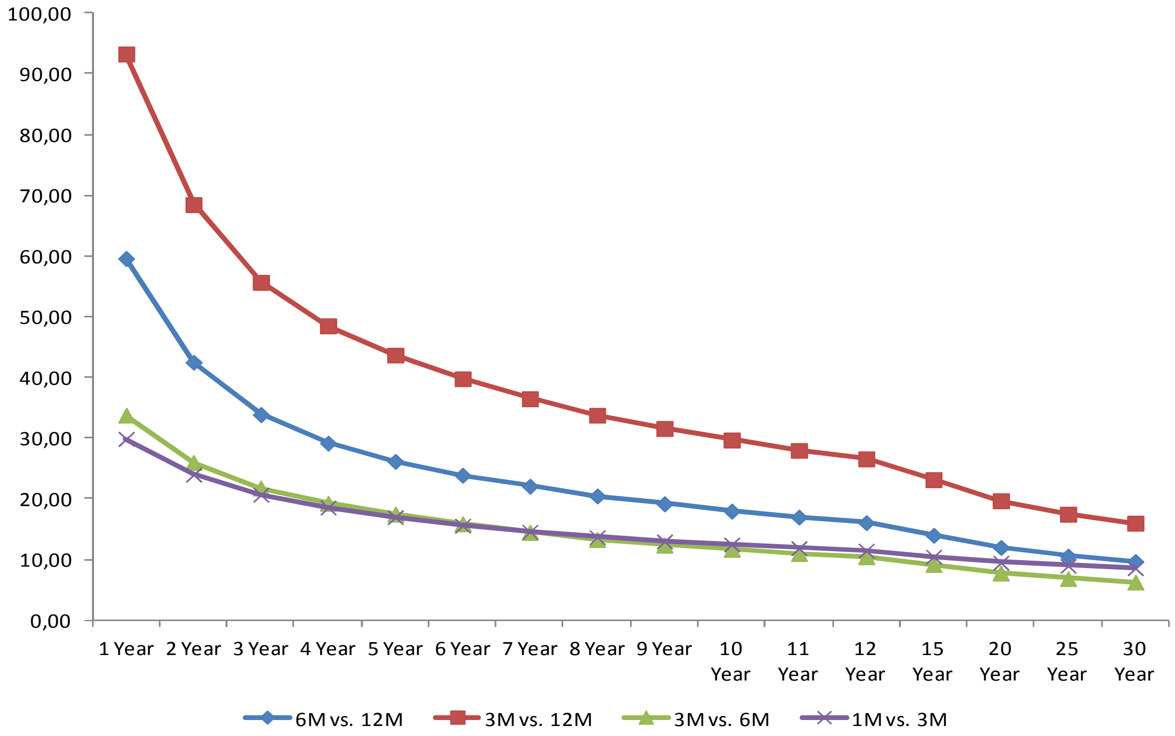

Figure 2.4 Euribor basis swap spreads for different rate tenors and maturities from 1 year to 30 years for value 8th December 2011

High basis spreads reflect the higher liquidity risk encountered by financial institutions and the corresponding preference for receiving payments with higher frequency for example, quarterly instead of annually. Monotonically decreasing feature of Euribor basis swap spreads indicate that in a longer time interval, for example after 20 years basis spreads are approximately between 10 and 20 basis points according to current expectations. Thus in a long-run spreads are expected to narrow.

3 PRICING AND VALUATION FRAMEWORK OF EURIBOR BASIS SWAPS

In this chapter I will first concentrate on two different basis swap valuation methods used commonly in finance and economics course literature. Then I shortly present the pre-crisis single-curve and post-crisis multi-curve adaptation for pricing and valuation basis swaps.

It might seem strange that basis swaps exist because an imaginary basis swap to exchange the default-free rate of one term for the default-free rate of another term should basically trade flat. This is the case because the compounded shorter-term rate must equal the longer-term rate and the arbitrage-free difference (spread) between these two should be zero. (Sadr, 2009. 73)

According to no-arbitrage condition the definition of the term structure of default-free rates is precisely that borrowers and lenders should be indifferent between 3 month money rolled over one year and 12 month money, otherwise there is arbitrage. Observed money market basis swaps exchange rates with a built-in credit premium, which is called basis spread. More precisely the credit premium built into one rate index differs from that built into another. For example, the credit risk of a 12 month loan is greater than that of rolling over 3 month loans for a year. The credit exposure is very important in a basis swap in which for example 3 month Euribor is exchanged to 12 month Euribor, namely the swap counterparty (bank) will make four quorterly payments before it gets its annual receipt. However with collateralization the two legs have both zero counterparty risk. A positive spread must be added to the 3 month leg to reach equilibrium in this context. For example in the Euribor basis swap without any counterparty default risk, 3 month Euribor plus a spread is fair against 12 month Euribor or other way around 3 month Euribor against 12 month Euribor minus a spread. In a basis swap, counterparties do not bear any credit risk built into the rates. They are only investigating the values of cash flows and comparing those of one certain rate against the value of another rate. (Tuckman & Porfirio, 2003)

In addition basis spreads are representing the relative supply and demand in the two cash markets, namely their liquidities and the inherent credit exposure (Flavell, 2002. 137). Liquidity risk may appear in at least three circumstances:

1. Lack of liquidity to cover short term debt obligations thus running short euros.
2. Lack of ability to liquidate assets thus run trading in a illiquid market with excessive bid-offer spreads.
3. Lack of possibilities to borrow funds on the market due to excessive funding cost in the illqiud market. (Acerbi & Scandolo, 2007)

These three elements cause serious problems if they appear together simultaneosly. This is because a bank facing, for example, problem 1 and 2 will be still able to finance itself by borrowing funds on the market but if all three occurs simultaneosly then a bank is not able to finance itself anymore. In the beginning of the recent crisis these three scenarios occurred jointly at the same time generating a systemic lack of liquidity (Michaud & Upper, 2008).

When first initiated, an interest rate swap is worth zero or close to zero. After it has initiated and it has existed for some time its value might have become positive or negative depending on how underlying interest rates have evolved. There are two common valuation approaches to interest rate swaps. The first valuation is based on differences between two bonds and the second is based on portfolio of forward rate agreements (FRAs). (Hull, 2006. 161) There does not necessarily exist forward rates in the markets for all different tenors. However any partcular forward curve can be constructed from each of the basis swap curves, using the Euribor/Libor forward curve, Euribor/Libor discount factors and swap rates (Flavell, 2002. 137). Forward rates indicate future expectations of the current expected development paths of short-term interest rates. For example, forward rate of 3x6 indicates what is the current expectation of the level of 3 month rate fixed after 3 month for the next 3 month period.

Figure 3.1 presents 3 month Euribor forward curve and 6 month Euribor discount curve. 12 month Euribor forward curve can be derived from 3 month forward curve and 3 month vs. 12 month Euribor basis swap spreads by adding these two together. Markets generate 12 month Euribor forward curve along with this manner. Respectively, 3 month vs. 12 month Euribor basis swap spread could be derived using 6 month discount curve plus 6 month vs. 12 month Euribor basis swap spread minus 3 month forward rate. Yield curves are structured using cash rates, spot forward rate agreements (or alternatively futures) and swap rates.

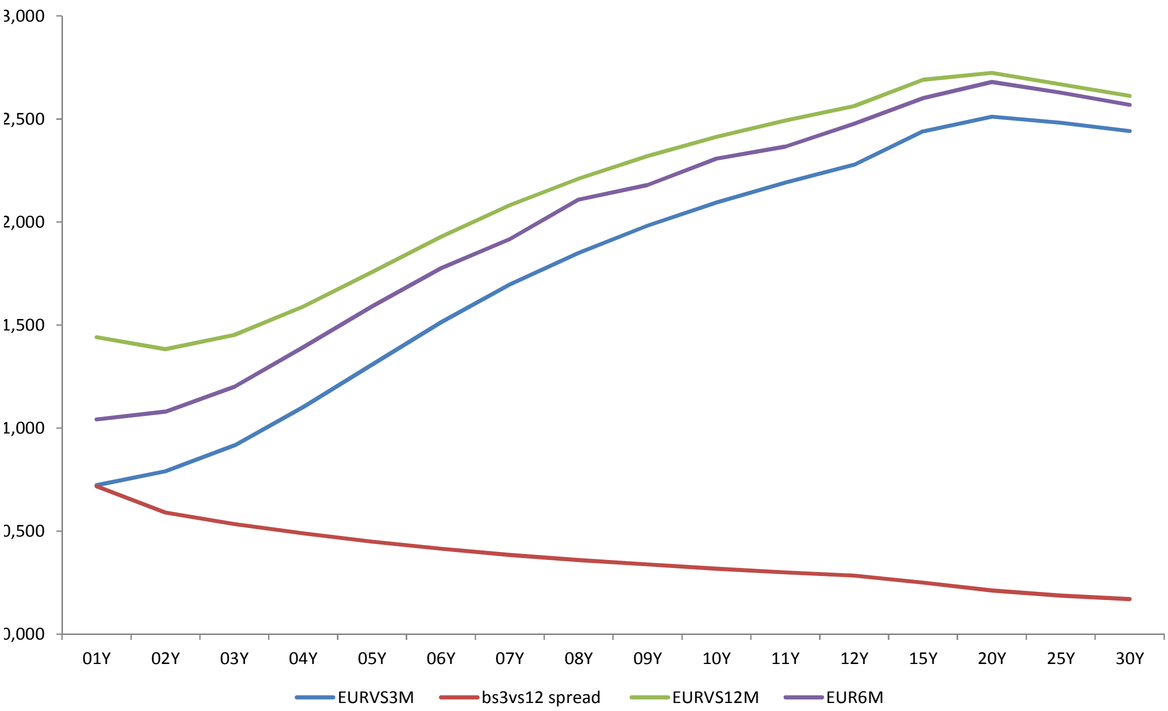

Figure 3.2 Forward and discount curves used in valuation and pricing for 1 year maturity to 30 year maturity. Curves were generated using 30th March 2012 quotations.

Figure 3.2 illustrates the curve structures of 3 month forward curve and 6 month discount curve.

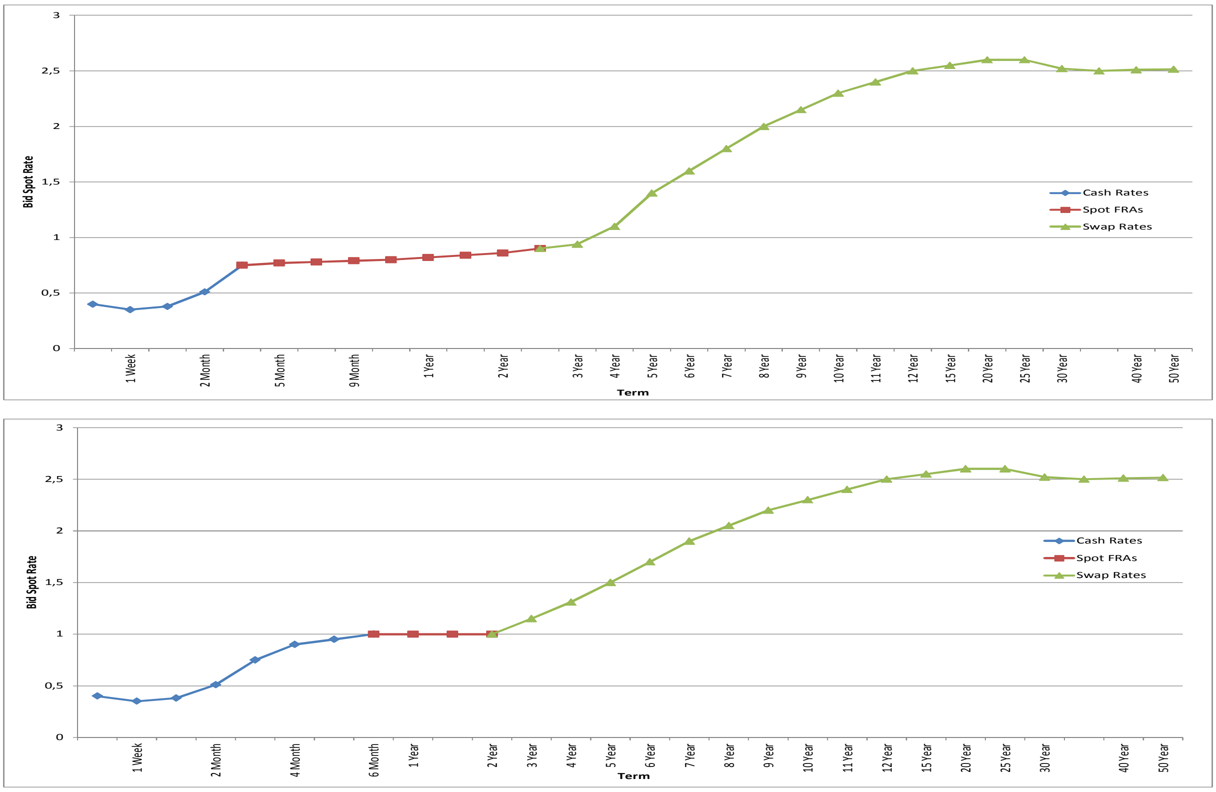

Figure 3.3 Structure of forward and discount curves for 50 years. Curves were generated using 30th March 2012 quotations.

For example in upper figure, curve from t_0 to 3 month is constructed from Euribor rates, curve from 3 month to 2 year using futures or forward rate agreements and 2 year onwards using swap rates. 6 month discount curve is constructed applying similar methods.

3.1 Valuation in terms of bond prices

From the point of view of the 3 month floating rate payer, a swap can be regarded as a long position in a 12 month floating rate note and a short position in a 3 month floating rate bond and of course vice versa from the point of view of the 12 month rate payer. Thus for 3 month payer

$$V_{SWAP} = B_{12m} - B_{3m} \tag{3.1}$$

Now V_{SWAP} is the value of the swap and B_{3m} is the value of payments made in 3 month floating rate leg and B_{12m} correspondingly the value of payments received 12 month floating rate leg. Floating rate bonds are worth the notional principal immediately after interest payment date that is $B_{fl} = L$. On the other hand immediately before the interest payment date B_{3m} or B_{12m} is equal to notional principal, *L*, plus floating payment, *k*. Thus discounting these gives us the value of both floating rate notes separately:

$$(L+k^{*})^{-r^{*}t^{*}} \tag{3.2}$$

in which r^* is the Euribor or swap zero rate for maturity of t^*. (Hull, 2006. 161 – 162)

3.2 Valuation in terms of forward rate agreements (FRAs)

Alternatively swap valuation can be and is generally done by using portfolios of forward rate agreements (FRAs). Consider the 3 month versus 12 month Euribor basis swap between a credit institution and a swap counterparty (bank) with five year maturity. The first exchanges of cash flows are known at the time the swap is negotiated but in the case of 3 month leg forthcoming nineteen exchanges and in the case of 12 month leg four exchanges can be regarded as forward rate agreements. Thus a plain vanilla interest rate swap can be regarded as a portfolio of forward rate agreements, by assuming that forward interest rates are realized and are used as discount factors for the cash flows. (Hull, 2006. 163)

At the outset of the swap the sum of values of the forward rate agreements underlying the swap should be zero (Hull, 2006. 164). Let us assume that there are risk-free interest rates $r_{tenor}(t)$ quoted by default-free banks for 3 month and 12 month at $r_{3m}(0)$ and $r_{12m}(0)$. Now the question is what should be the forward rates to be used for 3x6, 6x9 and 9x12 if it is assumed that banks are default-free. Then we can buy 3x6, 6x9 and 9x12 forward rate agreements with the corresponding prices of X_{3x6}, X_{6x9} and X_{9x12}, borrow at $r_{3m}(0)$ for the first three months and roll it over quarterly, pay the principal and interest $((1 + r_{3m}(0)/4))$ in every 3 month with the principal and interest financed by a new loan at the current 3 month rate, $r_{3m}(3m)$ and invest the amount for next 12 months. In 12 months cash flows can be expressed in forms of the following equations:

$$(1 + r_{3m}(0)/4)\times(1 + r_{3m}(3m)/4)\times(1 + r_{3m}(6m)/4)\times(1 + r_{3m}(9m)/4), \tag{3.3}$$

which express cash flows we need to pay from successive loans. Equation 3.4 express reinvested payoff of the forward rate agreements one receives and equation 3.5 express received cash flows from investment as the 12 month investment matures.

$$\left(r_{3m}(3m)+r_{3m}(6m)+r_{3m}(9m)-X_{3x6}-X_{6x9}-X_{9x12}\right)/4 \tag{3.4}$$

$$1+r_{12m} \tag{3.5}$$

Finally as it cost nothing to enter these transactions, in this theoretical illustration under efficient markets, the no-arbitrage condition requires that final amounts be the same in 12-month and X_{3x6}, X_{6x9} and X_{9x12} must satisfy:

$$\left(1+r_{3m}(0)/4\right)\times\left(1+X_{3x6}/4\right)\times\left(1+X_{6x9}/4\right)\times\left(1+X_{9x12}/4\right)=1+r_{12m} \tag{3.6}$$

In normal state of the economy and under competitive markets with free-entry, above relationship should hold. However, basis swaps are bilateral agreements and thus there is a limited access to this market, which may explain why the spread is not traded away. In addition, if we are dealing with default-free or vice versa risky counterparties of the same credit worthiness, the riskiest transaction is the longest maturity loan as it has the longest possible time and greatest probability to default. Although basis swaps are collateralized, Libor (Euribor) rates embed built-in credit premia because Libor (Euribor) rates are quoted in interbank markets. Therefore in order to illustrate the existence of spread in above relationship, counterparty that is lending a 12 month, will require a rate higher than what is implied by shorter-term rates that are 3 month rate, 3x6, 6x9 and 9x12 forward rate agreements. In addition the credit spread is also adjusted further for liquidity of one rate tenor versus another tenor which can make the spreads trade negative (Sadr, 2009. 74). This is the reason why four successive 3 month forward rate agreements do not appear to equate to a 12 month forward rate agreement and the error term, which I call *spread* has to be added. Notice that *spread* term can be added either on left hand side or right hand side, but its sign is opposite. This can be formulated as:

$$\left(1+r_{3m}(0)/4\right)\times\left(1+X_{3x6}/4\right)\times\left(1+X_{6x9}/4\right)\times\left(1+X_{9x12}/4\right)=1+\left(r_{12m}+spread\right) \tag{3.7}$$

Currently in markets, the *spread* is negative in above relationship. Thus counterparty that is receiving 3 month tenor in a swap will get 3 month rate plus *spread* or vice versa pay 12 month tenor minus *spread* as noted in above relationship. Finally both cash flows are discounted using the Euribor/swap zero curve and the swap value will be obtained by subtracting.

3.3 Pricing from single-curve approach towards multi-curve approach

To evaluate Euribor basis swaps correctly counterparties have to decide what funding index or yield curve is to be used. Is the index Euribor 3 month, Euribor 6 month or Eonia, for instance. Most plain vanilla swaps have been previously indexed to unsecured interbank, Libor or in the case of euro, Euribor, rates with 6 month tenors. With the recent financial crisis the reliability of Euribor/Libor as a benchmark rate has been challenged. More focus has been put towards overnight indexed swaps –rate and in the case of euro, euro overnight indexed average (Eonia) rate as these rates are keyed to actual traded policy rates. (Sadr, 2009. 74–76) The diffusion of collateral agreements among interbank counterparties during the recent crisis has invoked the use of Eonia as a discounting rate. By no-arbitrage condition, the credit support annex (CSA) margination rate and the discounting rate of future cash flows must match. However in the case of absence of credit support annex, a bank should discount future cash flows using its own funding cost term structure (Binchetti & Carlicchi, 2011). This implies an important problem of mismatch as counterparties assigns a different present value to the same future cash flow.

In addition to response to the recent crisis the classical pricing framework based on a single yield curve used to calculate forward rates and discount factors has been abandoned. There are several papers from Amentrano, Bianchetti, Carlicchi and Morini to name but a few, focusing on pricing and hedging interest rate derivatives in pre- and post-crisis framework. As discussed in the paper of Amentrano & Bianchetti (2009) they are studying both old traditional style of single-curve market practice for pricing and hedging interest rate derivatives and the recent market practice, known as multi-curve market practice, triggered by the credit crunch crisis.

Single-curve pricing framework does not take into account neither the market information carried by the basis swap spreads that are no longer negligible nor the interest rate market that is segmented to corresponding instruments with different underlying rate tenors characterized by different dynamics. Thus, pricing and hedging an interest rate derivative on a single yield curve can make prices and hedge ratios less stable and more difficult to interpret. (Bianchetti, 2009)

Multi-curve pricing takes into account the market segmentation as empirical evidence and incorporates the new interest rate dynamics into a multiple curve framework. Discounting curves are the yield curves used to discount futures cash flows that must be constructed and selected such that to reflect the cost of funding of the counterparty, in connection with the actual nature of the specific contract that generates the cash flows. In proportion forwarding curves are the yield curves used to compute forward rates that must be constructed and selected according to the tenor of the rate underlying the actual contract to be priced. (Binchetti & Carlicchi, 2011)

In the single-curve approach a unique yield curve is built and used to price and hedge any interest rate derivative on a given currency. This is equivalent to assume that there exists a unique fundamental underlying short rate process that is able to model and explain the whole term structure of interest rates of all tenors. Single-curve approach is not guaranteed to be an arbitrage free model because discount factors and forward rates obtained from a given yield curve through interpolation method are not necessarily consistent with those obtained by a no-arbitrage model. In practice bid-ask spreads, transaction costs and limited access hide any arbitrage possibilities. (Bianchetti, 2009)

Multi-curve framework is consistent with the present market situation. However it is a much more complicated model. First, the discounting curve must be built with particular care as there is no general principle for the discounting curve construction at the moment. The forwarding curves construction is driven by the underlying rate homogeneity principle. (Bianchetti, 2009) Basically in the discounting curve construction counterparties are currently using OIS discounting or are in a transitional phase towards adaptation of it. In spite of the difference when applying either OIS or Libor is very minor, it might cause significant valuation differences when notional principals are hundreds of millions. Second, building multiple curves requires multiple quotations and thus many more bootstrapping instruments must be considered (Bianchetti, 2009). Third, appropriate interpolation algorithms are crucial to produce smooth forward curves (Bianchetti, 2009). Fourth, multiple bootstrapping instruments implies multiple sensitivities which set challenges to hedging as it becomes more complicated (Bianchetti, 2009).

4 DATA

This chapter will describe datasets that I selected implicitly to model Euribor basis swap spreads. I will explain effects of the multiple variables under investigation and the reasoning behind the selected variables. Ongoing financial crisis has proven the complexity of economy and the functionality against the theories of economics. Datasets in the study consist of Eurobond yields, Eurobond credit default swap (CDS) spreads, euro zone budget deficit to GDP, euro zone government debt to GDP, the actions of European Central Bank, the CDS spreads of Euribor panel banks and euro – U.S. dollar foreign exchange rate. Datasets consist of daily observations gathered from Bloomberg and European Central Bank Statistical Data Warehouse. I will set my hypotheses one by one in the end of each specific subchapter. Hypotheses are based on conclusions made from the descriptive statistics and figures.

I gathered the data on 8th December 2011 and the sample period is between 10th July, 2008 and 8th December, 2011 as the earliest observation was available from 10th July, 2008 for all variables used in the study. The sample period represents the period just before and from the beginning of the actual crisis to the current state of the market and consist of 879 observations. The nature of the crisis has changed during the sample period. In the very beginning, everything initiated from U.S. mortgage sector in 2007, and just one year later, the collapse of Lehman Brothers caused illiquidity and uncertainty in markets all over the world. Later the crisis has located especially to banks in euro area and to some members of European Monetary Union that have not been able to fulfil the requirements of Maastricht Treaty during their EMU membership. These countries are Portugal, Ireland, Italy, Greece and Spain (PIIGS-countries).

4.1 Euribor basis swap spread

Fiqure 4.1 presents motions of Euribor basis swap spreads over the sample period. As we can see, spreads explode when Lehman Brothers collapsed in September 2008. Later on, range has been smaller and basis swap spreads have fluctuated between zero and forty basis points. In July 2011, there was again a peak in spreads, especially in 3M vs. 12M Euribor basis swap spread with 2 year maturity. There can be many explanations for sudden change, for example European Central Bank's decision in 7th July to increase the rate of the main refinancing operations by 25 basis points. I will present the operations of European Central Bank in more detail in subchapter 4.1.5. Altogether, spreads have been progressing mostly with positive upward trend since beginning of the 2009.

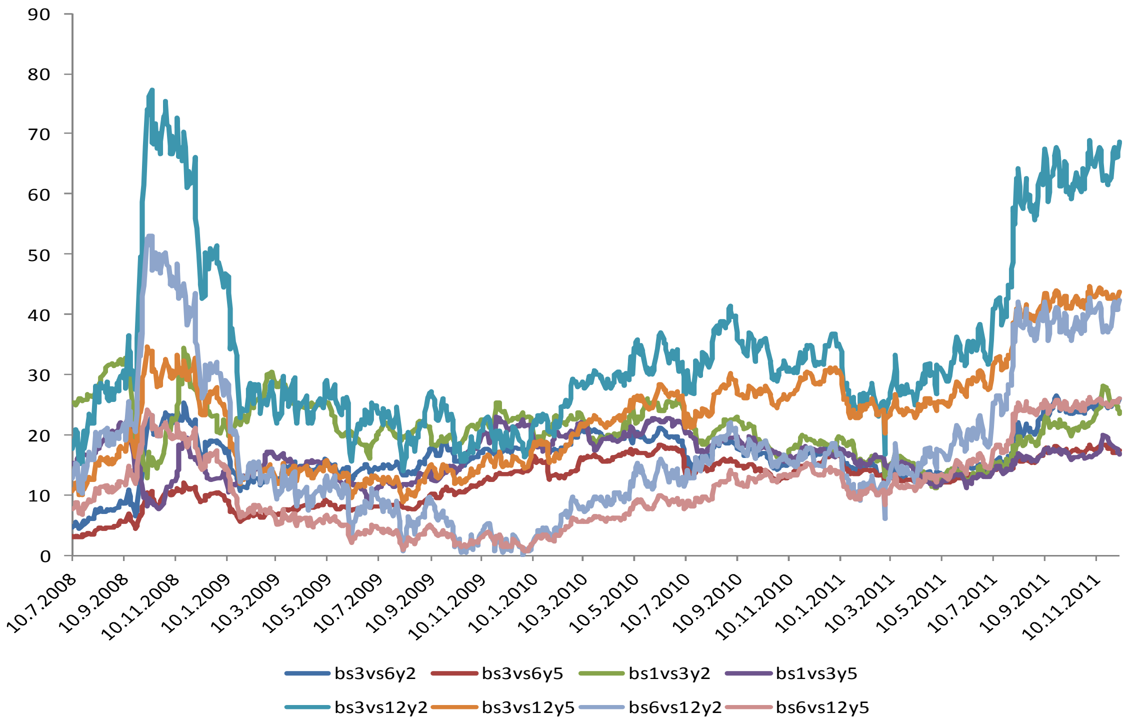

Figure 4.1 Euribor basis swap spreads from sample period (10/7/2008 – 8/12/2011)

Table 4.1 reports summary of descriptive statistics of Euribor basis swap spreads over the sample period. Means of Euribor basis swap spreads between different rate tenors and maturities ranges from 11,10 (6M vs. 12M 5y) to 34,17 (3M vs. 12M 2y) basis points and between a maximum of 77,30 (3M vs. 12M 2y) and a minimum of 0,10 (6M vs. 12M 2y) basis points over the sample period. Median ranges from 10,30 (6M vs. 12 M 5y) to 29,70 (3M vs. 12M 2y) basis points. Table 4.1 points a significant fact that means of basis spreads are lower in 5 year maturities. This may indicate that markets expect spreads to narrow more in a five year period than for example in a two year period. In addition, Table 3.2 supports the inverted slope of Euribor basis swap spread over multiple maturities. Standard deviation ranges from 3,31 (1M vs. 3M 5y) to 14,66 (3M vs. 12M 2y) basis points.

	bs3vs6y2	bs3vs6y5	bs1vs3y2	bs1vs3y5	bs3vs12y2	bs3vs12y5	bs6vs12y2	bs6vs12y5
Mean	16,64	12,26	21,00	16,31	34,17	23,36	17,53	11,10
Median	16,50	13,10	20,90	16,40	29,70	23,90	14,70	10,30
Standard Deviation	4,20	3,86	4,40	3,31	14,66	8,97	12,14	6,82
Kurtosis	0,47	-0,79	0,06	-0,60	0,52	-0,34	0,26	-0,44
Skewness	-0,13	-0,42	0,29	-0,09	1,27	0,56	1,04	0,64
Jarque-Bera	10,31	49,19	12,09	14,18	244,24	49,91	159,72	67,98
Minimum	4,40	3,10	11,10	7,70	13,90	8,80	0,10	0,60
Maximum	26,50	18,50	34,50	23,10	77,30	44,70	53,20	26,40
Count	879	879	879	879	879	879	879	879

Table 4.1 Descriptive statistics of Euribor basis swap spreads

Skewness is a measure of how symmetric or asymmetric the distribution is with respect to its mean. A value greater than zero is the degree to which the distribution is skewed in the positive direction and likewise, a value less than zero is the degree to which the distribution is skewed in the negative direction with respect to normal distribution. Kurtosis is similarly a descriptor of the shape of a probability distribution and it measures peakness of the distribution with respect to mode. A positive value, greater than +3, of kurtosis implies relatively peaked shape and flat tails of the distribution with respect to normal distribution. In proportion, distribution with kurtosis smaller than +3, implies a relatively flat distribution. Using the skewness and kurtosis of the least squares residuals the Jarque-Bera test for normality can be computed. If the data is normally distributed, chi-squared distribution with two degrees of freedom, the Jarque-Bera statistic can be used to test the hypothesis that the data is from a normal distribution. With the 5 % level of significance this means that test result have to be compared against the critical value of 5,99. Null hypothesis is that the distribution is normally distributed, which means that if test result is below critical value then null hypothesis is accepted, otherwise rejected. (Hill at al, 2001)

From Table 4.1 we can see that five of eight basis swap spreads are positively skewed to the right and the rest are negatively skewed to the left. The values of kurtosis implicate flat distributions different from the assumption of normal distribution. Neither skewness nor kurtosis supports the null hypothesis that data is normally distributed. The values of the Jarque-bera test are reported as well and they confirm the rejection of null hypothesis. Thus, Euribor basis swap spreads are not normally distributed.

4.2 Eurobond yield

In the first hand, I will regard Eurobond yield as a factor of credit risk component. However, interpretation is twofold as it may also indicate relationship with liquidity component. That is because for example every time when European central bank will buy government bonds from secondary markets in order to pull down government bond yields, it inevitably increases liquidity in markets.

I constructed Eurobond yields from market quotations of 2 year, 5 year and 10 year generic government bond indices of eleven different EMU-countries, later expressed just “country panel”. This is because there are no Eurobonds issued currently in the markets. Ongoing debt crisis in the euro area has invoked a severe discussion of Eurobonds in European Commission. There are at least three different suggestions how to implement Eurobonds, but the detailed presentation of those, are beyond the limited scope of this study. However, the basic idea in Eurobonds is according to Delpla & von Weizsäcker (2011) that they are covered by joint and several guarantee. Thus each country, each year, guarantees all the Eurobond of all other participating countries to be issued the following year. The joint and several guarantees will ensure that Eurobond would be considered even safer investment than the current benchmark bond which is the German Bund. This would mean that for example Greece would be able to borrow money with the same funding cost as for example Germany.

In order to construct Eurobond for the estimation purposes of the study, I will assume that countries belonging to country panel jointly represent the current financial state of the whole euro area economy. Thus, the weight and the current state of each member in country panel will affect to the Eurobond yield. Of course, if Eurobonds will be issued in future, the panel will cover all European Monetary Union members. Generic government bond yield reflect the current market yield quoted in markets for given government bond with given maturity. Each country belonging to the country panel has its own weight, which I derived as $GDP_{country\ panel}$

$_{member}/GDP_{Eurozone}$. For example each daily observation of generic government bond of Finland has been weighted using 2,06 % weight. Table 4.2 presents derived weights that are based on the average of quarterly gross domestic products of given panel member from 2002 to 2010.

	Austria	*Belgium*	*Finland*	*France*	*Germany*	*Greece*	*Ireland*	*Italy*	*Netherlands*	*Portugal*	*Spain*
Weight	3,36 %	4,43 %	2,06 %	21,30 %	29,35 %	2,29 %	2,24 %	16,80 %	6,18 %	2,16 %	10,11 %

Table 4.2 Members of country panel and average of quarterly gross domestic products from 2002 to 2010.

Figure 4.2 presents Eurobond yields with 2, 5 and 10 year maturities with respect to 3M vs. 12M Euribor basis swap spreads with 2 and 5 year maturities. In the uppermost is the 10 year Eurobond curve, in the middle 5 year Eurobond curve and in the bottom is 2 year Eurobond curve (take a look e.g. 10^{th} March 2010). After Lehman Brothers collapsed, bond yields with shorter maturities first decreased and then remained quite steady towards the end of 2010. During the sample period, bond yields have reflected normal, upward-sloping yield curve as bond yields with longer maturities have offered higher returns due to the risks associated with time. The liquidity theory by Hicks is one of the theories that have been presented, for what determines the term structure of interest rates. Hicks hypothesized that investors are typically risk averse and thus to induce them to hold bonds with longer maturities they must be compensated with higher rate than the average of expected future rates by risk premium that increases when maturity increases, meaning upward-sloping term structure of interest rates (Fabozzi, 1993). However, several studies have rejected the theory presented by Hicks. From the beginning of 2011, bond yields have been increasing especially in shorter maturities and as we can see from Figure 4.2 that the trend has been currently towards the inverted shape of the yield curve at least in maturities from 2 to 10 years. Inverted yield curve is rare and is often seen as a forecast of the turning points of the business cycle as well as lower interest rates in the future (Adrian et al. 2009).

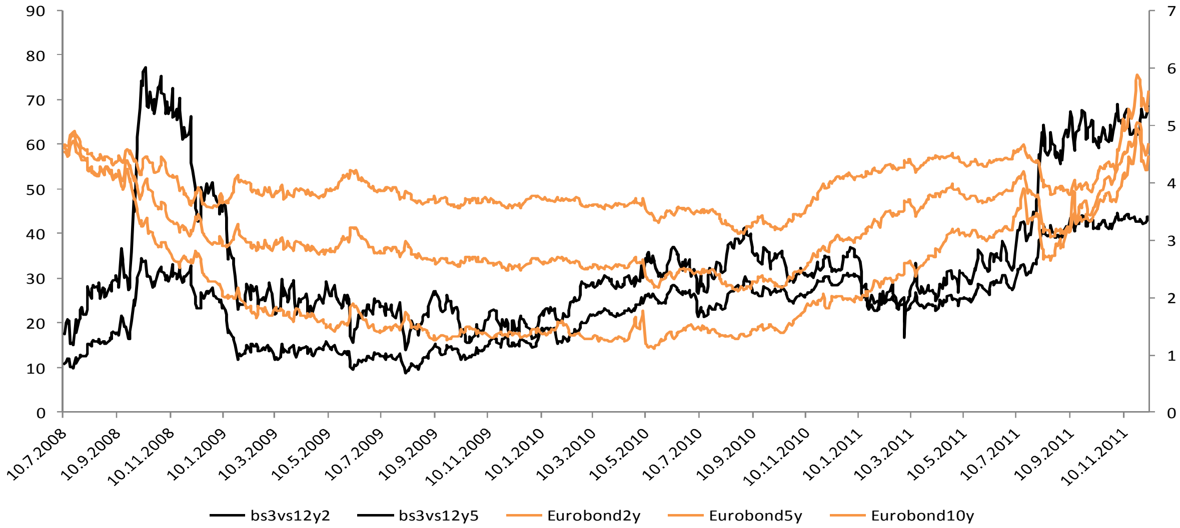

Figure 4.2 Eurobond yields (right axis) with 2 year, 5 year and 10 year maturities with respect to 3M vs. 12M Euribor basis swap spreads (left axis) with 2 and 5 year maturities. I constructed Eurobond yields from eleven different generic government bond yields that were chosen to country panel

When comparing Eurobond yields to Euribor basis swap spreads, it is noteworthy that since the breakdown of Lehman Brothers, they have moved more or less in a similar fashion, especially 2 year Eurobond yield and Euribor basis swap spread with 2 year maturity. Thus, I expect Eurobond yields and Euribor basis swap spreads to be significantly correlated. Correlation matrix presented in Appendix 1, supports the hypothesis. Two year Eurobond yield and 3M vs. 12M Euribor basis swap spreads are positively correlated in level stage with correlation coefficients of 0,50 (5 year) and 0,54 (2 year).

Table 4.3 reports summary of descriptive statistics of Eurobond yields over the sample period. Means of Eurobond between different maturities ranges from 2,27 percentage (Eurobond 2y) to 3,93 percentage (Eurobond 5y) and between a maximum of 5,88 percentage (Eurobond 2y) and a minimum of 1,10 percentage (Eurobond 2y) over the sample period. Median ranges from 1,81 percentage (Eurobond 2y) to 3,86 percentage (Eurobond 10y). Standard deviation ranges from 0,39 percentage (Eurobond 10y) to 1,06 percentage (Eurobond 2y) reflecting the fact that short-term rates are more volatile.

	Eurobond2y	*Eurobond5y*	*Eurobond10y*
Mean	2,27	3,10	3,93
Median	1,81	2,95	3,86
Standard Deviation	1,06	0,63	0,39
Kurtosis	0,41	-0,41	-0,64
Skewness	1,12	0,67	0,26
Jarque-Bera	188,10	71,71	24,61
Minimum	1,10	2,11	3,10
Maximum	5,88	4,94	5,05
Count	879	879	879

Table 4.3 Descriptive statistics of Eurobond yields

From Table 4.3 we can see that each Eurobond is positively skewed to the right end. The values of kurtosis below three implicate flat distributions different from the assumption of normal distribution. Neither skewness nor kurtosis supports the null hypothesis that data is normally distributed. The values of the Jarque-bera test as well, confirm the rejection of null hypothesis. Thus, Eurobond yields are not normally distributed.

4.3 Eurobond credit default swap (CDS) spread

I will regard Eurobond credit default swap as a factor of credit risk component. Previously conducted studies on Libor-OIS spread by Frank and Hesse (2009), Michaud and Upper (2008) and Heider et al. (2008) supports this assumption.

I constructed Eurobond CDS spreads from market quotations of 5 year and 10 year mid-market credit default swap spreads similarly from eleven different EMU-countries CDS spreads as Eurobond yields were constructed in previous subchapter. Neither Eurobond yields nor Eurobond credit default swaps are available currently in the markets. Credit default swaps with 2 year maturity were available only for Estonia, Slovakia and Slovenia and for that reason 2 year Eurobond CDS was not constructed. In order to construct Eurobond CDS for the estimation purposes of the study, I assumed that countries belonging to country panel jointly represent the current credit default risk of the euro area economy. Thus, the weight and the current state of each member in country panel will affect to the Eurobond CDS spread similarly as was the case with Eurobond yields.

A credit default swap (CDS) is a contract that provides insurance against the risk of a default by underlying entity such as a company, bank or government. Thus, a CDS can be used to hedge a position in a government bond, for instance. However, this requires that there is credit default swaps issued in the markets for the particular government bonds. The buyer of a credit default swap has right to sell bonds issued by the underlying entity for their face value (notional principal) if the financial entity defaults that is credit event occurs. The buyer of the credit default swap makes periodic payments, for example 360 basis points annually of notional principal to the seller until the end of maturity of the CDS or until a credit event occurs. In case of default by underlying entity, the buyer has either right to sell bonds issued by defaulted underlying entity with a face value or if the contract requires cash settlement, an independent calculation agent will poll dealers to determine mid-market value of the cheapest deliverable bond. The percent of the notional principal that is paid per year is known as the CDS spread. Market makers are quoting credit default swaps as bid and offer on CDS spreads, for example a new 5 year credit default swap on euro area government bond might bid currently 357 basis points and offer 367 basis points according to Figure 4.3. The n-year CDS spread should be approximately equal to the excess of the par yield on an n-year risky bond, for example government bonds of Greece, over the par yield on an n-year risk-free bond, that is for example German government bond. If the spread between risky and risk-free government bond yields are significantly higher than CDS spread, an investor can earn more than the risk-free rate by buying the risky bond and buying a protection. Conversely, if CDS spread is significantly higher than spread between risky and risk-free bond yields, an investor can borrow at less than the risk-free rate by shorting the risky bond and selling CDS protection. (Hull, 2006, 507 – 509)

Figure 4.3 presents the graph of the constructed Eurobond CDS spreads over the sample period. It is noteworthy that 5 year and 10 year Eurobond CDS spreads both, move along approximately similar paths and there are no significant difference between the two spreads. In addition, compared to Eurobond yields (Figure 4.2) the Eurobond CDS spreads have increased relatively more than Eurobond yields. The movements of CDS spreads indicate that the “term structure” of CDS spreads have been almost flat as the difference between 10 year and 5 year CDS spread has been on average 2,79 bps. However, from the beginning of September to mid September 2011 the difference was temporarily negative, although recovering later back into positive. Negative differences between spreads indicate inverted “term structure” accompanied by higher risks on the short-end. Causes for the movement are difficult to analyze but to name a one potential factor, there was announcement of European Commission, European Central Bank and IMF joint team that had been discussing recent economic developments and reviewing policy implementation in the context of the fifth review of Greece's economic program (ECB, 2011). The economic program of Greece consists of financial support provided by the euro area Member States and the IMF to Greece in the context of a sharp deterioration of its financing conditions (European Commission, 2011).

The Eurobond CDS spreads started to rise after Lehman Brothers crashed and problems started in the banking sector when the confidence suddenly disappeared. However, the ongoing debt crisis, the core of the euro area crisis, initiated from Ireland. The state of Ireland had guaranteed the six main Irish-based banks that had financed a real estate bubble in Ireland (Wikipedia, 2012). Irish banks had lost an estimated EUR 100 billion related to defaulted housing loans in the midst of the property bubble, which burst 2007 (Wikipedia, 2012). In the second quarter of 2009, Eurobond CDS spreads started to slightly decrease and remained somewhat steady until the sudden increase again in April 2010. In April 2010, Standard & Poor’s downgraded Greek’s debt ratings below investment grade to junk bond status, Portuguese debt two notches and issued negative outlook, which is a warning that further downgrades are likely, and finally downgraded ratings of Spanish bonds from AA to AA- (Wikipedia, 2012). In May 2010, concerns about the ability of the euro zone to deal with a spreading crisis effectively caused a severe market reaction and volatility continued to accelerate with a major widening in for example U.S. dollar - Euro currency spread.

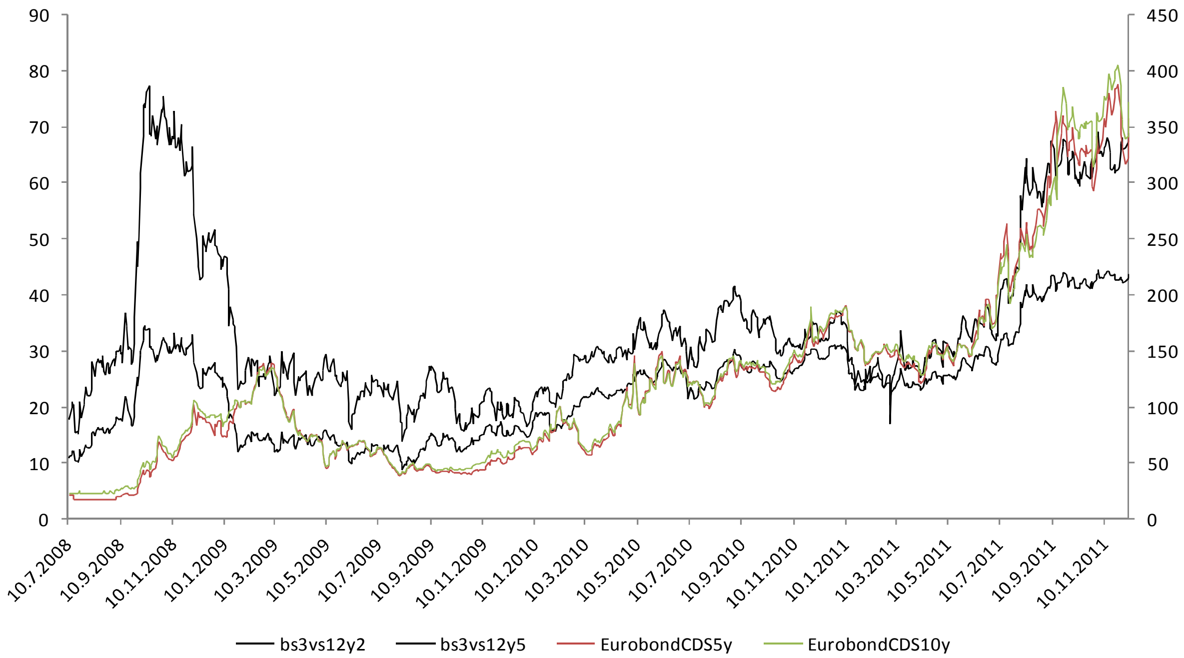

Figure 4.3 Eurobond credit default swap (CDS) spreads (right axis) with 5 year and 10 year maturities constructed from eleven different sovereign CDS spreads that I selected to country panel with respect to Euribor basis swap spread with 2 and 5 year maturities

When comparing Eurobond CDS spreads to Euribor basis swap spreads, it is noteworthy that the breakdown of Lehman Brothers had somewhat lagged effect on Eurobond CDS spreads. According to Figure 4.3, after the first quarter of 2009, they have moved significantly in a similar fashion, especially with Euribor basis swap spread with 2 year maturity. Thus, I expect Eurobond CDS spreads and Euribor basis swap spreads to be significantly correlated and will consider this factor as a credit risk component in my empirical test. Correlation matrix presented in Appendix 1, supports the hypothesis. Both Eurobond CDS spreads and 3m vs. 12m Euribor basis swap spreads are positively correlated with correlation coefficients of 0,84 (5 year) and 0,60 (2 year).

Table 4.4 reports summary of descriptive statistics on Eurobond credit default swap spreads over the sample period. Means of Eurobond CDS spread between 2 year and 5 year maturities ranges from 120,64 bps (Eurobond CDS 5y) to 123,42 bps (Eurobond CDS 10y) and between a maximum of 405,67 bps (Eurobond CDS 10y) and a minimum of 18,26 bps (Eurobond CDS 5y) over the sample period. Median ranges less from 104,01 bps (Eurobond CDS 5y) to 104,78 (Eurobond CDS 10y). Standard deviation ranges from 83,36 bps (Eurobond CDS 5y) to 85,02 bps

(Eurobond CDS 10y). Results support the theory that credit default risk is higher with longer maturities, reflecting higher CDS spread in 10 year maturity. In addition, 10 year CDS was more volatile than 5 year CDS, which supports the basic market observation that the price and yield of existing long maturity bonds are influenced far more by the effect of changes in interest rates and inflation expectations, which make them more volatile.

	EurobondCDS5y	*EurobondCDS10y*
Mean	120,64	123,43
Median	104,01	104,78
Standard Deviation	83,86	85,02
Kurtosis	1,42	2,02
Skewness	1,34	1,50
Jarque-Bera	336,36	474,95
Minimum	18,26	23,74
Maximum	388,56	405,67
Count	879	879

Table 4.4 Descriptive statistics of Eurobond credit default swap (CDS) spreads

From Table 4.4 we can see that each Eurobond CDS spread is positively skewed to the right end. The values of kurtosis below three implicate flat distributions different from the assumption of normal distribution. Neither skewness nor kurtosis supports the null hypothesis that data is normally distributed. The values of the Jarque-Bera test, confirm the rejection of null hypothesis. Thus, Eurobond CDS spreads are not normally distributed.

4.4 Euro zone budget deficit and debt to GDP ratio

I will regard euro area debt and deficit to GDP ratios as a factor of credit risk component. Increased indebtedness and running into government budget deficit inevitably leads to worsening of financial condition of the particular entity and increases the default risk.

I gathered quarterly observations of euro zone budget deficit and debt to GDP ratio from ECB Statistical Data Warehouse. The data comprise of euro area 17 countries' government debt and deficit to GDP ratios as a percentage points. As all Euribor basis swap data and other variables used in the study were daily observations, I generated daily observations from quarterly debt and deficit to GDP data. I assumed budget deficit and debt to GDP ratios for simplicity to grow linearly between each of the two quarterly observations. Thus, the government debt and budget deficit will accumulate between t and t_{+1} according to Figure 4.4.

According to the Protocol on the excessive deficit procedure annexed to the European Commission (Maastricht) Treaty and more precisely defined in the European System of Integrated Economic Accounts, government deficit means the net borrowing of the whole general government sector including central government, state government, local government and social security funds. Government deficit is calculated according to national accounts concepts known as European System of Accounts, ESA95. (Eurostat, 2011) Maastricht Treaty states that the ratio of the planned or actual government deficit to gross domestic product at market must not exceed three percent at the end of the preceding fiscal year (European Union, 2004).

Government debt is defined in the Maastricht Treaty as the total gross debt at nominal value outstanding at the end of the year and consolidated between and within the sectors of general government, which I defined in the previous section. The government debt to GDP ratio must not exceed sixty percent at the end of the preceding fiscal year. (European Union, 2004)

We can see from Figure 4.4 that euro zone government debt, in the left hand axis, exceeded the threshold amount defined in Maastricht Treaty by almost twenty percent in the end of the third quarter 2011. Additionally euro zone budget deficit exceeded the limit of the three percent of gross domestic product by one percent. In debt to GDP ratio, the trend has been positively sloped over the sample period. At the same time euro zone government deficit has been fluctuating more and is currently approaching more optimistically the three percent threshold level defined in Maastricht Treaty. We should notice that the scale in the right hand axis consist of positive values and is referred to absolute values on government deficit. Throughout the sample period, euro zone government budget has been in deficit and that is why it does not matter whether deficit or surplus is considered as absolute values or opposite of absolute values.

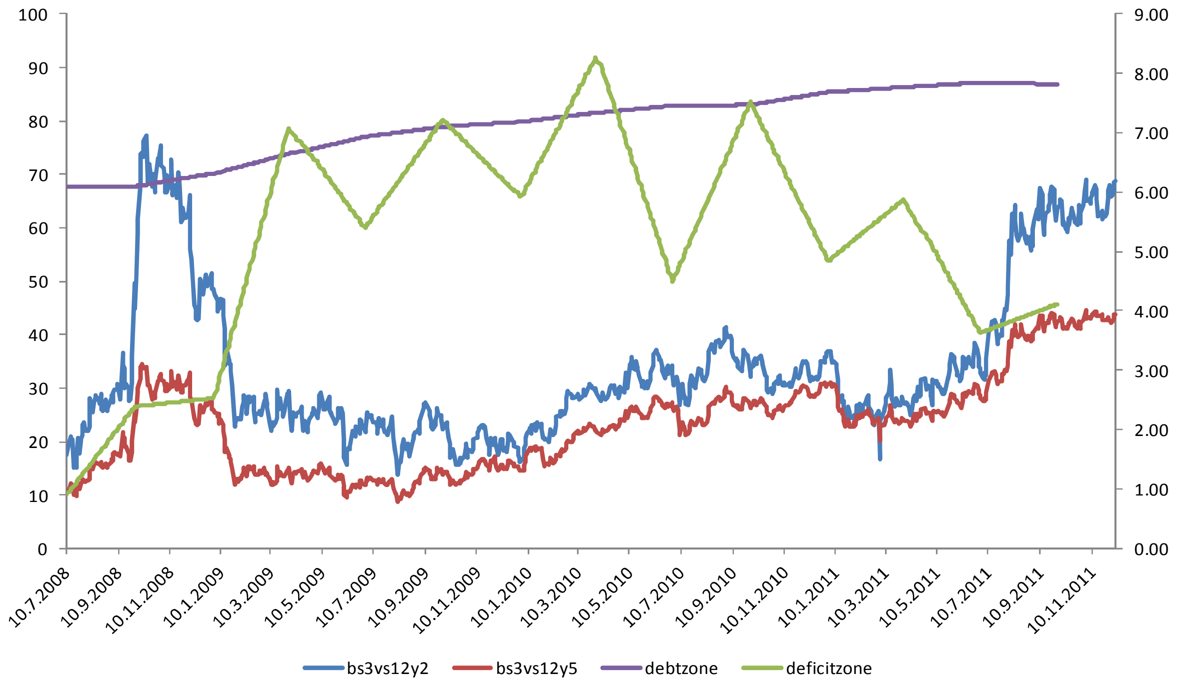

Figure 4.4 Euro zone government budget deficit (right axis) and debt (left axis) to GDP ratio in percentages over the sample period with respect to 3M vs. 12M Euribor basis swap spread with 2 year and 5 year maturities

When comparing euro zone government budget deficit and debt to GDP ratios to Euribor basis swap spreads, it is harder to make conclusions about the dependencies, as the data is linearly increasing or decreasing within every quarter. Even though, I conclude that euro zone government debt has been growing in a similar long-run trend as the Euribor basis swap spreads over the sample period. Correlation matrix presented in Appendix 1, indicates twofold correlations. Correlation coefficients are, despite the relationship between debt to GDP ratio and 5 year basis swap spread, negative. Based on descriptive statistics, I will not consider the debt or deficit to GDP as a significant credit risk component affecting to Euribor basis swap spreads.

Table 4.5 reports the summary of descriptive statistics on euro area government deficit and debt to gross domestic product ratios over the sample period. Mean of euro area government deficit relative to gross domestic product was 5,23 percent, maximum being 8,26 percent and a minimum 0,90 percent over the sample period. Meanwhile euro area government debt was on average 79,39 percent of GDP, maximum being 87,16 percent and a minimum 67,61 percent, confirming the conclusion made from Figure 4.4 that debt to GDP ratio has been over the boundary level of 60 percent throughout the sample period. Median for deficit was 5,62 percent and for debt 80,77 percent. Standard deviation of euro area deficit was 1,72 percent, while for debt the value in question was 6,28 percent.

	deficitzone	*debtzone*
Mean	5,23	79,39
Median	5,62	80,77
Standard Deviation	1,72	6,28
Kurtosis	-0,40	-0,89
Skewness	-0,68	-0,58
Jarque-Bera	69,61	74,31
Minimum	0,90	67,62
Maximum	8,26	87,16
Count	830	830

Table 4.5 Descriptive statistics of euro area government deficit and debt to GDP ratios

From Table 4.5 we can see that both euro area deficit and debt to GDP ratios are negatively skewed to the left end. The values of kurtosis below three implicate flat distributions different from the assumption of normal distribution. Neither skewness nor kurtosis supports the null hypothesis that data is normally distributed. The values of the Jarque-Bera test confirm the rejection of null hypothesis. Thus, neither the euro area deficit nor the debt with respect to gross domestic product is normally distributed.

4.5 The monetary policy and actions of European Central Bank (ECB)

The monetary policy strategy adopted by the ECB embodies the general principles in order to meet the challenges facing the central bank. The strategy aims to provide a comprehensive framework within which decisions on the appropriate policies can be explained to the public. I will regard European Central Bank actions in its entirety as a factor of liquidity component.

The challenges that the ECB faces can be roughly divided into five categories. First, proper functioning of markets is central to the transmission of the ECB’s policy rates. The transmission of the ECB's policy decisions to money market rates depends on banks' willingness to promote smooth exchanges of liquidity in the interbank market.

Recent financial turmoil has demonstrated that the transmission of monetary policy can be disturbed. In order to promote functional markets and maintenance price stability (one of the core policy target of the ECB), the ECB may need to introduce occasionally non-standard policy measures, like liquidity interventions aimed at facilitating the transmission of the interest rate policy and enhancing the flows of credit to the broad economy. Second, changes in monetary policy today will only have lagged effect on the price level after a number of quarters or years. Central banks need to confirm what policy stance is needed today in order to maintain price stability in the future. In this sense, monetary policy must be forward-looking and pre-emptive. Third, in the short-run, there is always a large element of uncertainty surrounding the effects of monetary policy. For these reasons, monetary policy should have a medium-term orientation in order to avoid excessive activism and unnecessary volatility into the real economy. Fourth, monetary policy will be considerably more effective if it firmly anchors inflation expectations. In this sense, the central bank should specify its goal, systematic method for conducting monetary policy and communicate clearly and openly. Well-anchored inflation expectations act as automatic stabilisers during heightened macroeconomic uncertainty and increase the impact of monetary policy. Finally, a successful monetary policy has to be broadly based, taking into account all relevant information in order to understand the factors driving economic developments. (ECB, 2011)

Taking into account all relevant market information, one of the most significant changes ECB has adopted in its monetary policy during the crisis, have been the switching of main refinancing operations from variable rate tenders to fixed rate tenders. In addition to previous, maturities of MROs have increased. Unusual is also that key interest rates are again near at their lowest levels recorded. Considering the ECB's role in securing financial stability in Euromarket, it is reasonable to distinguish interest rate and liquidity providing or absorbing operations from each other. This is commonly known as a separation principle based on a clear separation between the determination of the monetary policy stance and its implementation using liquidity operations. The monetary policy stance is determined to serve the maintenance of price stability (ECB, 2011). Liquidity operations as implementation vehicle aim at steering very short-term money market rates close to the ECB's key policy rate, which is the minimum bid rate in the Eurosystem's main refinancing operations (ECB, 2011). The purpose of the liquidity operations is to smooth impacts of financial shocks in interbank money markets and to secure that monetary policy decisions are transmitted into euro area economy.

After Lehman Brothers defaulted in September 2008, monetary atmosphere experienced a dramatic change. Suddenly interbank market became illiquid because banks that had excess liquidity refused to lend each other. The main reason was that it was hard to recognize the risks embedded in banks asking additional liquidity. Simultaneously the impacts of the ECB's monetary policy were endangered. Across the developed economies, the markets overheated and crisis deepened. The separation principle was abandoned and actions to gain ECB's monetary policy targets were combined. The European Central Bank decided to increase maturities of its main refinancing operations as the demand for longer maturities boosted in illiquid interbank markets. The interbank refinancing rates increased, which caused banks to ask intensively central bank money.

By setting the rates on the deposit and lending facilities, the Governing Council determines the corridor within which the overnight money market rate (EONIA) can fluctuate. In addition, European Central Bank's steering rate that is the rate applied in MROs should lie in the centre of the corridor. In normal circumstances, the EONIA has remained close to the rate of the MROs as it should be. This will demonstrate the importance of these operations as the main monetary policy instrument of the Eurosystem. The differences between the deposit and lending facility interest rates and the rate on the MROs were kept unchanged until October 2008 at ±1 percentage point. From Figure 4.5 we can see, in October 2008, the width of the corridor was narrowed to ±0.5 percentage point, and again widened to ±0.75 percentage point in May 2009, when the ECB decided to set the rate for the MROs at 1 percentage. The ECB reduced its key interest rates to historically low levels as other major central banks did, and took measures on a series of non-standard policies, with a view to preserving price stability, stabilising the financial situation and aiming to limit infection of the real economy. (ECB, 2011)

Appendix 2 reports the summary of descriptive statistics on European Central Bank's actions over the sample period. Rate means of deposit facility, marginal lending facility and MROs were 0,77 percent, 2,31 percent and 1,54 percent. Maximums were 3,25 percent, 5,25 percent and 4,25 percent while minimums were 0,25 percent, 1,75 percent and 1,00 percent over the sample period. Medians of these were 0,25 percent, 1,75 percent and 1,00 percent. Standard deviations of key interest rates of ECB were 0,96 percent, 1,00 percent and 0,98 percent. From Appendix 2 we can see that key interest rates of euro area are positively skewed to the right end. The values of kurtosis below three, in case of deposit facility rate and MROs rate, implicate flat distributions different from the assumption of normal distribution. The value of kurtosis of marginal lending facility rate supports the assumption of normal distribution. However, both skewness and kurtosis do not support the null hypothesis that data is normally distributed regarding key interest rates. The values of the Jarque-Bera test confirm the rejection of null hypothesis.

When comparing the key interest rates of the ECB with the most commonly used 3 month vs. 12 month Euribor basis swap spread over two and five year maturities (Figure 4.5) it is noteworthy that there has been quite a similar kind of trends in basis swap spreads and the key interest rates of the ECB along the sample period. This will give proof to hypothesis that key interest rates may have impacts on basis swap spreads as they are one of the key monetary policy instruments of the ECB. However, it is hard to say about the sign of the correlation, as the key interest rates do not fluctuate daily as the Euribor basis swap spreads do. According to the correlation matrix in Appendix 1, correlations are twofold. Key interest rates are correlated positively with 2 year and 3M vs. 12M Euribor basis swap spread. I will not consider these factors as significant component affecting to Eurbor basis swap spreads because they does not fluctuate daily and are probably stationary in levels.

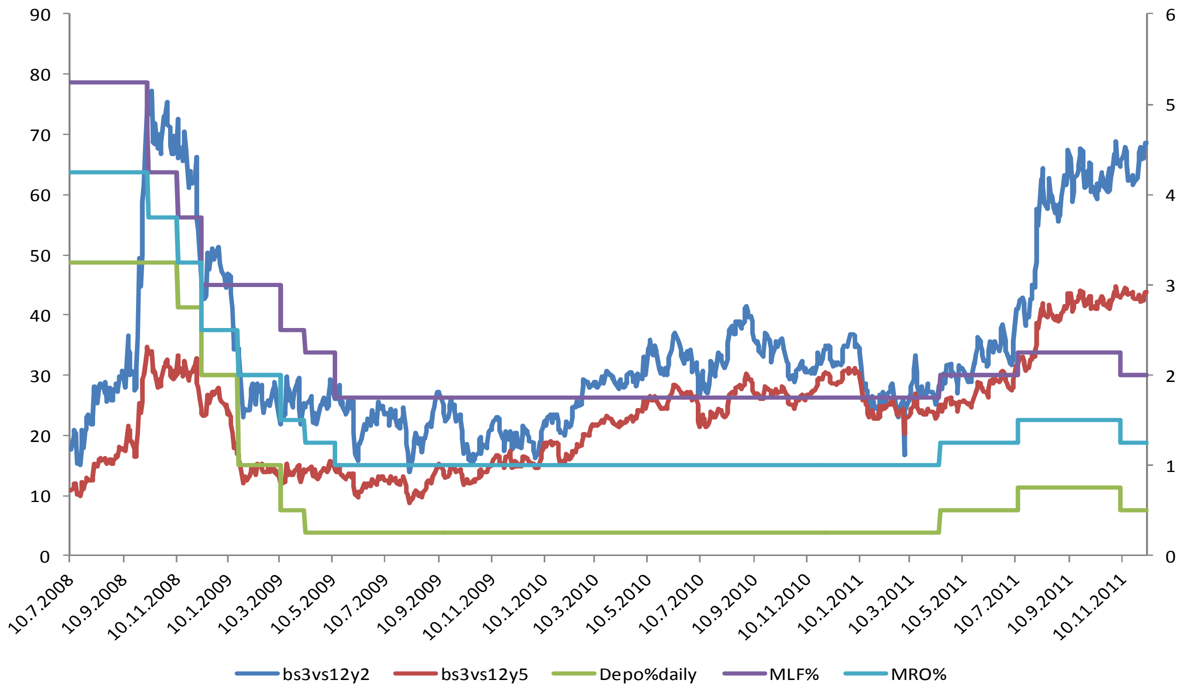

Figure 4.5 Rates (%) of ECB's main refinancing operations, deposit facility and marginal lending facility (right axis) with respect to 3M vs. 12M Euribor basis swap spread with 2 and 5 year maturities (left axis)

During exceptional times, the actions of ECB are reasonable, but as soon as the euro area and the world economy revert to normal circumstances, central banks also revert to normal monetary policy and will start to increase key interest rates and absorb excess liquidity from markets. On its way to normal monetary policy stance, the ECB will cease to conduct MROs with longer maturities. In addition, it will finish its covered bond purchase programme, sell bonds purchased from secondary markets and tighten the requirements of collateral posted by banks.

In the following subsections, I present actions of the European Central Bank (ECB) in more detail consisting of open market operations, recourse to the marginal lending facility, use of the deposit facility, autonomous liquidity factors, current account holdings and reserve requirements. In addition, I will use data on interest rate levels on the deposit facility, on the marginal lending facility and on the reverse open market operations that is the main refinancing operations as well. Finally I regard, ECB's monetary policy decisions that is, monthly meetings of the Governing Council of the ECB as dummy variable, with value one if meeting occurred and zero otherwise.

4.5.1 Open market operations excluding Securities Markets Programme

Open market operations play significant role in the European Central Bank monetary policy. The Securities Markets Programme, initiated in May 2010, was introduced in response to turbulence in the euro area sovereign bond markets. Under the securities market programme, Eurosystem interventions can be carried out in the secondary euro area public and private debt securities markets to ensure functionality and liquidity in dysfunctional markets. To ensure that liquidity conditions are not affected, all SMP purchases are fully neutralised through liquidity-absorbing operations conducted through open market operations. Open market operations do not include Securities Markets Programme itself but liquidity operations to neutralize the effect of the SMPs. (ECB, 2011)

Open market operations have central role in steering interest rates and managing the liquidity in the European market. Open market operations that are carried by ECB, signal the current and future state of the monetary policy in euro area. Euro area open market operations can be divided into four categories. What comes to the instruments used in operations, reverse transactions are the main open market instrument of the ECB and can be employed in all four categories of operations. In addition, debt certificates of ECB may be used for structural absorption operations that can on the other hand be conducted by means of outright transactions. Finally, the ECB can use foreign exchange swaps and the collection of fixed-term deposits for conducting its fine-tuning operations. (ECB, 2011) In the following sections, I will present specific features of the different types of open market operations and instruments used by the ECB in more detail.

First, I will present the most important policy instrument; that being the main refinancing operations that normally provide the bulk of liquidity to the banking system and are executed in a decentralised manner by the national central banks on a weekly basis. Main refinancing operations are executed through standard tenders where, in principle, all credit institutions located in the euro area are potential and eligible participating counterparties. Tenders may be executed in the form of fixed rate or variable rate tenders. In fixed rate tenders, the interest rate is specified at the fixed interest rate by ECB and participating counterparties bid the amount of money they wish to transact. In variable rate tenders, counterparties bid both the amount of money and the interest rate. Since 8th October 2008, weekly main refinancing operations have been carried out through a fixed-rate tender procedure. ECB intended to mitigate the adverse effects that money market turbulence were having on the liquidity situation of solvent banks in the euro area and to support the flow of credit to firms and households. (ECB, 2011)

Second, longer-term refinancing operations are regular, monthly operations with a three-month maturity and/or additionally with even longer maturities, for example lately there have been operations conducted with three year maturity. These operations are aimed at providing longer-term liquidity to the banking system. This is regarded as a useful tool in order to prevent all the liquidity in the money market from having to be rolled over each week or every three-months and to give counterparties access to longer-term refinancing. Longer-term operations are conducted in a similar fashion than standard main refinancing operations. Longer-term operations are normally executed in the form of pure variable rate tenders as in these operations, the ECB does not intend to send signals to the market and therefore normally acts as a rate taker. However, under exceptional circumstances, the ECB may also execute longer-term operations through fixed rate tenders and may decide to accommodate all bids in the operations. (ECB, 2011)

Third, fine-tuning operations are open market operations that can be carried on an ad hoc basis. These operations are known as fine-tuning operations that can absorb or provide liquidity. Frequency and maturity of such operations are not standardised. Fine-tuning operations are conducted for managing the liquidity situation in the money market and steering interest rates, in particular in order to smooth the effects on interest rates of unexpected liquidity fluctuations in the market. Fine-tuning operations are in first hand executed as reverse transactions, but may also take the form of foreign exchange swaps or the collection of fixed-term deposits. Reverse transactions are operations where the ECB buys or sells eligible assets under repurchase agreements or conducts credit operations against eligible assets as collateral. Normally fine-tuning operations are executed through quick tenders that take one hour from their announcement to the communication of the allotment results. Rapid unexpected market developments make these operations desirable for the ECB to retain a high degree of flexibility. However, for operational reasons, only a limited number of selected counterparties may participate in fine-tuning operations. During the financial crisis, the list of counterparties eligible for these operations was increased from around 140 to around 2000 eligible counterparties to secure demand for liquidity in markets. (ECB, 2011)

Fourth, structural operations can provide or absorb liquidity and their frequency can be regular or non-regular. Structural operations in the form of reverse transactions and the issuance of debt instruments are normally carried out through standard tenders. Structural operations may be possible also in the form of outright transactions that refer to operations where the ECB buys or sells eligible assets outright on the market. Outright transactions are normally executed through bilateral procedures. (ECB, 2011)

We can see from Figure 4.6 that open market operations excluding Securities Markets Programme (SMP) have been the central liquidity-providing and liquidity-absorbing factors as the liquidity provided through the open market operations were at the most 900 billion euros, reflecting the key role played by this monetary policy instrument. After third quarter of 2010, there has been a downward trend in providing or absorbing liquidity through open market operations. Downward spikes stem from the timings of reserve maintenance periods. Reserve maintenance period is the period over which credit institutions' compliance with reserve requirements is calculated. The Governing Council decided in March 2004 that maintenance periods would start on the settlement day of the first MRO following the Governing Council meeting at which the monthly assessment of the monetary policy stance was pre-scheduled (ECB, 2011). Reserve maintenance period would end on the day preceding the corresponding settlement day in the following month in order to prevent rate change speculation during a maintenance period from affecting very short-term money market conditions (ECB, 2011).

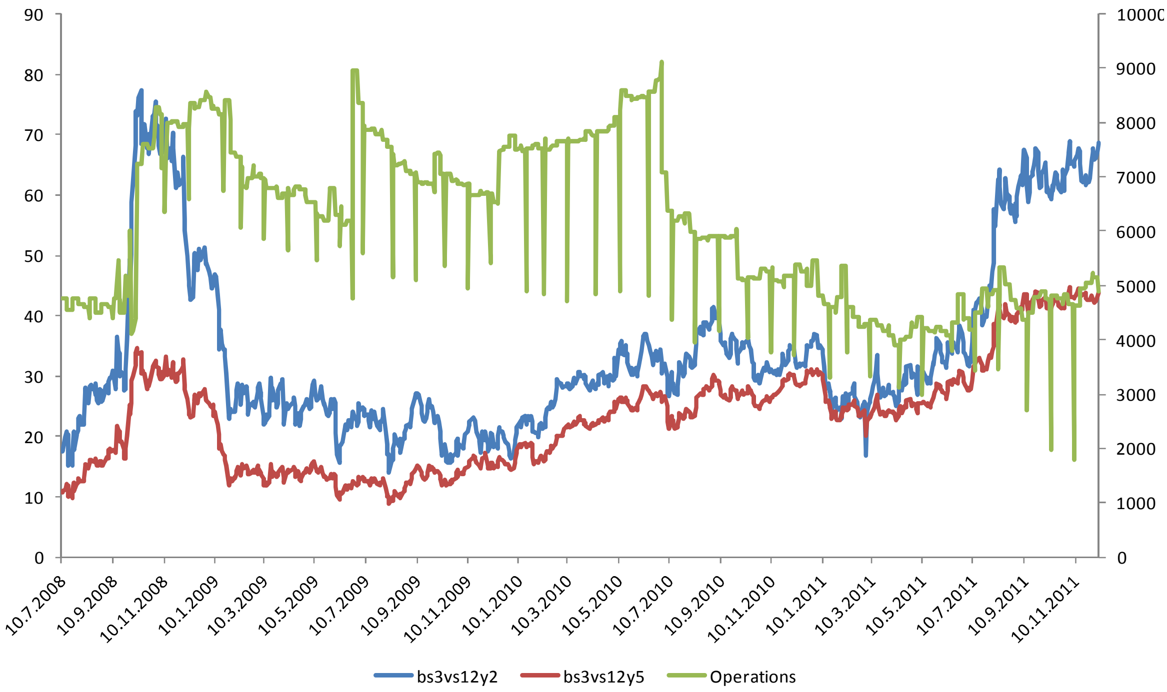

Figure 4.6 Open market operations (in EUR 100 millions in right axis) of ECB with respect to 3M vs. 12M Euribor basis swap spreads with 2 and 5 year maturities (in left axis)

When comparing open market operations to most commonly used 3 month vs. 12 month Euribor basis swap spread over two and five maturities it is noteworthy that there has been similar kind of movements in basis swap spread paths and the amounts of open market operations along the sample period. This will give proof to hypothesis that open market operations have impacts and are correlated signficantly with basis swap spreads. I will consider open market operations as a significant liquidity component affecting Euribor basis swap spreads.

Appendix 2 reports the descriptive statistics of open market operations. Mean of open market operations was EUR 610,6 billion. Maximum was EUR 910,5 billion, while minimum was EUR 180,4 billion over the sample period. Median of operations was EUR 618,3 billion. Standard deviation was EUR 150,0 billion. According to value of skewness, operations pursue the normal distribution. The value of kurtosis below three, on the other hand, will implicate a flat distribution. Altogether, the values of skewness and kurtosis together with Jarque-Bera test results, will result in rejection of normally distributed values.

4.5.2 Recourse to standing facilities

The European Central Bank implements monetary policy also by setting the interest rates on its standing facilities. There are two standing facilities available to eligible counterparties. These are known as the marginal lending facility and the deposit facility. Standing facilities provide or absorb liquidity with an overnight maturity on the initiative of counterparties. Generally, there is a little incentive for banks to use standing facilities, as the interest rates applied to them are in normal circumstances much more less when compared with market rates. The use of the standing facilities increased significantly during the financial crisis as banks preferred to keep more central bank reserves than required and to deposit the additional reserves in the deposit facility instead of lending them out to other banks. The reasons for this were obvious as banks perceived increasing uncertainty and counterparty risk. As the overall amounts requested by banks during the crisis have been higher than the liquidity needs of the banking system during this period, the excess liquidity has been deposited in the deposit facility (see Figure 4.7). (ECB, 2011)

Counterparties can use the deposit facility to make overnight deposits with National Central Banks (NCBs). The interest rate of deposits is fixed at a pre-specified level and in general, it is a floor for the overnight market interest rate (see Figure 4.5). The ECB may change the interest rate at any time effective at the earliest from the following business day. Access to the deposit facility is granted only on days when TARGET2 is open. TARGET2 is the real-time gross settlement system owned and operated by the Eurosystem and it has to be used for all payments involving the Eurosystem. There is no limit to the amount counterparty may deposit under the facility.

Appendix 2 reports the descriptive statistics on deposit facility. Mean of deposit facility was EUR 110,7 billion. Maximum was EUR 384,3 billion, while minimum was EUR 40 million over the sample period. Median of deposit facility was EUR 85,9 billion. Standard deviation was EUR 90,7 billion. The value of kurtosis below three, implicate flat distribution while skewness different from zero indicates positively skewed distribution. The value of the Jarque-Bera test rejects the null hypothesis that the distribution of deposit facility is normally distributed.

Figure 4.7 illustrates the relationship between deposit facility (in EUR 100 millions) and 3M vs. 12M Euribor basis swap spread with 2 and 5 year maturities. Deposits with national central banks peaked soon after the Lehman Brothers collapsed, reflecting the unwillingness to lend each other in interbank markets when the banks in euro area preferred to deposit excess liquidity in central bank. Based on Figure 4.7 I draw a conclusion that deposit facility and 3M vs. 12M Euribor basis are expected to be positively correlated. Fluctuations in deposit facility seem to be more volatile than in Euribor basis swap spreads. However, overall picture gives support to hypothesis that deposit facility and Euribor basis swap spreads have elaborated quite much in similar fashion in the long-run. Correlation matrix (in Appendix 1) gives support to hypothesis that deposit facility mat be a significant liquidity component affecting Euribor basis swap spreads.

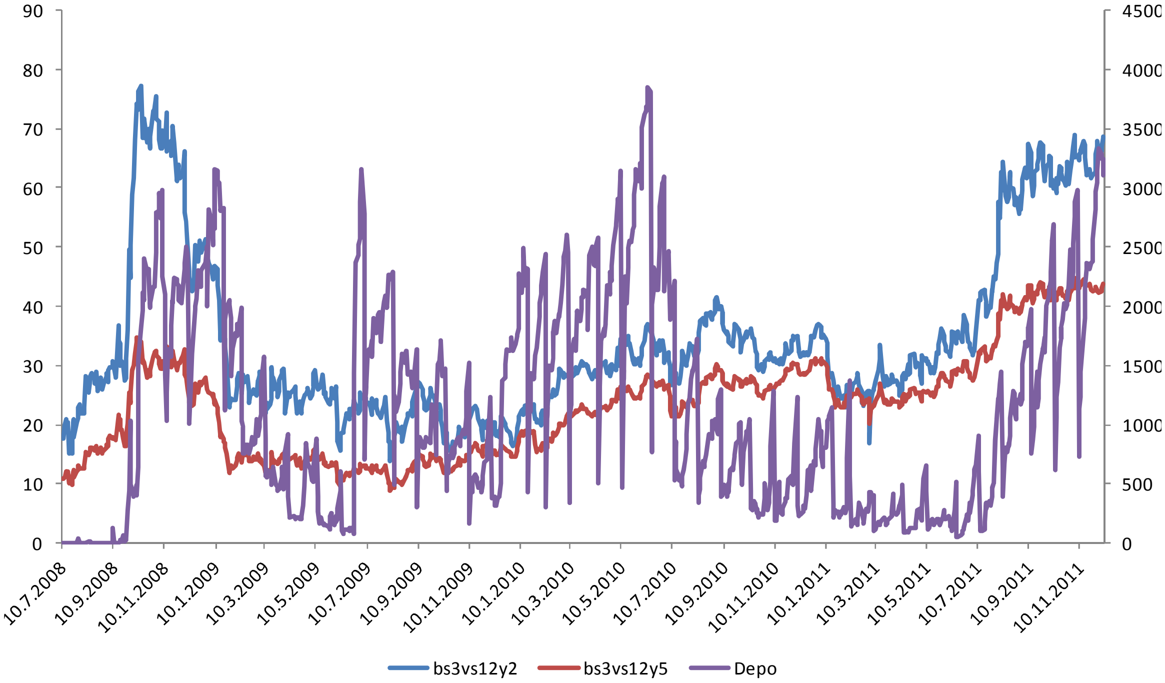

Figure 4.7 Deposit facility (in EUR 100 millions in right axis) with respect to 3M vs. 12M Euribor basis swap spreads (left axis)

In similar manner as above, counterparty may use the marginal lending facility to obtain overnight liquidity from NCBs. The interest rate is fixed at a pre-specified level against eligible assets. The ECB may change the interest rate at any time, effective, at the earliest, from the following business day. The marginal lending facility is intended to satisfy counterparties' temporary liquidity needs (see Figure 4.8). Generally, the interest rate on the facility provides a cap for the overnight market interest rate (see Figure 4.5). The NCBs may provide liquidity under the marginal lending facility either in the form of overnight repurchase agreements or as overnight collateralised loans with overnight maturity. Access to the marginal lending facility is granted only on days when TARGET2 is open. There is no limit to the amount of funds that can be advanced under the marginal lending facility.

Appendix 2 reports the descriptive statistics of marginal lending facility. Mean of marginal lending facility was EUR 1,5 billion. Maximum was EUR 28,7 billion, while minimum was EUR 0 over the sample period. Median of marginal lending facility was EUR 0,23 billion. Standard deviation was EUR 3,4 billion. The value of kurtosis above three, implicate peaked distribution while skewness indicates positively skewed distribution. The value of the Jarque-Bera test rejects the null hypothesis that the distribution of marginal lending facility is normally distributed.

Figure 4.8 illustrates the relationship between marginal lending facility (in EUR 100 millions) and 3M vs. 12M Euribor basis swap spread with 2 and 5 year maturities. Marginal lending facility from NCBs peaked similarly as deposit facility soon after the Lehman Brothers collapsed, reflecting the banks' willingness to obtain liquidity from the central bank. However, based on Figure 4.8 I draw a conclusion that marginal lending facility and 3M vs. 12M Euribor basis are not correlated as significantly as was the case with deposit facility. Actually, it seems that marginal lending facility has fluctuated mostly between zero and 5 billion euros following quite smooth trend. Overall picture gives support to hypothesis that marginal lending facility and Euribor basis swap spreads have not elaborated in similar fashion in the long-run. Correlation matrix (in Appendix 1) gives support to hypothesis and the correlation is rather lower compared to other independent variables.

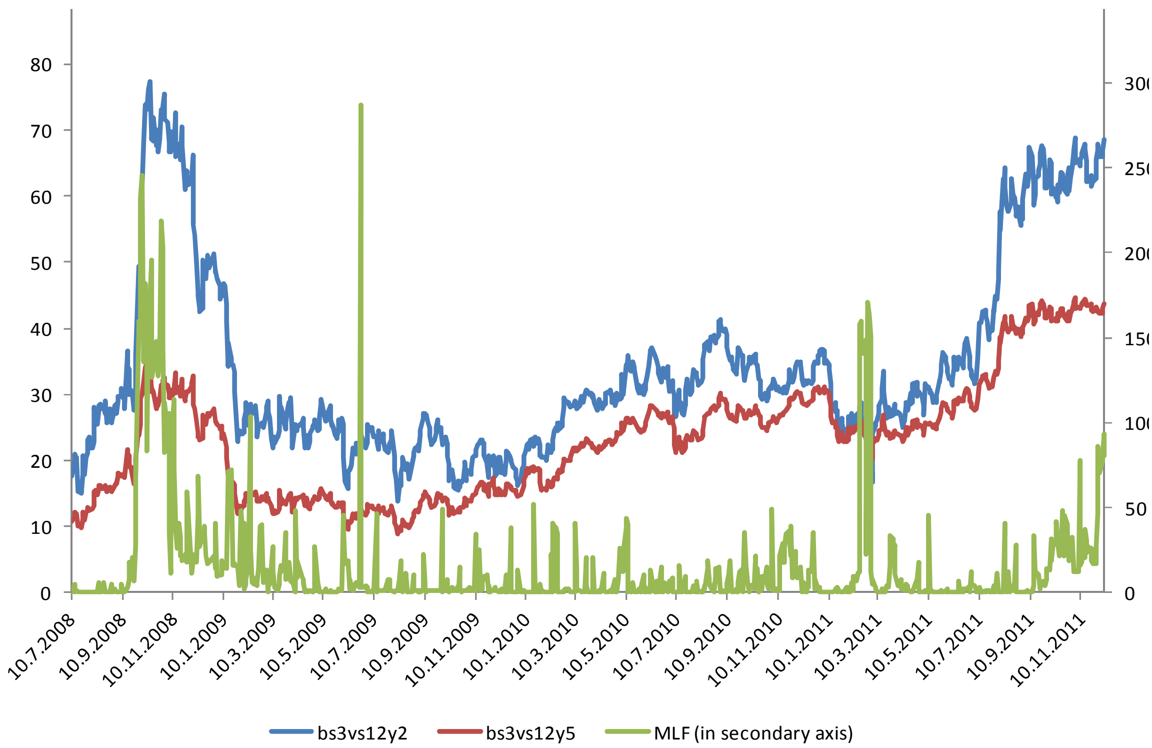

Figure 4.8 Marginal lending facility (in EUR 100 millions in right axis) with respect to 3M vs. 12M Euribor basis swap spreads (left axis)

4.5.3 Autonomous liquidity factors and Securities Markets Programme

The liquidity provision coming from the Securities Markets Programme (presented in 4.5.1) is displayed together with the autonomous factors. Autonomous factors are the sum of banknotes in circulation plus government deposits minus net foreign assets plus other factors. These factors all together affect on the liquidity of the banking system, and are labelled autonomous, because they are not the result of the use of monetary policy instruments as for example banknotes in circulation and government deposits are not under the control of the monetary authorities. Banknotes in circulation and government deposits with the ECB generate the liquidity absorbing effect of autonomous factors because notes are obtained from the central bank, and credit institutions borrow funds from the central bank. Other factors instead, such as net foreign assets, can be controlled by the monetary authorities. Even though, transactions in these assets are not related to monetary policy operations. Purchases of foreign assets by the ECB provide liquidity into the banking system and reduce the need for liquidity providing monetary policy operations. The net foreign asset position of a country is the value of the sum of foreign assets held by monetary authorities and commercial banks, less their foreign liabilities.

Appendix 2 reports the descriptive statistics of autonomous liquidity factors and SMP. Mean of autonomous liquidity factors and SMP was EUR 286,1 billion. Maximum was EUR 417,2 billion, while minimum was EUR 1,8 billion over the sample period. Median of autonomous liquidity factors and SMP was EUR 312,8 billion. Standard deviation was EUR 98,7 billion. The value of kurtosis below three, implicate flat distribution while skewness indicates negatively skewed distribution. The value of the Jarque-Bera test rejects the null hypothesis that the distribution of autonomous liquidity factors and SMP is normally distributed.

Figure 4.9 illustrates the relationship between autonomous liquidity factors and Securities Markets Programme (in EUR 100 millions) with respect to 3M vs. 12M Euribor basis swap spread with 2 and 5 year maturities. In a similar fashion than ECB's actions presented so far, autonomous liquidity factors (including Securities Markets Programme) peaked in the fourth quarter of 2008. Based on Figure 4.9 I draw a conclusion that autonomous liquidity factors (including Securities Markets Programme) and 3M vs. 12M Euribor basis are significantly correlated. Correlation matrix presented in Appendix 1 supports the hypothesis. I will consider autonomous liquidity factors including SMP as a significant liquidity component affecting Euribor basis swap spreads.

Over the sample period, basis swap spreads have increased, while the autonomous liquidity factors have decreased. According to the ECB the sum of banknotes in circulation have increased smoothly during the past ten years, while the government deposits aggregated at the euro area level, have continuously been the most volatile autonomous factor, causing a large part of the errors in the forecast of liquidity needs underlying the allotment decisions for the open market operations of the ECB (ECB, 2011). Increase in net foreign assets should decrease the autonomous liquidity factors, which would support the evidence in favour of current account surplus over the sample period. According to ECB Statistical Data Warehouse, there has been current account deficit in euro area over the sample period. Increase in net foreign assets is due to current account surplus. Respectively, if the country has current account deficit, like over the sample period, it has to be financed through borrowing from foreign countries, which will in turn decrease net foreign assets and increase autonomous liquidity factors. This in turn will indicate that for example banknotes in circulation, government deposits and other factors have decreased over the sample period.

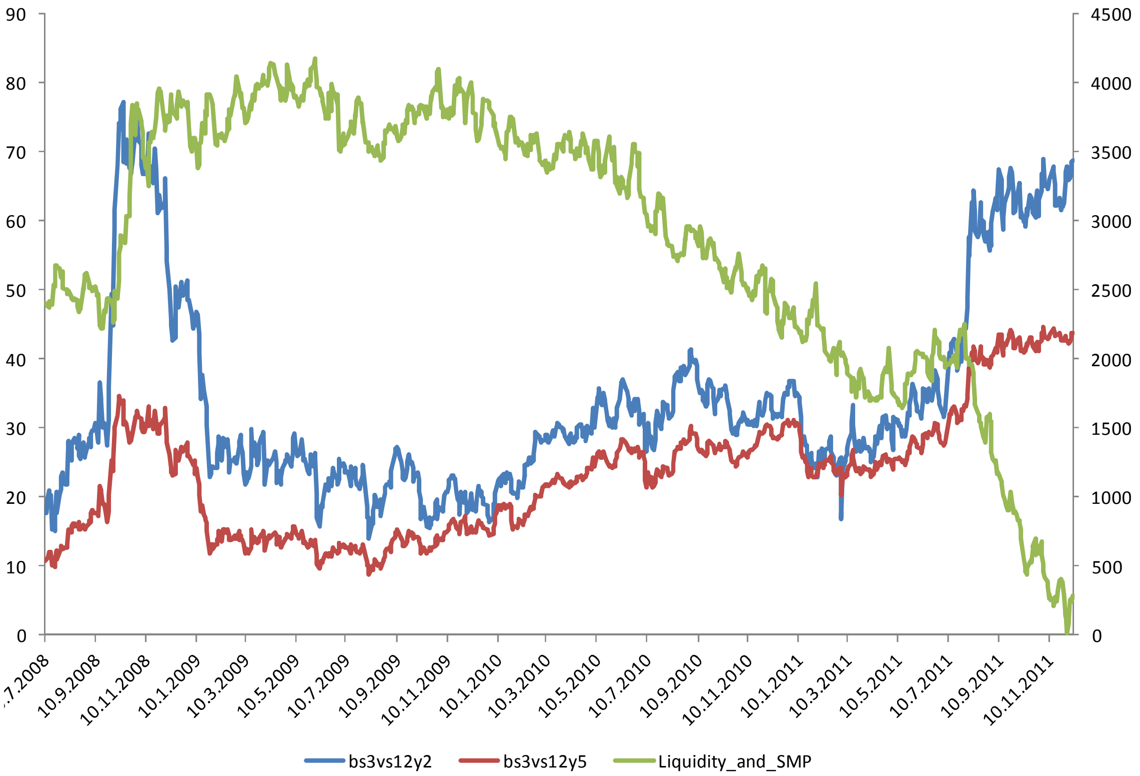

Figure 4.9 Autonomous liquidity factors and Securities Markets Programme (in EUR 100 millions in right axis) with respect to 3M vs. 12M Euribor basis swap spreads with 2 and 5 year maturities (left axis)

4.5.4 Current account holdings

In order to meet its reserve requirements and settlement obligations from interbank transactions, a credit institution has to hold balances on its current accounts with the National Central Bank. Current account holding is not fixed and it may fluctuate around its reserve requirement. On average, though, the current account holding must be at least equal to the reserve requirement over the maintenance period. The interaction between the Eurosystem and the banking system's current account holdings could be illustrated more precisely with the help of the consolidated balance sheet of the Eurosystem, but is beyond the scope of this study. However, to give an overall insight of current account holdings of credit institutions, it consists of factors like deposit facility, banknotes in circulation, government deposits and other factors on the liabilities side. (ECB, 2011)

Appendix 2 reports the descriptive statistics on current account holdings. Mean of current account holdings was EUR 215,2 billion. Maximum was EUR 384,9 billion, while minimum was EUR 79,4 billion over the sample period. Median of current account holdings was EUR 215,8 billion. Standard deviation was EUR 44,5 billion. The value of kurtosis below three, implicate flat distribution while skewness indicates negatively skewed distribution. The value of the Jarque-Bera test rejects the null hypothesis that the distribution of current account holdings is normally distributed.

Figure 4.10 illustrates the relationship between current account holdings (in EUR 100 millions) and 3M vs. 12M Euribor basis swap spread with 2 and 5 year maturities. Current account holdings with NCBs have been fluctuating heavily over the sample period. This reflects the nature of current account holdings, that is, those are not fixed and may fluctuate around its reserve requirement over the maintenance period. According to Figure 4.10 I expect current account holdings to be stationary in levels. Based on Figure 4.10 I cannot draw a clear conclusion about the correlation between current account holdings and 3M vs. 12M Euribor basis. Altogether, overall picture indicates that current account holdings and Euribor basis swap spreads have not elaborated in a similar fashion in the long-run. Correlation matrix (Appendix 1) supports the hypothesis, that is, no significant correlation. I will not consider current account holdings as a significant liquidity component affecting Euribor basis swap spreads.

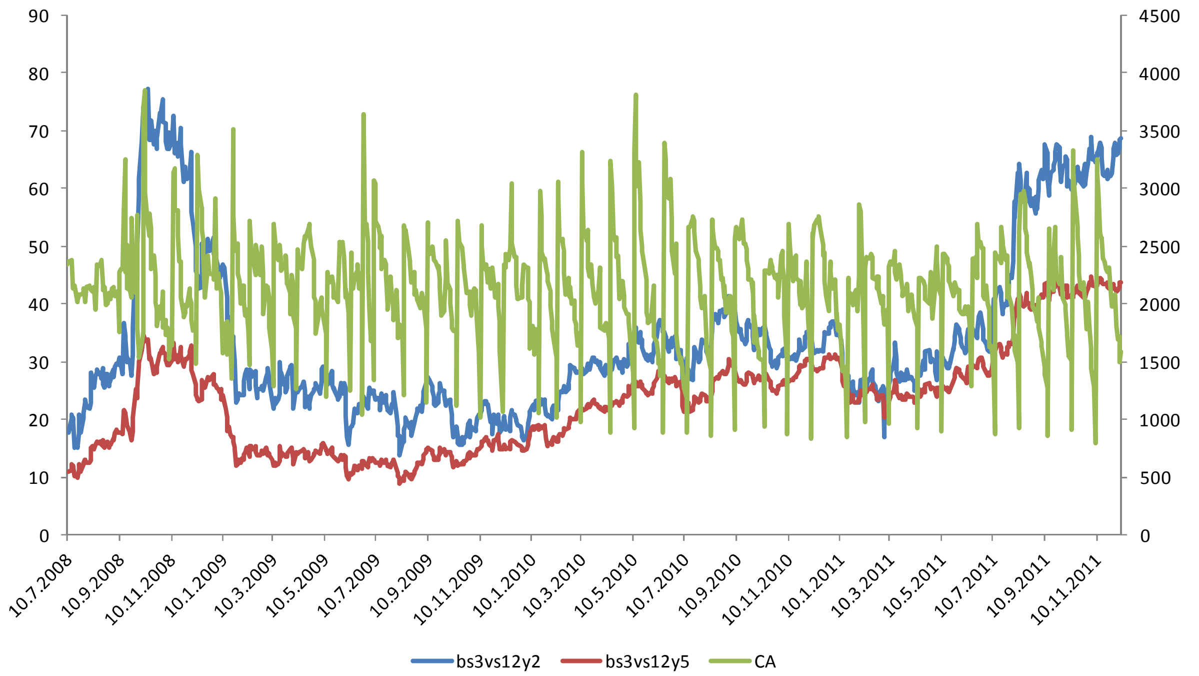

Figure 4.10 Current account holdings (in EUR 100 millions in right axis) with respect to 3M vs. 12M Euribor basis swap spreads with 2 and 5 year maturities (left axis)

4.5.5 Reserve requirements

In order to determine the reserve requirement of a credit institution, the reserve base is multiplied by a reserve ratio. The ECB applies a uniform positive reserve ratio to most of the balance sheet items included in the reserve base. This reserve ratio has currently been set at two percent. Reserve base is the sum of the eligible balance sheet items, in particular most of the liabilities that constitute the basis for calculating the reserve requirement of a credit institution. (ECB, 2011)

The difference between credit institutions' holdings on current accounts with the ECB and reserve requirements makes up the excess reserves. Before 2004 reserve requirements accounted for more than half of the total liquidity needs of the banking system but since 2004 onwards, the total liquidity-absorbing effect of autonomous factors have exceeded the effect from reserve requirements. For clarification, required reserves have a liquidity absorbing effect, which have relatively similar size power to the effect of all the autonomous factors together. (ECB, 2011)

Appendix 2 reports the descriptive statistics of reserve requirements. Mean of reserve requirements was EUR 212,7 billion. Maximum was EUR 221,1 billion, while minimum was EUR 206,1 billion over the sample period. Median of reserve requirements was EUR 211,9 billion. Standard deviation was EUR 4,0 billion. The value of kurtosis below three, implicate flat distribution while skewness indicates positively skewed distribution. The value of the Jarque-Bera test rejects the null hypothesis that the distribution of reserve requirements is normally distributed.

Figure 4.11 illustrates the relationship between reserve requirements (in EUR 100 millions) and 3M vs. 12M Euribor basis swap spread with 2 and 5 year maturities. Reserve requirements peaked soon after the Lehman Brothers collapsed, reflecting increase in reserve base, that is, the sum of the most liabilities on the balance sheet that constitute the basis for calculating the reserve requirement of a credit institution. Based on Figure 4.11 I conclude that reserve requirements and 3M vs. 12M Euribor basis were somewhat correlated until the beginning of 2011. Correlation matrix indicates a negative relationship between reserve requirements and 3M vs. 12M Euribor basis swap spreads. Since second quarter of 2011 reserve requirements and Euribor basis swap spreads have moved to opposite directions. This will make it more difficult to assess the overall effects of reserve requirements on Euribor basis swap spreads over the sample period. Fluctuations in Euribor basis swap spreads seem to be more volatile than in reserve requirements. I will not consider reserve requirements as a significant liquidity component affecting Euribor basis swap spreads.

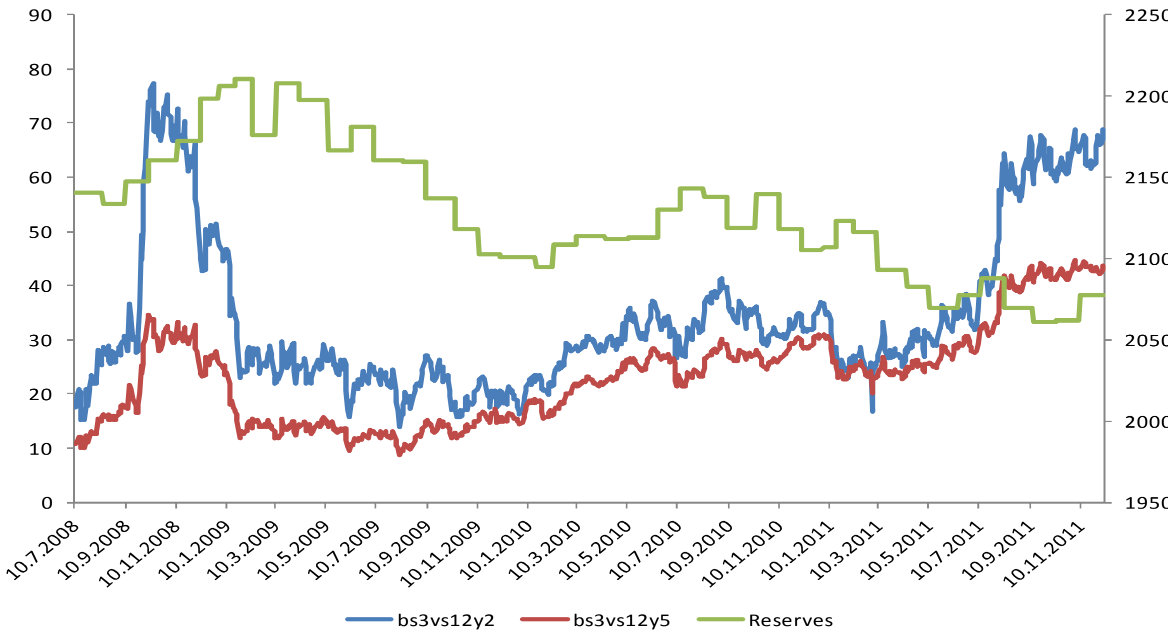

Figure 4.3 Reserve requirements (in EUR 100 millions in right axis) with respect to 3M vs. 12M Euribor basis swap spreads with 2 and 5 year maturities (left axis)

4.5.6 Covered bond purchase programme (CBPP)

The Covered bond purchase programme of ECB, that was initiated on 9th July 2009. The European Central Bank has purchased covered bonds issued in the euro area at total value of €60 billion so far. The reason why ECB decided to start purchasing covered bonds was mainly due to illiquid covered bond markets. The aim of the covered bond purchase programme was naturally to revive the covered bond market. The covered bond market is a very important financial market in euro area and it is a primary source of financing for financial institutions. As a result of covered bond purchase programme, the relationship between the main refinancing rate and money market rates temporarily changed. In normal circumstances, the EONIA (Euro Overnight Index Average) is an effective overnight interest rate that closely follows movements in the main refinancing rate. According to ECB the high demand from banks for central bank liquidity in refinancing operations during the crisis has resulted in the deposit facility rate playing a greater role in steering the EONIA. (ECB, 2011)

Covered bonds are issued by financial institutions and created from public sector or mortgage loans where the covered bond is backed by a separate group of loans called cover or collateral pool. In the euro area, covered bonds are further defined by the Capital Requirements Directive (CRD), which limits the range of accepted collateral. The dual nature of protection offered by covered bonds distinguishes covered bonds for example from asset-backed securities. The fact that they are secured by a collateral in addition to the issuer's creditworthiness results in a higher credit rating than bank bonds. Assets pledged as collateral for a covered bond issue remain on the balance sheet of the issuer giving an incentive to keep only high quality assets. (ECB, 2011a)

The financial crisis caused the lack of confidence between financial institutions, which raised concerns about the liquidity risk of a large number of banks, thereby threatening the whole banking system. To hinder this from happening, the European Central Bank decided to provide support to the covered bond market in the euro area through outright purchases of covered bonds under the Covered Bond Purchase Programme (CBPP). The objectives of European Central bank purchases under the CBPP were clear: promoting the ongoing decline in money market term rates, easing funding conditions for financial institutions, encouraging financial institutions to maintain and expand their lending to clients, improving market liquidity in important segments of the private debt securities market. Following the announcement of the CBPP led markets to a sharp tightening. In secondary market, covered bond yield spreads narrowed in the euro area and the primary market started to recover. (ECB, 2011a)

Appendix 2 reports the descriptive statistics on covered bond purchase programme. Mean of covered bond purchase programme was EUR 48,3 billion. Maximum was EUR 61,1 billion, while minimum was EUR 66 million over the sample period. Median of covered bond purchase programme was EUR 59,7 billion. Standard deviation was EUR 18,4 billion. The value of kurtosis below three, implicate flat distribution while skewness indicates negatively skewed distribution. The value of the Jarque-Bera test rejects the null hypothesis that the distribution of covered bond purchase programme is normally distributed.

Figure 4.12 demonstrates the relationship between covered bond purchase programme (in EUR 100 millions) and 3M vs. 12M Euribor basis swap spread with 2 and 5 year maturities. Between July 2009 and August 2010, one can spot slight upward trend in basis swap spreads, giving justification to liquidity factors to be taken into account in a comprehensive model. Even though there is a similar kind of trend in basis swap spreads and CBPP soon after initiation of CBPP, dependencies remain unclear. After July 2010, the CBPP has started to decline smoothly, but one cannot see the similar kind of fashion in Euribor basis swap spreads. Based on Figure 4.12 I draw a conclusion that covered bond purchase programme and 3M vs. 12M Euribor basis are correlated. Correlation matrix (Appendix 1) indicates quite significant positive correlation between CBPP and 3M vs. 12M basis swap spread, namely 0,54 (2y) and 0,76 (5y). However, fluctuations in Euribor basis swap spreads are more volatile than in covered bond purchase programme and the data starts from the initiation of CBPP in July 2007. These will lead me to omit this variable from empirical testing and I will not consider covered bond purchase programme as a significant liquidity component affecting Euribor basis swap spreads.

Figure 4.4 Covered bond purchase programme (in EUR 100 millions in right axis) with respect to 3M vs. 12M Euribor basis swap spreads with 2 and 5 year maturities (left axis)

4.5.7 Meetings of the Governing Council of the ECB

The Governing Council of the ECB is the main decision-making voice of the monetary union. It consists of the six members of the Executive Board and the governors of the national central banks of the 17 euro area countries. Main responsibilities of the Governing Council are to adopt the guidelines and make the decisions necessary to ensure the performance of the Eurosystem and to formulate monetary policy decisions. In assessing risks to price stability in the euro area, the Governing Council has relied on its monetary policy strategy, implying a comprehensive analysis of both economic and monetary developments in the euro area. Central monetary policy decisions concerning euro area are related to key interest rates, the supply of reserves in the Eurosystem, and the establishment of guidelines for the implementation of these decisions. (ECB, 2011)

The Governing Council usually meets twice a month. At first meeting of each month, the Governing Council assesses economic and monetary developments and according to current stance in euro area takes its monthly monetary policy decision. At the second meeting, the Council discusses mainly issues related to other tasks and responsibilities of the ECB and the Eurosystem. The monetary policy decision is explained in detail at a press conference held right after the first meeting of each month. (ECB, 2011) I will impose for dummy variable value one when first meeting of the month occurred. I will not take stand whether the desicions of each meeting was positive or negative and that is why I use only value one (instead of one and minus one).

According to Figure 4.13 Euribor basis swap spreads increased in the following of the announcement of Governing Council's monthly monetary policy decision in 19 out of 41 cases over the sample period. Respectively, in 22 out of 41 cases spreads decreased. Thus, I can not unambiguosly conclude the sign of the correlation, which gives support to omit this factor when aiming to build a comprehensive model to estimate direction of driving forces of Euribor basis swap spreads. Additionally, correlation matrix presented in Appendix 1, supports to omit the variable. I will consider meetings of the governing council as a significant component affecting Euribor basis swap spreads.

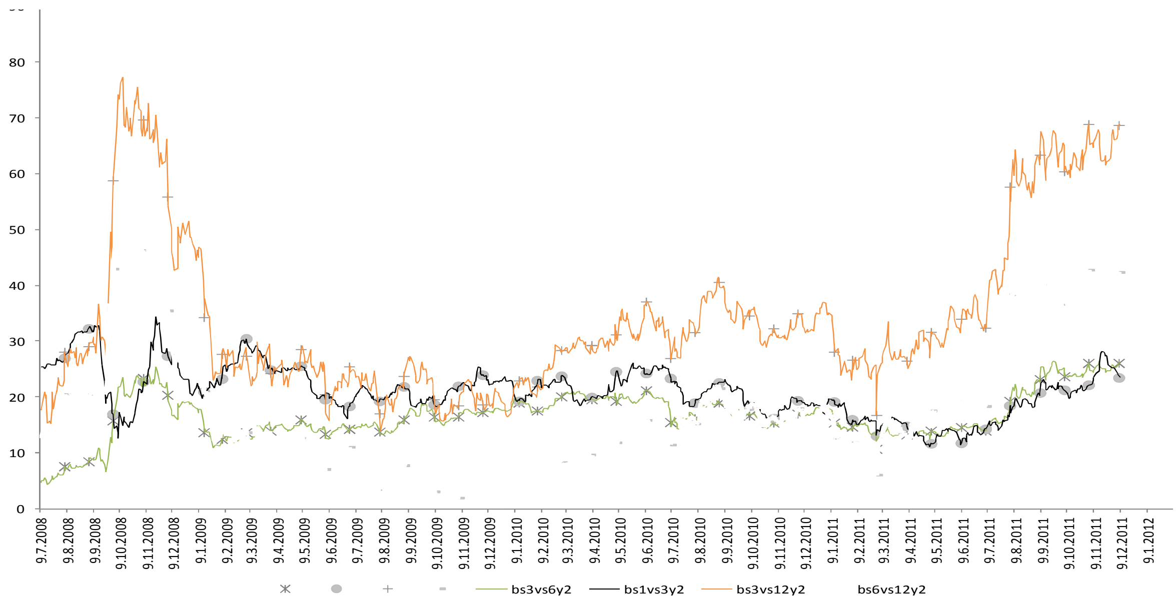

Figure 4.5 Monthly monetary policy decisions in meetings of Governing Council of the ECB (dot, cross, plus and minus signs) with respect to 3M vs. 12M Euribor basis swap spreads with 2 and 5 year maturities

4.6 Credit default swap (CDS) spreads of Euribor panel banks

I will regard Euribor panel bank credit default swap spreads as a factor of credit risk component similarly as was the case with Eurobond CDS spread. I constructed credit default swap spreads of Euribor panel banks from market quotations of 2 year and 5 year mid-market credit default swap spreads of 34 Euribor panel banks with equal weights in the case of 2 year maturity Euribor panel CDS. Respectively, Euribor panel CDS with 5 year maturity consist of 36 Euribor panel banks and their CDS market quotations. Euribor panel bank credit default swaps are not available in the markets by themselves and thus had to be constructed using CDS quotations of each Euribor panel banks. The comprehensive list of banks that had credit default swap quotations in Bloomberg platform is available in Appendix 3. In order to construct Euribor panel CDS for the estimation purposes of the study, I assume that countries belonging to Euribor panel jointly represent the current credit default risk of the representative euro area credit institutions and credit risk component in Euribor rates. The similar weights and the current state of each panel member will affect to the Euribor panel CDS spread.

Figure 4.14 there presents graphs of the constructed Euribor panel CDS spreads over the sample period. It is noteworthy that 2 year and 5 year Euribor panel CDS spreads both move along quite similar paths. The difference between 5 year and 2 year CDS spreads have been fluctuating within the range of -38,19 to 48,48 bps. The movements of Euribor panel CDS spreads indicate that the "term structure" of CDS spreads have been fluctuating from upward sloping to inverted across the sample period. The average difference between the 5 year and 2 year CDS spreads has been 14,70 bps. Inverted "term structure" of CDS spreads, that is, negative difference between 5 year and 2 year spreads, indicate that investors are expecting the underlying entity to be defaulted in the short-run more likely than in the long-run.

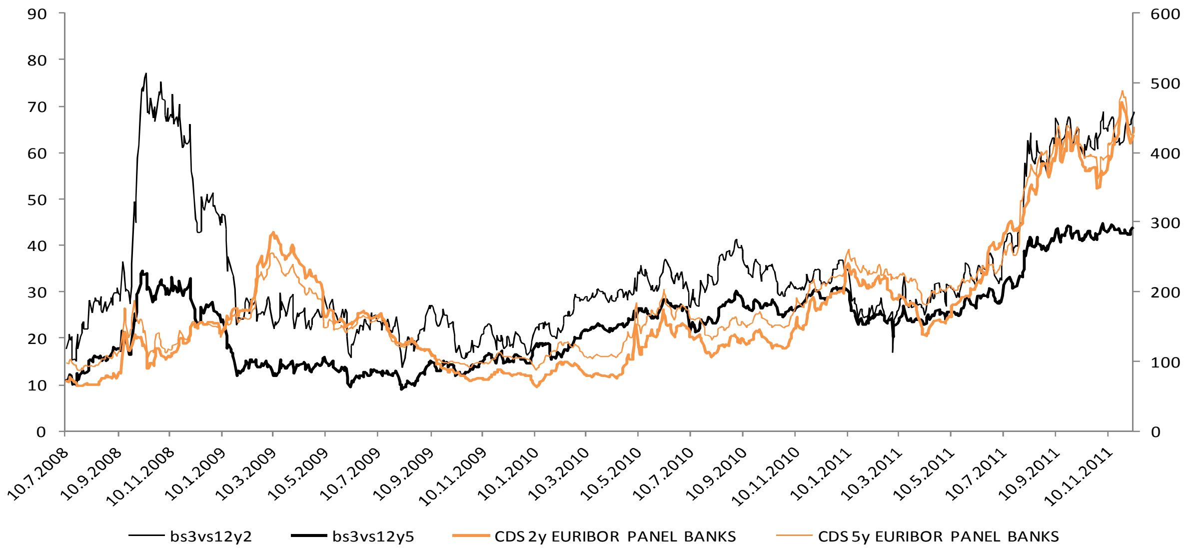

Figure 4.14 Euribor panel credit default swap (CDS) spreads with 2 year and 5 year maturities (right axis) constructed from 34 and 36 different Euribor panel bank member CDS spread quotations that were available with respect to 3M vs. 12M Euribor basis swap spread with 2 year and 5 year maturities (left axis).

The Euribor CDS panel spreads started to rise already before Lehman Brothers crashed and problems started in banking sector. I see that rise in Euribor panel CDS spreads started after the U.S. subprime crisis in 2007 and peaked in the end of the first quarter in 2009. Since the fourth quarter of 2009, Euribor panel CDS spreads started again to rise slightly, and finally culminated by the heavy increase in spring 2011. The heavy increase in CDS spreads in second quarter of 2011, might arose from uncertainty regarding the future of the joint currency of the euro zone. If Greece or any other member country of EMU defaulted, it would mean also a series of defaults what comes to euro area banks and sovereigns. This is an essential factor that affects to increase in Euribor panel CDS spreads as well as Eurobond CDS spreads.

When comparing Euribor panel CDS spreads to Euribor basis swap spreads, it is noteworthy that the breakdown of Lehman Brothers had a lagged effect on Euribor panel CDS spreads similarly as was the case with Eurobond CDS spreads. According to Figure 4.14, after the third quarter of 2009, they have moved significantly in a similar fashion, especially with Euribor basis swap spread with 2 year maturity. Thus, I expect Euribor panel CDS spreads and Euribor basis swap spreads to be positively correlated. Correlation matrix presented in Appendix 1, supports the hypothesis. Both Euribor panel CDS spreads and 3M vs. 12M Euribor basis swap spreads are positively correlated. I will consider Euribor panel CDS spread as a significant credit risk component affecting Euribor basis swap spreads.

Table 4.6 reports summary of descriptive statistics of Euribor panel credit default swap spreads over the sample period. Means of Euribor panel CDS spread between 2 year and 5 year maturities ranges from 171,64 bp (Euribor panel CDS 2y) to 186,34 bp (Euribor panel CDS 5y) and between a maximum of 490,27 bp (Euribor panel CDS 5y) and a minimum of 63,17 bp (Euribor panel CDS 2y) over the sample period. Median ranges from 148,29 bp (Euribor panel CDS 2y) to 159,02 (Euribor panel CDS 5y). Standard deviation ranges from 89,42 bp, (Euribor panel CDS 5y) to 92,83 bp (Euribor panel CDS 2y). Results support the theory that credit default risk is higher with longer maturities, reflecting higher CDS spread in 5 year maturity. However, 2 year CDS was more volatile than 5 year CDS, which do not support the basic market observation that the price and yield of existing long maturity bonds are influenced far more by the effect of changes in interest rates and inflation expectations, which should make them more volatile and thus have greater CDS spread also.

	CDS 2y EURIBOR PANEL BANKS	CDS 5y EURIBOR PANEL BANKS
Mean	171,64	186,34
Median	148,29	159,02
Standard Deviation	92,83	89,42
Kurtosis	1,05	1,75
Skewness	1,30	1,52
Jarque-Bera	286,66	448,36
Minimum	63,17	87,84
Maximum	472,82	490,27
Count	879	879

Table 4.6 Descriptive statistics of Euribor panel credit default swap (CDS) spreads

From Table 4.6 we can see that each Euribor panel CDS spreads are positively skewed to the right end. The values of kurtosis below three implicate flat distributions different from the assumption of normal distribution. Neither skewness nor kurtosis supports the null hypothesis that data is normally distributed. The values of the Jarque-Bera test confirm the rejection of null hypothesis.

4.7 Euro – U.S. dollar foreign exchange rate

I wanted to take into account euro – U.S. dollar foreign exchange rate as well. Reasoning behind this is that currencies are traded on an open market, and the demand for them fluctuates based on what is happening in the country or area that uses the currency. In addition, the responses to news about macroeconomic variables will be reflected rapidly in exchange rates, although the relative importance of individual macroeconomic variables shifts over time (Chinn, 2003). However, according to Chinn (2003) economic fundamentals appear to be more important at longer horizons. Correspondingly, short-run deviations of exchange rates from their fundamentals refer more to speculation and institutional customer or hedge fund manipulation. Thus, I take this factor as a component providing information of responses to news about macroeconomic variables.

I gathered bilateral exchange rate data from ECB Statistical Data Warehouse. Bilateral exchange rate between euro and the U.S. dollar is the price of dollars in terms of euros. The European Central Bank has no explicit exchange rate objective. The euro floats freely in world foreign exchange markets against other currencies such as the U.S. dollar. However, ECB may prevent fluctuations in the euro exchange rate by purchasing or selling euro against other currencies, when needed.

The ECB have supplementary instruments needed to effectively implement exchange rate policy. Effective exchange rate policy requires four main ingredients: First, monitor and assess exchange rate markets and developments. Second, discuss about market developments with the other major partners. Third, make public statements. Fourth, intervene in the foreign exchange markets. International exchange rate policy is targeted to the specific circumstances such as to prevent the negative effect of the current crisis. This, in turn should help to restore confidence in the financial markets. (ECB, The Euro Area's Exchange Rate Policy and the Experience with International Monetary Coordination during the Crisis, 2009)

During the financial turmoil, foreign exchange markets swings in euro – U.S. dollar bilateral rates have been quite smooth according to Figure 4.15. Until the June 2008, the U.S. dollar weakened against the euro (out of the data scope of this study). This reflected the market perception that the turbulence originated in the United States. However, later on and especially after the Lehman Brothers collapsed, the euro has weakened against the U.S. dollar. The U.S. dollar benefited from increased risk aversion worldwide as well as widespread shortage of dollar liquidity in financial markets. Recently, the foreign exchange rate has been fluctuating around 1,3 and 1,4.

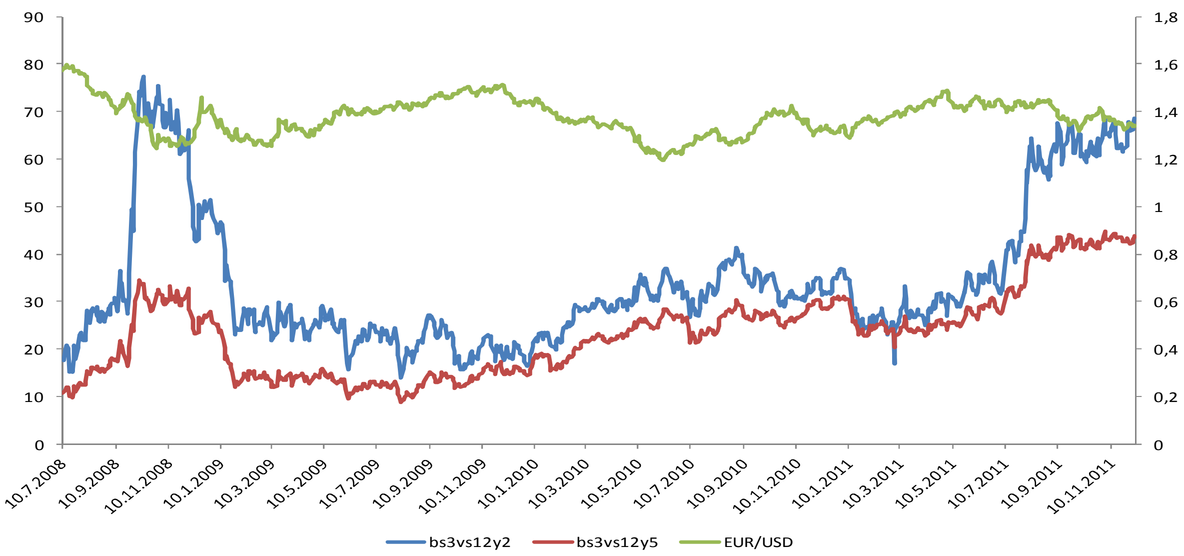

Figure 4.15 Euro – U.S. dollar exchange rate (right axis) with respect to 3M vs. 12M Euribor basis swap spreads with 2 year and 5 year maturities (left axis)

Figure 4.15 demonstrates the relationship between euro – U.S. dollar exchange rate and 3M vs. 12M Euribor basis swap spread with 2 and 5 year maturities. Based on Figure 4.15 I am not able to draw a clear conclusion whether foreign exchange rate and 3M vs. 12M Euribor basis have been significantly correlated or not. According to correlation matrix I presented in Appendix 1, the correlation is negative. In overall, fluctuations in Euribor basis swap spreads are more volatile than in foreign exchange rate. This will lead me to consider euro – U.S. foreign exchange rate as a significant macroeconomic component affecting Euribor basis swap spreads.

Table 4.7 reports summary of descriptive statistics on euro – U.S. dollar exchange rate over the sample period. Mean and median of euro – U.S. dollar exchange rate is 1,38. Maximum is 1,60 and a minimum 1,19 over the sample period. Standard deviation is 0,08. Euro – U.S. dollar exchange rate is slightly positively skewed to the right end but the distribution is very close to normal distribution. On the other hand, the values of kurtosis below three implicate flat distributions different from the assumption of normal distribution. Skewness supports properties of the normal distribution but kurtosis is against the null hypothesis that data is normally distributed. The value of the Jarque-Bera test confirm the acceptance of null hypothesis.

Table 4.7 Descriptive statistics of euro – U.S. dollar exchange rate

	EUR/USD
Mean	1,38
Median	1,38
Standard Deviation	0,08
Kurtosis	-0,21
Skewness	0,10
Jarque-Bera	3,08
Minimum	1,19
Maximum	1,60
Count	879

5 METHODS

The empirical part of the study is based on historical values of Euribor basis swap spreads and explanatory variables. Aim of the study is to build a comprehensive model that could explain Euribor basis swap spreads. Another aim of the study is to understand short-run and long-run relations between explanatory variables. In the empirical part, I will first use regression analysis. In the second part, I will run co-integration analysis in order to determine whether the model has any short-run or long-run relations. Similar kind of regression methods have been used by Baglioni (2009), Frank et al. (2009) and Taylor et al. (2009) in investigation of Libor-OIS spreads. Co-integration techniques used in the study, are developed by Johansen (1988) and Engle & Granger (1987).

5.1 Linear regression model

I will estimate linear regression models in this study using the regression analysis with straightforward ordinary least squares (OLS) method. I tested the empirical data and obtained result with the Gretl. The multiple variable linear regression model is of the form:

$$Y_i = \alpha + \beta_1 X_{i1} + \beta_2 X_{i2} + ... + \beta_k X_{ik} + \varepsilon_t \, , \qquad (5.1)$$

where Y_i is the ith observation on the dependent variable Y, X_{ik} is the ith observation on the independent variable X_k. α is the intercept and β_1, β_2,..., β_k are the slope coefficients and ε_i is the error term (residual). The model is linear because increasing the value of the ith regressor by one unit increases the value of the dependent by β_i units.

Underlying assumptions of the linear regression analysis are:

Assumption	*Interpretation*
1. $E(\varepsilon_i\|X_i) = 0$	The errors have zero mean
2. $Var(\varepsilon_i\|X_i) = \sigma^2$	The variance of the errors is constant and finite over all values of X_i
3. $cov(\varepsilon_{i,} \varepsilon_j\| X_{i,} X_j) = 0$	The errors are linearly independent of another
4. $cov(\varepsilon_{i,} X_{ik}) = 0$	There is no relationship between the error and corresponding X variant
5. $\varepsilon_i \sim N(0, \sigma^2)$	Errors are normally distributed
6. No perfect multicollinearity	There should be no relationship between the explanatory variables

Table 5.1 OLS assumptions (Brooks, 2008. 44)

If the data to be analyzed by linear regression violate one or more of the linear regression assumptions, the results of the analysis may be incorrect or misleading. In this study, I will assume that log-differentiated variables (1st degree) closely qualify the assumptions of the linear regression analysis. This is because the level variables of the study are non-stationary (test results are available further in chapter 6) and thus cannot provide realistic results. Instead, the estimation results indicate spurious regressions, when linear regression is used with non-stationary data. If the assumption of independence is violated, linear regression is not appropriate. This I will avoid by omitting variables that are significantly correlated (correlation coefficient ≥0,8) with each other and taken into account the variable alone that is more correlated dependent variable. The impact of an assumption violation on the linear regression result usually depends on the extent of the violation. However, some small violations may have little practical effect on the analysis and results.

5.2 Towards the co-integration analysis (Augmented Dickey-Fuller test)

Co-integration is a special case of non-stationary variables and restores the feasibility of linear regression models in this sense. In this special case, non-stationary variables are co-integrated, if they are independently integrated with the same degree. Many time series are non-stationary, but tend to be moving together over time. In general, researchers may make a conclusion that there exist some influences, for example market forces on the series, which imply that the two series are tied by some relationship in the long-run. A co-integrating relationship may also be seen as a long-term or equilibrium phenomenon, since it is possible that co-integrating variables may deviate from their relationship in the short run, but would return on track in the long-run. (Brooks, 2008. 336) On the other hand, if there were no co-integration, there would be no long-run relationship binding the series together. Such a relationship would arise since all linear combinations of the series would be non-stationary. If the dependent variable and explanatory variable(s) are co-integrated, they are expected to be variables of the same process at different points in time, and hence will be affected in very similar ways by given pieces of information.

In order to test whether the data is stationary or not, I will apply the augmented Dickey-Fuller test for auto-correlated time-series (ADF). Stationary process has the same parameters between different time and position. In this study, for example time-series of euro area debt to GDP is not stationary, because they exhibit time trends. Most of the non-stationary time-series can be converted to stationary processes through differentiating as many times as it is needed to get a stationary time-series. A case when the first difference of the process is stationary is difference stationary process. Stationarity of the data closely implicates the properties of estimation methods used in the study, like linear regression model and the co-integration analysis. If the variable is not stationary, it must be transformed to stationary before OLS-regressions can be calculated as mentioned in previous subchapter. The first order integration of the data is crucial for the co-integration analysis. If, the data series follows an autoregressive process where, the error term in the standard Dickey-Fuller test will be auto-correlated, will invalidate the use of the Dickey-Fuller test. Thus, I must apply the augmented Dickey-Fuller (ADF) test, which includes additional lagged difference terms to account the autocorrelation problem. The test of a unit root existence is based on one of the following regression equations according to Dickey and Fuller (Enders, 2004. 181 – 183):

$$\Delta Y_t = \gamma Y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta Y_{t-i+1} + \varepsilon_t \qquad (5.2)$$

$$\Delta Y_t = a_0 + \gamma Y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta Y_{t-i+1} + \varepsilon_t \tag{5.3}$$

$$\Delta Y_t = a_0 + \gamma Y_{t-1} + a_2 t + \sum_{i=2}^{p} \beta_i \Delta Y_{t-i+1} + \varepsilon_t , \tag{5.4}$$

where Δ represents first differences of Y_t. a_0 and a_2t are deterministic elements, γ and β are coefficients to be estimated, *p* is the number of lagged terms, t is the trend, a_2 is the estimated coefficient for the trend, and the error term ε_t is white noise process. The null hypothesis to be tested is $\gamma=0$. If the null hypothesis is rejected then the series is stationary and $\gamma<0$. (Enders, 2004. 181 – 183)

The equation 5.2 is a pure random walk model without a constant and time trend, the second model includes constant without time trend, and third includes both constant and time trend.

In order to test the significance of the estimated γ coefficients, I will calculate the augmented Dickey-Fuller unit root test using the τ-statistic for each estimated coefficient, in the same way as with the student's t-statistic. However, the estimated τ values do not follow the same distribution as student's t-test. I assess the statistical significance of the estimated τ values by comparing them with critical values derived for the τ distribution presented by Dickey and Fuller (1981). If the estimated τ value is less than the critical value in absolute terms, then the null hypothesis of the existence of unit root cannot be rejected. Critical values depend on the sample size, as is the case with most type of hypothesis tests in statistics. For any given level of significance the critical values of the t-statistic decrease as sample size increases. (Enders 2004, 182 - 183) MacKinnon (1991) estimates the calculation of Dickey-Fuller critical values for any sample size. In this study I will use MacKinnon (2010) critical values for comparison of ADF tests results with critical values.

In addition, I have to investigate the degree of integration of each variable in order to proceed to co-integration tests. Variable Y_t is said to be integrated of degree zero I(0), if it is stationary. Conversely, if the variable Y_t is integrated of degree one I(1), it is non-stationary, but the first difference of a variable, ΔY_t is stationary. In general case, variable has to be differentiated d times in order to get stationary variable. According to common market evidence, economic time-series are usually integrated of degree zero or one.

In order to attain error term that is white noise process, lagged differences (ΔY_{t-1+1}) have to be added into the equation under estimation. The selection of lag length can be done, for example by using Akaike information criteria. From multiple alternative lag lengths, the lag-length with smallest information criteria value should be chosen. Another way to select the appropriate lag-length is to start with relatively long lag length and pare down the model by the usual *t*-test until lag is significantly different from zero (Enders, 2004. 192). Including too few lags will not remove all of the autocorrelation and will cause biased results, while using too many will increase the coefficient standard errors.

5.3 Engle-Granger method

First, I make sure that all of the individual variables are integrated of degree one. Then the co-integrating regression is estimated using ordinary least squares -method (OLS).

$$y_t = \beta_0 + \gamma x_t + \varepsilon_t \tag{5.5}$$

It is not possible to perform any conclusion or relations on the coefficient estimates in this OLS regression. All that can be done is to estimate the parameter values. I conduct the OLS estimation, save the residuals ε_t of the co-integrating regression and see whether residuals are integrated of degree zero. In this case the modified critical values are required in augmented Dickey-Fuller unit root test as the test is now operating on the residuals of an estimated model rather than on raw data (Brooks, 2008. 339). Engle and Granger (1987) have tabulated a new set of critical values for this purpose and hence the test is known as the Engle-Granger (EG) test. However, the critical values of MacKinnon (2010) will be applied in this study, as they fit for any sample size.

If residuals are integrated of degree one, a model needs to be re-estimated using only first differences. After I have tested and found residuals to be integrated of degree zero, residuals are used as one variable in the error correction model. When the concept of non-stationary variables was first considered in the 1970s, a usual practise was to take the first differences of each of the I(1) variables and then to use these first differences in any subsequent modelling process. However, when the relationship between variables is important, such a procedure is not the recommended approach. This is mainly because the pure first difference models have no long-run solution. For example, consider two series, y_t and x_t, that are both I(1) processes. The kind of model has no long-run solution and it therefore has nothing to say about whether *x* and *y* have an equilibrium relationship. Fortunately, several models can handle this issue by using combinations of first differenced and lagged levels of co-integrated variables. An error correction model is one of these models. (Brooks, 2008. 337 – 338). If there exists a dynamic linear model with stationary disturbances and the y_t and x_t datasets are I(1), then the variables must be co-integrated of order CI(1,1). The model can be expressed in general form as follows (Enders, 2004. 335 – 338).

$$\Delta y_t = \beta_1 + \beta_y (y_{t-1} - \gamma x_{t-1}) + \sum_{i=1} \beta_{11}(i) \Delta y_{t-i} + \sum_{i=1} \beta_{12}(i) \Delta x_{t-i} + \varepsilon_{yt} \tag{5.6}$$

$$\Delta x_t = \beta_2 + \beta_x (y_{t-1} - \gamma x_{t-1}) + \sum_{i=1} \beta_{21}(i) \Delta y_{t-i} + \sum_{i=1} \beta_{22}(i) \Delta x_{t-i} + \varepsilon_{xt} \tag{5.7}$$

in which the term $(y_{t-1} - \gamma x_{t-1})$ is known as the error correction term or co-integrating vector form. It is possible to use saved residuals $\dot{\varepsilon}_{t-1}$ obtained in equation 5.5 as an instrument for the expression of error correction term. Additionally, an error correction model can be estimated for more than two variables. Provided that y_t and x_t are co-integrated, the parameters of co-integrating vector are expressed in γ. Then $(y_{t-1} - \gamma x_{t-1})$ will be I(0) even though the ordinary variables are I(1). It is thus valid to use OLS and standard procedures. Error correction model can be interpreted as follows. *y* is expected to change between *t–1* and *t* as a result of changes in the values of the explanatory variable(s), *x*, between *t–1* and *t*, and also in part to correct for any possible disequilibrium existed during the previous period. γ defines the long-run relationship between *x* and *y*. β_1, β_{11}(i), β_{12}(i), β_2, β_{21}(i) and β_{22}(i) are parameters, which describe the short-run relationship between changes in *x* and changes in *y*. The speed of adjustment coefficicient β_y and β_x are of particular interest and describes the speed of adjustment back to equilibrium. The higher the coefficient the more significant the reaction to deviation from previous period. Strict definition of β_y and β_x is that it measures the proportion of last period's equilibrium error that is corrected for. (Brooks, 2008. 338 – 339). In general, both variables of co-integrated process should react to deviations from equilibrium. For example, coefficient β_y should be negative and β_x positive, in order to process adjust back to long-run equilibrium. However, it is possible that one of the speeds of adjustment (e.g. β_y) coefficients is zero. This would implicate that variable y_t is not reacting to deviation from long-run equilibrium and variable x_t is responsible for adjustment. In this case y_t is said to be weakly exogenous.

The Engle-Granger approach is easy to use, but one of its major drawbacks is that it can estimate only up to one co-integrating relationship between the multiple variables. This lacks the reliability of the method. In addition, there could be a simultaneous equations bias if the causality between variables y and x runs in both directions but Engle-Granger approach requires one variable to be normalized (i.e. one variable to be specified as the dependent variable and the others as independent variables). (Brooks, 2008. 342) This is why the co-integrating relation must be tested in both directions.

5.4 Johansen's method

Johansen's method provides an improvement to problems that arose in Engle-Granger method. It allows to test a hypothesis for one or more coefficients in the co-integrating relationship. This is conducted by viewing the hypothesis as a restriction on the Π matrix. If there exist r co-integrating vectors then only these linear combinations of the co-integrating vectors, will be stationary (Brooks, 2008. 354). Johansen's method is based on maximum likelihood approach for testing co-integration in multivariate autoregressive models. The method is relying on the relationship between the rank of a matrix and its characteristic roots. It provides two tests to determine the number of co-integrating vectors. These are known as trace and maximum characteristic roots (also known as eigenvalues) tests.

In a starting point to Johansen's methodology, I consider simple *n*-variables vector autoregressive (VAR) model

$$x_t = A_1 x_{t-1} + \varepsilon_t . \tag{5.8}$$

Then x_{t-1} is subtracted in the above equation so that

$$\begin{aligned} \Delta x_t &= A_1 x_{t-1} - x_{t-1} + \varepsilon_t \\ \Delta x_t &= (A_1 - I)\, x_{t-1} + \varepsilon_t \\ \Delta x_t &= \Pi\, x_{t-1} + \varepsilon_t , \end{aligned} \tag{5.9}$$

in which x_t and ε_t are (n x 1) vectors, A_1 is an (n x n) matrix of parameters, I is an (n x n) identity matrix and Π is defined to be ($A_1 - I$). (Enders, 2004. 348)

Equation 5.9 can be generalized in a multiple different ways. For example, a drift can be added into equation, when a process generating the observations involve according to a linear trend. On the other hand, lagged differences can be added if higher-order autoregressive AR(p) processes are approved. (Enders, 2004. 349 – 352) I used Akaike information criteria to select the appropriate number of lags to eliminate autocorrelation from the co-integration relation.

The number of co-integration vectors may be solved by investigating statistical significance of the characteristic roots of Π matrix. The key feature is rank, *r*, of the Π matrix as it is equal to the number of independent co-integrating vectors. If the rank of the matrix is zero, none of the characteristics roots differs statistically significantly from zero and variables are not co-integrated. On the other hand if matrix is of rank *n*, the vector process is stationary. Between these extreme cases, in which the rank of the matrix is $1 < r < n$, there exist *r* co-integrating vectors. (Enders, 2004. 352)

In practice, only estimates can be obtained of Π and its characteristic roots. To estimate the number of characteristic roots that are different from zero can be conducted using the following two statistics

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \quad (5.10)$$

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}), \quad (5.11)$$

in which T is the number of usable observations and $\hat{\lambda}_i$ are the estimated values of the characteristic roots (eigenvalues) obtained from the estimated Π matrix. (Enders, 2004. 352 – 353)

The equation 5.10 tests the null hypothesis that the number of distinct co-integrating vecrtors is less than or equal to *r* against the alternative hypothesis that the number of co-integrating vectors is greater than *r*. The alternative result of the λ_{trace} statistics is rather general and the exact number of co-integrating vectors cannot be cocluded from the test results. Conversely, the exact number of co-integrating vectors can be estimated by the λ_{max} statistics. The λ_{max} test is usually preferred for trying to estimate the number of co-integrating vectors. The null hypothesis is now that the number of co-integrating vectors is *r* against the alternative *r+1* co-integrating vectors. In both cases, the null hypothesis is rejected, if the value from test statistics is greater than the critical value. Critical values of the λ_{trace} and the λ_{max} statistics are obtained from Osterwald-Lenum (1992). (Enders, 2004. 353)

Finally, when the co-integration rank is established, I will form a vector error correction model quite similarly as was the case with Engle-Granger method in order to investigate short- and long-run co-integrating relations together. A vector error correction model (VECM) is a restricted VAR constructed for use with non-stationary series that are known to be co-integrated. I will use Gretl VAR lag-length selection and VECM functionalities to conduct Johansen's tests.

6 EMPIRICAL TEST RESULTS

In this chapter I will first introduce unit root test results of augmented Dickey-Fuller tests. After that I have obtained the unit root test results, I will analyse and present OLS regression results. This is the first part of the empirical testing of the study. In the second part, I will conduct co-integration tests to variables that are integrated with the same degree. I use two alternative methods that were described in chapter 5. As a first method, I run two-stage Engle-Granger co-integration test and estimate the error correction model (ECM). As a second method, I use Johansen's co-integration test methodology, which provides two test statistics λ_{trace} and the λ_{max}. After I have obtained the test results, I will shortly analyse causes and effects of each result separately in the end of each subchapter. I make my final comments and conclusions in the chapter 7.

Initially, I will use each test method using variables based on my hypothesis about significant factors in chapter four. In summary, those were open market operations, deposit facility, reserve requirements, euro – U.S. dollar foreign exchange rate, Eurobond CDS spread with 10 year maturity and Eurobond yields of the same maturities than dependent variable. If I find that my variables of my hypothesis do not provide significant results when conducting these tests, I will try to estimate a model that could provide significant results. Thus in each subchapter results are in some sense different. However, I found out one significant relationship between Euribor basis swap spreads and one independent factor in each of the three tests.

6.1 Unit root tests

I used the Augmented Dickey-Fuller test to test the null hypothesis of a unit root for each datasets without a constant and time trend, with a constant and with a constant and a time trend. I select the appropriate lag length using general to specific rule, where I start with a relatively large value of lags (p^*), test the significance of the last coefficient and reduce p iteratively until the process is significantly different from zero. In this study, the initial p value I have used is twenty lags. In the case of a daily data, it is quite impossible to conclude anything reasonable about the lag length selection. As a rule of thumb, monthly data should contain twelve lags, conversely in a quarterly data, lag length of four would be appropriate.

The results from the ADF tests are available in Appendix 4. The null hypothesis I tested is γ=0. If the null hypothesis is rejected, then the series is stationary and contains unit root. I compare the results to MacKinnon (2010) critical values for any sample size. The level data of 3M vs. 6M 1 year, 3M vs. 6M 2 year, 1M vs. 3M 2 year and 1M vs. 3M 5 year Euribor basis swap spreads was found to be stationary if constant term is included in the regression in 5 percentage significance level (in each case). In addition 1M vs. 3M 2 year and 5 year Euribor basis swap spreads are stationary respectively in 1 percentage and 10 percentage significance level if constant and trend are included. However, these are not at particular interest of the study and in addition, every other basis swap spreads are non-stationary. Explanatory variables on my way to estimating a comprehensive model are mostly non-stationary in level stage. Only marginal lending facility, current account holdings and key interest rates of the ECB are stationary. Key interest rates are stationary in two of the first cases, which I could already expect beforehand based on the Figure 4.5. in chapter 4. They do not contain a deterministic or stochastic trend. In chapter 4, I assumed marginal lending facility and current account holdings to be correlated insignificantly with Euribor basis swap spreads, which do not support the use of those variables in the model construction. Marginal lending facility is stationary in each of three cases. Current account holdings are stationary in two of the last cases. In addition, I will omit euro area debt to GDP ratio from model estimation because it is stationary in level stage with 10 percentage significance level. However, I will include euro – U.S. dollar exchange rate and euro area deficit to GDP ratio, as they both are stationary in the differences level, but non-stationary in the level stage (neither constant nor trend case). My logic behind omitting stationary variables (in level stage) in this point, comes from the fact that when running a co-integration test, testable variables must be integrated of the same degree, that is I(1) in order them to be co-integrated CI(1,1). Variables that were stationary in level stage are I(0), and thus cannot co-integrate with the first degree integrated variables as they are of the different degree.

I found the ADF test results of the first differences of raw data to support the evidence that different datasets could be co-integrated. Variables that were non-stationary in level stage were found to be stationary when differentiated with the first degree. As we can see from Appendix 4, the null hypothesis is rejected in every case, except in the case of covered bond purchase programme and euro area debt to GDP ratio. Thus, I will not take into account the covered bond purchase programme when conducting co-integration tests. The next step will be the test of co-integration using Engle-Granger methodology as well as Johansen's methodology in order to provide proof for the possible co-integration. The test results are presented in subchapters 6.3 and 6.4.

The third column of table on Appendix 4, provides unit root test results for relative factor changes. Except the debt and deficit to GDP ratios, all datasets are stationary in relative changes level and in each of the three cases. These results give support to use relative factor changes in linear regression model as explanatory variables in order to aim to build a comprehensive model. In the following subchapter I will present the OLS test results.

6.2 Linear regression model

Relating to the augmented Dickey-Fuller tests I presented in the previous subchapter, I will use the relative changes in factors as a dependent and explanatory variables in OLS regression. I see that use of relative changes is supported in this case, as the variables are in several different units, that is, basis point, percentage and EUR 100 millions. In general, the use of relative changes is adopted as a general method in time-series analysis and modelling. The interest of the study is particularly in 3M vs. 12M Euribor basis swap spread movements, as they are probably the most commonly used by financial institutions. Especially, this is the case for credit institutions that have their funding in 3 month tenor but lending in 12 month tenor. Thus, movements in spreads are quite significant factor in order to plan timing of hedging. In addition, basis spreads may cause difficulties with respect to valuation in IFRS-accounting. In the limited scope of the study, I will conduct tests only for 3M vs. 12M Euribor basis swaps with 2 year and 5 year maturities, but parts of the other test results are reported in appendices.

Descriptive statistics of relative changes in factors can be found from Appendix 5. One clear conclusion that arises from the test results is that datasets of relative factor changes do not support all of the OLS assumptions as they are skewed (in most of the cases to the right) and peaked, reflecting high skewness and kurtosis values. Jarque-Bera test results support the rejection of null hypothesis that datasets are normally distributed. In spite of the fact that datasets do not fully fulfil the requirements of OLS assumptions, I decided to carry the linear regression model in order to estimate a comprehensive model and find out what are the differences of the results between different methods applied in the study. Initially, I conducted OLS estimations and co-integration analysis using same independent variables that were open market operations, deposit facility, reserve requirements, euro – U.S. dollar foreign exchange rate, Eurobond CDS spread with 10 year maturity and Eurobond yields of the same maturities than dependent variable. I decided to omit autonomous liquidity factors including SMP at this point, because at level stage it is correlated significantly with Eurobond CDS spreads. However, Eurobond CDS spreads were correlated more significantly with Euribor basis swap spreads. Appendix 6 presents test results. Results indicate that relative changes in open market operation, deposit facility or reserve requirements do not explain significantly changes in 3M vs. 12M Euribor basis swap spreads.

As the variables based on my initial hypothesis could not provide a comprehensive model, in which each explanatory variable would have been significantly different from zero, I decided to proceed my way to estimate a model which could handle this problem. First, I used correlation matrix in Appendix 7 and the table of correlation between 3M vs. 12M Euribor basis swap spreads with 2 year and 5 year maturities including one to five leads and lags of explanatory variables in (Appendix 8) in order to see what factors are correlating with relative changes in basis swap spreads. In order to circumvent multicollinearity between explanatory variables, construction of a pair-wise correlation matrix will yield indications of the likelihood that any given pair of explanatory variables have multicollinearity. Correlation values between 0,6 and 0,8 can indicate a problem of multicollinierity (Chennamaneni et al. 2008). Sometimes variables may be correlated as high as 0,8 without causing problems. In this study, I use values higher than 0,8 as a limit value in order to omit the less correlated value with Euribor basis swap spreads. Before moving deeper into the multicollinearity topic, I will point some interesting observations from table regarding correlation between 3M vs. 12M Euribor basis swap spreads with 2 year and 5 year maturities including one to five leads and lags of explanatory variables

(Appendix 8). Altogether, I conclude from the table that correlations are minor. The explanatory variables and their leads and lags that were greater or equal than for value 0,1 correlated with spreads are highlighted in green colour. The relative changes in deposit facility, euro – U.S. dollar foreign exchange rate, Eurobond yields, Eurobond CDS spreads and Euribor panel banks CDS spreads were correlated with values more than 0,1. Based on these correlations, I conducted multicollinearity check according to previously presented procedure for each significant variable by investigating the values over 0,8 (highlighted in red) in correlation matrix presented in Appendix 7. As a result, I estimated models in equations 6.1 and 6.2 for 2 year and 5 year maturities of 3M vs. 12M Euribor basis swap spreads, respectively. For 2 year maturity the model is:

$$
\begin{aligned}
&\Delta \ln(bs3vs12\_y2_t) \\
&= \beta_1 \Delta \ln(EUR\_USD_t) + \beta_2 \Delta \ln(EurobondCDS10y_{t-1}) \\
&+ \beta_3 \Delta \ln(Deposit\_facility_{t+4}) + \beta_4 \Delta \ln(CDS\_5y\_EBR\_panel)_t \\
&+ \beta_5 \Delta(\ln Eurobond2y_t) + \varepsilon_t
\end{aligned} \quad (6.1)
$$

The estimation results for 3M vs. 12M 2 year Euribor basis swap spread are in Table 6.1.

Model 1: OLS, using observations 2008/07/14-2011/12/02 (T = 873)
Dependent variable: bs3vs12y2

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
EUR_USD	-0,55721	0,222804	-2,5009	0,01257	**
EurobondCDS10y_1lag	0,102794	0,046928	2,1905	0,02876	**
Deposit_facility_4lead	0,00178118	0,00077272	2,3051	0,02140	**
CDS_5y_EBR_Panel	0,305584	0,0613001	4,9850	<0,00001	***
Eurobond2y	-1,14111	0,0620061	-18,4031	<0,00001	***

Mean dependent var	0,003292	S.D. dependent var	0,060111
Sum squared resid	2,200789	S.E. of regression	0,050353
R-squared	0,303600	Adjusted R-squared	0,300391
F(5, 868)	75,68204	P-value(F)	7,28e-66
Log-likelihood	1372,898	Akaike criterion	-2735,797
Schwarz criterion	-2711,937	Hannan-Quinn	-2726,669
rho	-0,071700	Durbin-Watson	2,135501

Table 6.1 Ordinary least squares (OLS) estimation results for 3M vs. 12M 2 year Euribor basis swap spread.

Coefficient of determination R^2, as well as adjusted coefficient of determination is approximately 0,30. Thus, model explains 30 percent of the movements in 3M vs. 12M Euribor basis swap spread with 2 year maturity. In order to estimate the model, I conducted several estimations to find a definitive combination in both cases. The coefficient of determination cannot provide alone trustworthy results in way to estimate the most comprehensive model. As a supplementary method, I used the Akaike information criterion, which is a measure of the relative goodness of fit of a statistical model. The model is based on the fact that there will almost always be information loss due to using one of the candidate models to represent the true model. Thus from among several models, the model that minimizes the information loss will be selected. Constant and trend terms were not included in the models. The constant term was not significantly different from zero in either of the two cases. In addition, it is best to avoid the use of trend as an explanatory variable unless there is some good reason to include that in the estimation (Enders, 2004. 352).

Durbin-Watson test results can be also found from the table. They test for autocorrelation in the residuals from a regression analysis. A value of near two means that there is no autocorrelation in the sample dataset while values approaching to zero indicate positive autocorrelation and values towards four indicate negative autocorrelation. Standard errors of the regression coefficients are quite acceptable as well standard error of the regression. They measure respectively the amount of sampling error in a regression coefficient and the scatter of the actual observations outside the regression line. P-value of *F*-statistic tests the hypothesis that all coefficients are equal to zero. However, when errors are not normal this statistic becomes invalid. According to *t-ratios* each variable is significantly different from zero in 5 percentage significance level. A general assumption regarding *student's t* distribution is that if the error terms of the regression approximately follow a normal distribution, then *t*-statistics follow a *student-t* distribution. However, because the errors ε_t do not follow a normal distribution in this case, the interpretation of the results becomes more complicated. Finally, the interpretation of coefficients of least squares estimates (Table 6.1) indicate that: 1 percentage increase in euro – U.S. dollar foreign exchange rate is associated with an decrease of 0,56 percentage in 2 year Euribor basis swap spread, 1 percentage increase in second lag of 10 year Eurobond CDS spread is associated with an increase of 0,10 percentage in 2 year Euribor basis swap spread, 1 percentage increase in fourth lead of deposit facility is associated with an increase of approximately 0,002 percentage in 2 year Euribor basis swap spread, 1 percentage increase in 5 year Euribor panel bank CDS spread is associated with an increase of 0,31 percentage in 2 year Euribor basis swap spread, 1 percentage increase in 2 year Eurobond yield is associated with an decrease of 1,14 percentage in 2 year Euribor basis swap spread.

The model equation for the 3M vs. 12M Euribor basis swap spread with 5 year maturity is:

$$\begin{aligned} &\Delta \ln(bs3vs12\_y5_t) \\ &= \beta_1 \Delta \ln(EUR\_USD_t) + \beta_2 \Delta \ln(EurobondCDS10y_{t-1}) \\ &+ \beta_3 \Delta \ln(Deposit\_facility_{t+4}) + \beta_4 \Delta \ln(CDS\_5y\_EBR\_panel)_t \\ &+ \beta_5 \Delta (\ln Eurobond5y_t) + \varepsilon_t \end{aligned} \tag{6.2}$$

Model 2: OLS, using observations 2008/07/14-2011/12/02 (T = 873)
Dependent variable: bs3vs12y5

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
EUR-USD	-0,55634	0,159554	-3,4869	0,00051	***
EurobondCDS10y_1lag	0,0569563	0,033673	1,6915	0,09111	*
Deposit_facility_4lead	0,00126459	0,000553041	2,2866	0,02246	**
CDS_5y_EBR_Panel	0,104584	0,0440905	2,3720	0,01791	**
Eurobond5y	-1,16142	0,0725691	-16,0044	<0,00001	***

Mean dependent var	0,002411	S.D. dependent var	0,041667
Sum squared resid	1,127320	S.E. of regression	0,036038
R-squared	0,257833	Adjusted R-squared	0,254413
F(5, 868)	60,30970	P-value(F)	5,67e-54
Log-likelihood	1664,905	Akaike criterion	-3319,810
Schwarz criterion	-3295,950	Hannan-Quinn	-3310,682
rho	-0,025537	Durbin-Watson	2,050646

Table 6.2 Ordinary least squares (OLS) estimation results for 3M vs. 12M 5 year Euribor basis swap spread.

Coefficient of determination R^2, as well as adjusted coefficient of determination is approximately 0,25. Thus, model explains 25 percent of the movements in 3M vs. 12M Euribor basis swap spread with 2 year maturity. Test statistics of Durbin-Watson is supportive to no autocorrelation. Standard errors of the regression coefficients are quite acceptable as well standard error of the regression. According to *t-ratios* each variable is significantly different from zero in 5 percent significance level (except 10 year Eurobond CDS spread in 10 percent significance level). The coefficients of least squares estimates of parameters (Table 6.2) indicate that: 1 percentage increase in euro – U.S. dollar foreign exchange rate is associated with an decrease of 0,56 percentage in 5 year Euribor basis swap spread, 1 percentage increase in second lag of 10 year Eurobond CDS spread is associated with an increase of 0,06 percentage in 5 year Euribor basis swap spread, 1 percentage increase in fourth lead of deposit facility is associated with an increase of approximately 0,001 percentage in 5 year Euribor basis swap spread, 1 percentage increase in 5 year Euribor panel bank CDS spread is associated with an increase of 0,10 percentage in 5 year Euribor basis swap spread, 1 percentage increase in 5 year Eurobond yield is associated with an decrease of 1,16 percentage in 5 year Euribor basis swap spread.

In addition, I estimated both models using the Newey-West procedure that produces HAC (Heteroscedasticity and Autocorrelation Consistent) standard errors that correct for both possible autocorrelation and heteroscedasticity that may be present. The results of estimations (variables significantly different from zero) did not change as the result of applying Newey-West procedure.

6.3 Engle-Granger co-integration test

The co-integration analysis focuses on the short- and long-term relationship between the variables whereas linear regression model with log-differences focuses exclusively on the short-run relationship. In this sense co-integration analysis provides more comprehensive results on relations between dependent and explanatory variables.

In step 1, I conducted co-integrating regression using OLS with level variables. The explanatory variables in regression were open market operations, deposit facility, reserve requirements, 2 year Eurobond yield, 10 year Eurobond CDS spread and euro – U.S. dollar foreign exchange rate. In order to avoid multicollinearity, I used pair-wise examination and omitted variables that were correlated more insignificantly with Euribor basis swap spread. Appendix 1 presents correlation matrix of level variables. In step 2, I saved the residuals from OLS estimation, took lags and conducted unit root test with MacKinnon critical values. Table 6.3 present the results and critical values for unit root tests.

	level of signifcance	test result
resid_bs3vs12y2_t-1		-3,6646
resid_bs3vs12y5_t-1		-2,7043
Critical values (constant)	1 %	-4,9825
T=6 N=879	5 %	-4,7261
	10 %	-4,4400

resid_bs3vs12y2_t-1		-3,7939 or -4,0919
resid_bs3vs12y5_t-1		-3,3029 or -3,6353
Critical values (constant)	1 %	-5,2750
T=7 N=879	5 %	-5,0008
	10 %	-4,7154

T= number of variables
N=number of observations

Table 6.3 Unit root test results for residuals from six, seven and eight variable regression models.

Initially, I ran the unit root tests for residuals from regression with constant and six variables, one dependent and six independent. Results indicate that null hypothesis cannot be rejected in any of the three significance levels. Thus, there is no co-integration according to Engle-Granger method when all reasonable variables are taken into account. However, I wanted to investigate further whether the omitting of euro – U.S. dollar foreign exchange rate or more variables, will modify the test results. I rationalize the ignorance of euro - U.S. dollar exchange rate relying on the fact that it was stationary with 5 percentage significance level in level stage if constant term was included. Generally, Engle-Granger method is rather fragile to errors made in step 1. This gives reason to test different combinations. As we can see from Table 6.3, neither unit root tests with six nor seven variables in regression cannot reject the null hypothesis. Finally, I took into account all variables presented in chapter four similarly as was the case with linear regression model in latter part of the previous subchapter. I conducted pair-wise OLS-estimation for levels and saved the residuals to see are they stationary or not. We can find the results were unit-root was found from Table 6.4. 3 month vs. 12 month 2 year Euribor basis swap spread and Eurobond 2 year, rejects the null hypothesis in 5 percentage significance level. In addition, combination of 3M vs. 12M Euribor basis swap spread with 2 year maturity and euro area deficit to GDP ratio rejects the null in 5 percentage significance level whereas 3M vs. 12M 5 year Euribor basis swap spread and autonomous liquidity factors including SMP rejects the null in 10 percentage significance level. The latter result is quite interesting because if we have a quick glance back on Figure 4.9 that is in subchapter 4.5.3, autonomous liquidity factor including SMP is converging to zero, while Euribor basis swap spread is currently increasing. Altogether, the result indicate that Euribor basis swap spread with 5 year maturity and liquidity factors are converging in the long-run towards the same path.

		level of signifcance	test result
resid_bs3vs12y2_t-1			-3,6475
resid_bs3vs12y5_t-1			-3,1279
Critical values (constant)		1 %	-3,9089
T=2	N=879	5 %	-3,345
		10 %	-3,0493

resid_bs3vs12y2_t-1			-3,4686
Critical values (constant)		1 %	-3,9096
T=2	N=830	5 %	-3,3431
		10 %	-3,0496

T= number of variables
N=number of observations

Table 6.4 Unit root test results for residual of three pair-wise regression model combinations where null hypothesis was rejected.

The rejection of null hypothesis gives reason to estimate the error correction model. Although I ran unit root tests for residuals including several lagged (maximum was 20) values, in order to preserve degrees of freedom, only one lag was included for simplicity in error correction model estimation. The error correction model is in general form:

$$bs3vs12yy_t = \beta_1 + \beta_{bs3vs12yy}(bs3vs12yy_{t-1} - \gamma regressor_{t-1}) + \sum_{i=1}\beta_{11}(i)\,\Delta bs3vs12yy_{t-i} + \sum_{i=1}\beta_{12}(i)\,\Delta regressor_{t-i} + \varepsilon_t \tag{6.3}$$

$$regressor_t = \beta_2 + \beta_{regressor}(bs3vs12yy_{t-1} - \gamma regressor_{t-1}) + \sum_{i=1}\beta_{21}(i)\,\Delta bs3vs12yy_{t-i} + \sum_{i=1}\beta_{22}(i)\,\Delta regressor_{t-i} + \varepsilon_t \tag{6.4}$$

in which, *bs3vs12yy* is 2 year or 5 year maturity Euribor basis swap spread, the *regressor* corresponds to explanatory variable that had co-integrating relation with Euribor basis swap spread. Table 6.5 presents estimation results of error correction models for each pair-wise co-integrating relation. Constant term is included in regression equations although it proved to be insignificant.

Model 2: OLS, using observations 2008/07/14-2011/12/08 (T = 877)
Dependent variable: d_bs3vs12y2

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0,0642507	0,064069	1,0028	0,31622	
d_Eurobond2_1	-2,15104	1,05693	-2,0352	0,04213	**
resi1_1	-0,0168729	0,00521823	-3,2335	0,00127	***
d_bs3vs12y2_1	-0,0602783	0,0370528	-1,6268	0,10414	

Model 3: OLS, using observations 2008/07/14-2011/12/08 (T = 877)
Dependent variable: d_Eurobond2y

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0,000748418	0,00221499	0,3379	0,73553	
resi1_1	0,000365785	0,000180404	2,0276	0,04291	**
d_bs3vs12y2_1	0,00348098	0,00128098	2,7174	0,00671	***
d_Eurobond2_1	0.250632	0.0365401	6.8591	<0.00001	***

Model 8: OLS, using observations 2008/07/14-2011/10/11 (T = 835)
Dependent variable: d_bs3vs12y2

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0,0583918	0,0667797	0,8744	0,38216	
d_deficitzo_1	-0,596207	1,80784	-0,3298	0,74164	
resi_1	-0,0141298	0,00580983	-2,4320	0,01522	**
d_bs3vs12y2_1	-0,025852	0,0346592	-0,7459	0,45594	

Model 5: OLS, using observations 2008/07/14-2011/09/30 (T = 828)
Dependent variable: d_deficitzone

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	8,25791e-05	0,000295234	0,2797	0,77977	
d_bs3vs12y2_1	5,93041e-05	0,000153538	0,3863	0,69941	
resi2_1	-3,88776e-05	2,6219e-05	-1,4828	0,13851	
d_deficitzo_1	0,972249	0,00796708	122,0332	<0,00001	***

Model 7: OLS, using observations 2008/07/14-2011/12/08 (T = 877)
Dependent variable: d_bs3vs12y5

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0,0379437	0,0281704	1,3469	0,17835	
d_Liquidity_1	0,000385908	0,000381645	1,0112	0,31222	
resi3_1	-0,0145472	0,00495649	-2,9350	0,00342	***
d_bs3vs12y5_1	0,0197938	0,0337749	0,5861	0,55799	

Model 7: OLS, using observations 2008/07/14-2011/12/08 (T = 877)
Dependent variable: d_Liquidity_a

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	-2,59564	2,49753	-1,0393	0,29896	
d_bs3vs12y5_1	0,936055	2,99441	0,3126	0,75466	
resi3_1	-0,559511	0,439432	-1,2733	0,20326	
d_Liquidity_1	-0,0693885	0,0338358	-2,0507	0,04059	**

Table 6.5 Estimation results of error correction model for each co-integrating relations according to pair-wise Engle-Granger methodology.

I consider first the signs and significances of the coefficients in the uppermost model. Two-sided co-integration tests are needed in order to prove the mutual co-integrating relation. β_{12} is negative and significant in the equation 6.3, indicating that the Eurobond yield does lead the Euribor basis swap spread market, since lagged changes in Eurobond yields lead to an opposite change of 2,15 basis points in the subsequent period in 3M vs. 12M Euribor basis swap spread with 2 year maturity. In addition, this means that the change in Eurobond yield alone is responsible for the adaptation in the short-run. The coefficient β_{11} of lagged basis spread is not significant. *T-ratio* of $\beta_{3vs12yy}$ rejects the null hypothesis in 1 percentage significance level, meaning that error correction model is significant. It indicates that if there is a positive difference between 3M vs. 12M 2 year Euribor basis swap and 2 year Eurobond yield, then Euribor basis swap spread will fall during the next period to restore equilibrium and vice versa.

Conversely, β_{21} is positive and significant in the equation 6.4, indicating that the Euribor basis swap spread does also lead the Eurobond yield, since lagged changes in Euribor basis swap spreads lead to change of 0,0035 percentage in Eurobond yield in the subsequent period. The coefficient of lagged Eurobond yield is also significant, since lagged changes in Eurobond yields lead to a change of 0,25 percentage in Eurobond yield in the subsequent period. *T-ratio* of $\beta_{regressor}$ rejects the null hypothesis (in equation 6.4) in 1 percentage significance level, meaning that error correction model is significant. It indicates that if there is a positive difference between 3M vs. 12M 2 year Euribor basis swap and 2 year Eurobond yield, then both Euribor basis swap spread and Eurobond yield will increase during the next period which is not reasonable compared to the estimation result other way round.

The estimation results of second and third model I presented in Table 6.5 are interesting because when I estimated ECM for model 6.3, results indicated that there is significant relationship between the variables only in the long-run. The coefficient of adaptation was 0,014 basis points in both cases (2 year and 5 year maturity), if there was a deviation from long-run equilibrium in the previous period. When estimations were done other way round, the regressors being dependent variable, results did not support either long-run co-movement among variables or short-run relations between regressor and Euribor basis swap spreads. Noteworthy though, ECM coefficients are negative in both cases as it should be according to nature of long-run convergence to exist among variables.

6.4 Johansen's co-integration test

After that I proved variables to be stationary in first differences, I will proceed to obtain appropriate lag length for the VAR. The results of the Johansen's test can be quite sensitive to the lag length. Appendix 9 presents results of the VAR lag length selection. The preferred model is that with the lowest Akaike information criteria value. According to Appendix 9, the optimal number of lags included in the VAR is three.

I took into account constant, dependent 3M vs. 12M 2 year (5 year) Euribor basis swap spread and six independent variables being open market operations, deposit facility, reserve requirements, euro – U.S. dollar foreign exchange rate, Eurobond 2 year (5 year) yield and 10 year Eurobond CDS spread. The results for Johansen's co-integration test with three lags can be found from Table 6.6.

In addition, Engle-Granger test results lead me to estimate a model in which euro area deficit to GDP and autonomous liquidity factors were taken into account. Incorporation of euro area deficit to the model did not change the number of co-integrating relations but autonomous liquidity factors did. However, when I estimated the error correction model including autonomous liquidity factors, test results indicated insignificant correlation in the short- and long-run. Results of the previous were not reported in this scope.

I used two test statistics, trace and maximum eigenvalue, to investigate the co-integration among dependent and explanatory variables. The values of the trace test statistic can be found from column three of the Table 6.6 with 5 percentage critical values in column four. Correspondingly, the maximum eigenvalue test statistics are shown in column five together with their critical values in column six. Critical values are values obtained from Osterwald-Lenum (1992).

Johansen test bs3vs12y2:
Number of equations = 7
Lag order = 3
Estimation period: 2008/07/15 - 2011/12/08 (T = 876)
Case 3: Unrestricted constant

Log-likelihood = -12633,8 (including constant term: -15119,8)

Rank	Eigenvalue	λ_{trace}	CV 5 %	λ_{max}	CV 5 %
0	0,11916	228,88	131,70	111,14	46,65
1	0,046743	117,74	102,14	41,934	40,30
2	0,029924	75,805	76,07	26,614	34,30
3	0,021825	49,191	53,12	19,330	28,14
4	0,017733	29,861	34,91	15,673	22,00
5	0,015753	14,188	19,96	13,910	15,67
6	0,00031755	0,2782	9,24	0,27822	9,24

Johansen test bs3vs12y5:
Number of equations = 7
Lag order = 3
Estimation period: 2008/07/15 - 2011/12/08 (T = 876)
Case 3: Unrestricted constant

Log-likelihood = -11814,4 (including constant term: -14300,4)

Rank	Eigenvalue	λ_{trace}	CV 5 %	λ_{max}	CV 5 %
0	0,11525	203,44	131,70	107,27	46,65
1	0,042022	96,178	102,14	37,607	40,30
2	0,022383	58,570	76,07	19,831	34,30
3	0,017185	38,740	53,12	15,185	28,14
4	0,015308	23,555	34,91	13,513	22,00
5	0,011201	10,042	19,96	9,8674	15,67
6	0,00019920	0,1745	9,24	0,17452	9,24

Table 6.6 Johansen's co-integration test results, trace and maximum eigenvalue tests

The trace and maximum eigenvalue statistics reveals that there are two co-integrating relationship among the variables that are compared with 2 year maturity Euribor basis swap spread. In other words, the trace and maximum statistics results are significant at the 5 percent significance level. Correspondingly, the trace and maximum eigenvalue statistics reveals that there is one co-integrating relationship at the 5 percent significance level among the variables that are compared with 5 year maturity Euribor basis swap spread.

These results together with the pair-wise Engle-Granger test results indicate that there is a long-run co-movement among variables under interest. Therefore, the movement of as particular explanatory variable is related to the movement in Euribor basis swap spread. These results will lead to estimate the vector error correction model (VECM) for the co-integrating variables. Table 6.7 presents the results of the VECM estimation:

	Short-run						
	d_bs3vs12y2	d_Operations	d_Depo	d_EurobondCDS	d_Reserves	d_EUR_USD	d_Eurobond2y
d_bs3vs12y2_1	-0,084**	10,596	5,233	0,165	0,028	-0,000**	0,000
d_bs3vs12y2_2	0,052	25,285***	13,912**	-0,136	-0,015	0,000	-0,000
d_Operations_1	0,000	-0,482***	-0,086**	-0,000	0,000	-0,000	0,000
d_Operations_2	0,000	-0,061	0,020	0,000	0,000	0,000	-0,000
d_Depo_1	0,000	-0,595***	-0,171***	0,000	-0,000	0,000	0,000
d_Depo_2	0,000	-0,457***	-0,100**	-0,000	0,000	0,000	0,000**
d_EurobondCDS_1	0,014	-2,572	0,788	0,276***	-0,031	0,000***	0,003***
d_EurobondCDS_2	-0,005	0,961	-2,579	-0,093**	-0,022	0,000	-0,000
d_Reserves_1	-0,004	2,002	1,370	-0,047	-0,002	0,000*	0,000
d_Reserves_2	0,001	2,437	2,546	-0,062	-0,002	0,000	0,000
d_EUR_USD_1	-2,179	-2611,81*	-1367,21	-0,928	-5,637	-0,046	0,121
d_EUR_USD_2	-3,921	1107,78	528,591	-5,430	-19,202*	-0,003	0,030
d_Eurobond2y_1	-3,113**	51,342	12,640	-3,284	0,907	0,007	0,141***
d_Eurobond2y_2	0,231	161,445	72,716	-1,351	3,637*	0,005	-0,035
EC1	-0,009**	2,539***	1,908***	0,000	0,010	-0,000	-0,000***
EC2	0,000	0,216***	0,217***	-0,000	0,000**	0,000	-0,000*

	Short-run						
	d_bs3vs12y5	d_Operations	d_Depo	d_EurobondCDS	d_Reserves	d_EUR_USD	d_Eurobond5y
d_bs3vs12y5_1	-0,022	10,585	-12,248	0,500**	-0,045	-0,001**	0,002
d_bs3vs12y5_2	0,096**	28,607	16,108	-0,012	0,015	0,000*	-0,001
d_Operations_1	-0,000	-0,477979***	-0,084**	-0,000	0,000*	-0,000	0,000
d_Operations_2	-0,000	-0,0565832	0,023	0,000	0,000	0,000	0,000
d_Depo_1	0,000	-0,607***	-0,185***	0,000	-0,000	0,000	0,000
d_Depo_2	-0,000	-0,466***	-0,114**	-0,000	0,000	0,000	0,000
d_EurobondCDS_1	0,002	-2,478	1,434	0,265***	-0,028	-0,000***	0,001***
d_EurobondCDS_2	-0,000	2,149	-1,523	-0,120***	-0,018	0,000	0,000
d_Reserves_1	-0,004	2,119	1,443	-0,051	-0,002	0,000*	0,000
d_Reserves_2	-0,001	2,567	2,414	-0,063	-0,003	0,000	0,000
d_EUR_USD_1	-1,486	-3055,22**	-1772,25*	-0,990	-7,744	-0,000	0,116
d_EUR_USD_2	-0,318	763,427	281,043	-4,846	-19,346*	0,001	0,165
d_Eurobond5y_1	-1,068*	197,956	-154,350	-0,805	0,783	0,009	0,126***
d_Eurobond5y_2	0,989*	-182,223	-97,064	3,8369	5,811**	0,016**	-0,029
EC1	-0,000	9,554***	9,764***	-0,001	0,014	0,000	-0,000*

***1 % significance
**5 % significance
*10 % significance

Table 6.7 VECM estimation results. Upper table represents VECM for co-integrating relation between 3M vs. 12M 2 year basis swap spread and explanatory variables. Correspondingly, lower table presents relation between 3M vs. 12M 5 year Euribor basis swap spread and explanatory variables.

As we can see from Table 6.7 Johansen's co-integration test partially supports the results of significant factors obtained from Engle-Granger test. The second column, regarding co-integrating relation between 3M vs. 12M 2 year basis swap spread and explanatory variables, presents coefficients for model 6.3. Johansen's test indicates significance in 5 percentage level. Coefficients of lagged differences in 3M vs. 12M 2 year Euribor basis swap spread and 2 year Eurobond yield are higher although error correction model has lower coefficient compared to Engle-Granger test results. In addition, comparing the co-integrating relationship the other way round, lagged differences do not explain changes in 2 year Eurobond yield. Instead, second lag of deposit facility, first lags of 10 year Eurobond CDS spread and 2 year Eurobond yield itself explain movements in 2 year Eurobond yield. In this case, both error correction terms are significant in 1 percent and 10 percent level, respectively.

Latter part of the Table 6.7 presents estimation results from vector error correction for co-integrating relations between 3M vs. 12M 5 year Euribor basis swap spread and regressors. Now results are different obtained from Engle-Granger method. Engle-Granger proved only autonomous liquidity factors to be co-integrated with 5 year Euribor basis swap spread. According to Table 6.7 lagged differences of 5 year Eurobond yield is in 10 percentage significance level correlated with Euribor basis swap spread with 5 year maturity. Vice versa, the correlation of lagged Euribor basis swap spread with 5 year maturity is not significantly correlated with differences of 5 year Eurobond yield. In addition, error correction term is not significantly correlated, when 5 year Euribor basis swap spread is regarded as dependent variable.

7 CONCLUSIONS

This study investigated effects of different factors affecting on Euribor basis swap spreads, 3 month versus 12 month Euribor basis swap spreads with 2 and 5 year maturities especially. Currently, the large spread between for example, 3M vs. 12M Euribor basis swap spread is in my sense consequence of markets expectations of higher 12 month than 3 month Euribor rate also in future but also the limited access to basis swap markets.

Hypotheses were generally based on previous studies regarding factors driving Libor-OIS spreads. In those studies, credit risk component together with liquidity component have found out to be significantly correlated with Libor-OIS spreads. The aim of the study was to provide understanding of Euribor basis swap spread movements, particularly factors that correlate significantly with basis swap spreads. Currently, there are no previous research done on this particular topic. Credit default swap spreads represent the credit risk component of the study and European Central Bank's actions the liquidity component. In addition, the euro – U.S. dollar foreign exchange rate presents variable reflecting view of market participants on macroeconomics conditions and news.

In empirical part of the study, I applied linear regression model, Engle-Granger and Johansen co-integration tests. Linear regression model is suitable for short-run relationship examination between variables. However, linear regression models remove information of long-run relations between variables. Thus, Engle-Granger and Johansen tests together with vector error correction model are able to provide both the short-run and the long-run determinants. Engle-Granger and Johansen co-integration analyses are also suitable for non-stationary time series used in this study.

I laid out seven hypotheses in chapter four what comes to significant factors affecting on Euribor basis swap spreads. These hypotheses about significant factors were: Eurobond yields, Eurobond CDS spreads, Euribor panel CDS spreads, open market operations, deposit facility, autonomous liquidity factors including SMP and euro – U.S. dollar foreign exchange rate are significantly correlated with Euribor basis swap spreads. Although these were my hypotheses about significant factors, I conducted analysis including also variables that I assumed to be insignificant.

I considered Eurobond CDS spreads and Euribor panel bank CDS spreads as a part of credit risk component. I considered open market operations, deposit facility and autonomous liquidity factors as building blocks of the liquidity component. Eurobond yield had twofold relationship as I predicted in chapter four and thus it was not clear whether it is more kind of credit risk or liquidity component. In the following subchapters, I will provide my conclusions about the results.

Unit root test results proved the general market observation that most of the financial time-series data are integrated of degree zero or one. Although coefficients of determination as well as adjusted coefficients of determination remained quite low (30 and 25 percentage) in OLS estimations, linear regression model provided promising results about significance liquidity and credit risk component. Noteworthy was also that euro – U.S. dollar foreign exchange rate, variable that has not been taken into account in previous Libor-OIS spread studies, was significant in OLS estimation.

I conclude that based on my hypothesis made in chapter 5, deposit facility together with twofold interpretation on Eurobond yield represent liquidity components and Eurobond CDS spread together with Euribor panel CDS spread represent credit risk components and finally, euro – U.S. dollar foreign exchange rate presents additional "macroeconomic" component in my OLS model. It is worth mentioning that there were neither multicollinearity between log-differences of Eurobond CDS spread and Euribor panel CDS spread or Eurobond yields and CDS spreads. In both OLS estimations (2 year and 5 year Euribor basis swap spread), 10 year Eurobond CDS spread and 5 year Euribor panel CDS spread were more significant and provided lower values of Akaike information criteria as well higher coefficient of determination than credit default swap spreads with shorter maturities. I deduce that long-run credit risk is more significant what comes to markets expectations about forthcoming risks and effects on Euribor basis swap spreads.

Unit root test result indicated also that after differentiating the level data once, data became stationary. This gave reason to analyse whether there is long-run co-movement between explanatory variables and dependent variables or not. Engle-Granger and Johansen tests provided consistent results about the number of co-integrating relations although in Engle-Granger method in order to find any relations, I had to conduct pair-wise estimations. Johansen test provided promising results when all six independent factors were taken into account. Based on both co-integration estimations, I found out that there are two co-integrating relations with respect to 2 year Euribor basis swap spread and one relation between 5 year Euribor basis swap spread.

Pair-wise Engle-Granger co-integration test results with respect to 2 year Euribor basis swap spread provided two different co-integrating relations that were with 2 year Eurobond yield and euro area deficit to GDP. However, I conclude that the result of euro zone deficit to GDP should be considered in cautious, because deficit was stationary already in levels when constant was included. Thus, they are integrated of different degrees. Respectively, 5 year Euribor basis swap spread had co-integrating relation with autonomous liquidity factors including securities markets programme. Johansen test provided same amount of relations in both maturities. When I conducted Johansen tests taking into account deficit to GDP ratio and autonomous liquidity factors, they were not found out to be co-integrating with Euribor basis swap spreads.

Finally, I estimated error correction models for Engle-Granger and Johansen co-integrating relations. Error correction model for Engle-Granger test provided results from two-sided ECM estimations that there is significant short-run and long-run relationship only between 2 year Euribor basis swap spread and 2 year Eurobond yield. In spite of the promising results, it found out that ECM term was positive in latter estimation. This would implicate that if for example there was a positive difference in previous period between Eurobond yield and Euribor basis swap, both are increasing also in the current period and the difference is not narrowing. Thus, results indicate twofold relations because on the other hand the difference between spread and bond yield indicates convergence but then again on the other hand difference is increasing. In this sense Johansen method and VECM provided more realistic results as it indicated there to be negative ECM coefficient in both of the two-sided estimations. Correlation coefficients of the short-run parameters in absolute terms are a bit higher in VECM for Johansen than for Engle-Granger estimations. Respectively, long-run coefficients are in absolute terms a bit lower in VECM for Johansen estimations.

Error correction estimation results for pair-wise Engle-Granger test between 2 year 3M vs. 12M Euribor basis swap spread and euro area deficit to GDP ratio as well as 5 year 3M vs. 12M Euribor basis swap spread and autonomous liquidity factors including SMP were insignificant for both short- and long-run relations when results of two-sided test were interpreted. In the short-run it found out that lags of euro area deficit to GDP explains the future values of deficit to GDP in euro area. This is the case naturally because euro area deficit data was based on linearly increasing or decreasing data constructed from quarterly data. Lags of liquidity factors including SMP indicated similar behaviour than euro area deficit to GDP ratio and explained future values of autonomous liquidity factors. In spite of the error correction term was significant in first estimation (Euribor basis swap spread as independent variable), it found out to be insignificant in second estimation (regressor as independent variable). VECM for Johansen estimations did not find any co-integrating relations either between Euribor basis swap speads and euro area deficit to GDP ratio or autonomous liquidity factors including SMP. VECM for Johansen provided the result that Euribor basis swap spread as a dependent variable and yield of Eurobond 5 year as an independent are co-integrated in 10 % significance level but the inversion could not confirm the co-integrating relation.

My overall conclusions of the study are that in spite of the figures and descriptive statistics in chapter four indicated several significant correlations between dependent and independent variables, it found out that because the main part of the variables were non-stationary in levels, the correlations were consequence of time trend in variables. After each data was differentiated in order to conduct reasonable estimations, it found out that I could use co-integration estimations for level data or linear regression models for differences or log-differences in this case. Finally, the linear regression model could provide most realistic results what comes to my initial hypothesis. Co-integration estimations also provided significant results, but the explanatory power of two-sided relations altogether were not that significant in spite of the relation between 2 year Eurobond yield and 2 year Euribor basis swap spread.

According to OLS results decrease of euro – U.S. dollar foreign exchange rate will lead to increase in basis spreads, which sounds reasonable. Generally, markets react to negative macroeconomic news that stem from euro area in a way that it will depreciate euro with respect to U.S. dollar, which will in turn increase uncertainty, and increase basis swap spreads. Expected increase in deposit facility will lead to increase in Euribor basis swap spread significantly four days beforehand. We have seen that currently ECB has provided significant amounts of liquidity to markets but in spite of that the spreads are increasing. This will reflect in my sense the fact that markets see that as long as there is excess liquidity in markets and banks keep depositing those funds with National Central Banks because they refuse to lend each other or their customers, Euribor basis swap spreads will increase. Increase in credit default swap spreads indicated that as long as credit risk of Euribor panel banks and euro area sovereigns increase so does Euribor basis swap spread. Increase in CDS spreads reflect higher funding cost for banks and sovereigns. This in turn will affect to liquidity in my sense in a way that banks deposit excess liquidity with central bank. Thus, higher CDS spread will decrease liquidity (increase deposit facility), which will increase basis swap spreads. I found out when conducting additional estimation that Eurobond CDS spread and deposit facility were positively correlated, which supports my conclusion.

The correlation coefficients of Eurobond yields with respect to Euribor basis swap spreads were negative in both OLS tests and co-integration tests. The result indicate that in spite of the positive correlation between Eurobond yields and Eurobond CDS spread, those does not necessarily move in similar fashion with respect to Euribor basis swap spreads. It should be noted that ECM indicates that in the short run Euribor basis swap spreads and Eurobond yield deviate but in the long-run they convergence. I see that one possible explanation for negative correlation between Eurobond yields and Euribor basis swap spreads in the short-run is a result of ECB's supporting sovereign bond purchases. The negative correlation might stem if Eurobond yield is increasing and markets expect ECB to come help to push sovereign bond yields down, which will in turn increase liquidity, which should decrease

Euribor basis swap spreads as does the ECM implicate in the long-run. On the other hand, more robust conclusion in my sense is that increased Eurobond yields reflect steepening yield curve, which is usually profitable for banks. Banks have their funding in shorter tenor and lending in longer tenor. Thus steepened yield curve usually means higher profits and higher net interest income for banks as the long rate increase and short rate remains at relative low levels. Higher profits for banks together with more activity at markets, will lead to increased liquidity, which will decrease Euribor basis swap spreads. I found market evidence that increased Eurobond yield correlates positively with respect to outstanding amounts of euro denominated single currency plain vanilla swap contracts in billions of U.S. dollars (see Appendix 10). Swap data was gathered from Bank of International Settlements (BIS) web page.

According to OLS test result my initial hypotheses regarding liquidity and credit risk components as well as macroeconomic variable could all be accepted. Engle-Granger and Johansen co-integrating tests together with error correction models are supportive to accept at least liquidity risk. In the short- and long-run the relationship between only Eurobond yield and Euribor basis swap spreads were found out to be significant. In the last resort, I see that according to OLS results and conclusions I made, each significant factor can be regarded affecting to Euribor basis swap spreads through liquidity component.

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APPENDICES

Appendix 1. Correlation matrix (levels)

	bs3vs6y1	*bs3vs6y2*	*bs3vs6y5*	*bs1vs3y1*	*bs1vs3y2*	*bs1vs3y5*	*bs3vs12y1*	*bs3vs12y2*	*bs3vs12y5*	*bs6vs12y1*	*bs6vs12y2*	*bs6vs12y5*	*Depo%daily*
bs3vs6y1	1,00	0,84	0,29	0,34	0,15	-0,11	0,83	0,77	0,49	0,71	0,65	0,48	0,19
bs3vs6y2	0,84	1,00	0,75	-0,03	-0,02	0,21	0,58	0,69	0,69	0,45	0,49	0,48	-0,24
bs3vs6y5	0,29	0,75	1,00	-0,49	-0,29	0,46	0,11	0,36	0,70	0,04	0,18	0,36	-0,54
bs1vs3y1	0,34	-0,03	-0,49	1,00	0,89	0,10	0,40	0,23	-0,15	0,39	0,29	0,07	0,61
bs1vs3y2	0,15	-0,02	-0,29	0,89	1,00	0,50	0,11	0,02	-0,21	0,08	0,03	-0,11	0,38
bs1vs3y5	-0,11	0,21	0,46	0,10	0,50	1,00	-0,25	-0,11	0,11	-0,28	-0,20	-0,12	-0,17
bs3vs12y1	0,83	0,58	0,11	0,40	0,11	-0,25	1,00	0,95	0,65	0,98	0,94	0,79	0,55
bs3vs12y2	0,77	0,69	0,36	0,23	0,02	-0,11	0,95	1,00	0,85	0,93	0,97	0,92	0,37
bs3vs12y5	0,49	0,69	0,70	-0,15	-0,21	0,11	0,65	0,85	1,00	0,65	0,79	0,92	0,03
bs6vs12y1	0,71	0,45	0,04	0,39	0,08	-0,28	0,98	0,93	0,65	1,00	0,97	0,84	0,63
bs6vs12y2	0,65	0,49	0,18	0,29	0,03	-0,20	0,94	0,97	0,79	0,97	1,00	0,94	0,53
bs6vs12y5	0,48	0,48	0,36	0,07	-0,11	-0,12	0,79	0,92	0,92	0,84	0,94	1,00	0,34
Depo%daily	0,19	-0,24	-0,54	0,61	0,38	-0,17	0,55	0,37	0,03	0,63	0,53	0,34	1,00
MLF%	0,04	-0,37	-0,62	0,63	0,44	-0,12	0,42	0,26	-0,07	0,52	0,43	0,26	0,97
MRO%	0,11	-0,30	-0,59	0,63	0,41	-0,15	0,49	0,32	-0,02	0,58	0,49	0,30	0,99
Operations	0,36	0,22	-0,10	0,36	0,36	0,09	0,02	-0,14	-0,39	-0,10	-0,25	-0,46	-0,03
MLF	0,41	0,19	-0,09	0,11	-0,11	-0,31	0,52	0,42	0,20	0,51	0,44	0,31	0,38
Depo	0,60	0,62	0,34	0,24	0,23	0,15	0,37	0,36	0,23	0,27	0,22	0,12	-0,02
Liquidity_and_SMP	-0,01	-0,22	-0,43	0,28	0,29	-0,01	-0,31	-0,53	-0,77	-0,38	-0,56	-0,77	-0,03
CA	0,02	-0,02	-0,06	0,07	0,05	-0,03	0,02	0,00	-0,04	0,02	0,01	-0,02	0,04
Reserves	0,04	-0,35	-0,70	0,58	0,40	-0,31	-0,01	-0,24	-0,60	-0,02	-0,17	-0,40	0,28
CBPP1	-0,11	0,15	0,67	-0,29	-0,27	0,15	0,40	0,54	0,76	0,51	0,61	0,70	0,36
EUR/USD	-0,37	-0,43	-0,34	-0,23	-0,23	-0,21	-0,27	-0,30	-0,28	-0,21	-0,22	-0,17	0,14
Eurobond2y	0,08	-0,03	-0,09	0,21	0,07	-0,15	0,49	0,54	0,50	0,59	0,66	0,70	0,57
Eurobond5y	-0,07	-0,25	-0,28	0,15	-0,04	-0,32	0,35	0,33	0,27	0,46	0,49	0,51	0,58
Eurobond10y	-0,12	-0,27	-0,26	0,03	-0,14	-0,37	0,23	0,22	0,19	0,33	0,36	0,40	0,43
EurobondCDS5y	0,26	0,55	0,65	-0,21	-0,19	0,08	0,36	0,60	0,84	0,36	0,54	0,74	-0,27
EurobondCDS10y	0,28	0,56	0,64	-0,19	-0,18	0,08	0,37	0,62	0,84	0,37	0,55	0,75	-0,25
CDS 2y EURIBOR PANEL	0,28	0,41	0,36	0,00	-0,08	-0,13	0,40	0,58	0,68	0,41	0,56	0,69	-0,16
CDS 5y EURIBOR PANEL	0,27	0,45	0,46	-0,07	-0,11	-0,04	0,41	0,61	0,76	0,42	0,58	0,74	-0,16
deficitzone	-0,08	0,27	0,41	-0,44	-0,19	0,24	-0,56	-0,49	-0,26	-0,67	-0,67	-0,59	-0,85
debtzone	-0,24	0,31	0,79	-0,83	-0,64	0,17	-0,33	-0,06	0,48	-0,34	-0,18	0,13	-0,76
Monetary dummy	0,00	0,00	0,00	-0,01	0,00	0,00	0,01	0,01	0,00	0,00	0,00	0,00	0,00

	Depo	Liquidity_and_SMP	CA	Reserves	CBPP1	EUR/USD	Eurobond2y	Eurobond5y	Eurobond10y	EurobondCDS5y	EurobondCDS10y	2y EURIBOR PANEL BA	5y EURIBOR PANEL BA	deficitzone	debtzone	Monetary dummy
bs3vs6y1	0,60	-0,01	0,02	0,04	-0,11	-0,37	0,08	-0,07	-0,12	0,26	0,28	0,28	0,27	-0,08	-0,24	0,00
bs3vs6y2	0,62	-0,22	-0,02	-0,35	0,15	-0,43	-0,03	-0,25	-0,27	0,55	0,56	0,41	0,45	0,27	0,31	0,00
bs3vs6y5	0,34	-0,43	-0,06	-0,70	0,67	-0,34	-0,09	-0,28	-0,26	0,65	0,64	0,36	0,46	0,41	0,79	0,00
bs1vs3y1	0,24	0,28	0,07	0,58	-0,29	-0,23	0,21	0,15	0,03	-0,21	-0,19	0,00	-0,07	-0,44	-0,83	-0,01
bs1vs3y2	0,23	0,29	0,05	0,40	-0,27	-0,23	0,07	-0,04	-0,14	-0,19	-0,18	-0,08	-0,11	-0,19	-0,64	0,00
bs1vs3y5	0,15	-0,01	-0,03	-0,31	0,15	-0,21	-0,15	-0,32	-0,37	0,08	0,08	-0,13	-0,04	0,24	0,17	0,00
bs3vs12y1	0,37	-0,31	0,02	-0,01	0,40	-0,27	0,49	0,35	0,23	0,36	0,37	0,40	0,41	-0,56	-0,33	0,01
bs3vs12y2	0,36	-0,53	0,00	-0,24	0,54	-0,30	0,54	0,33	0,22	0,60	0,62	0,58	0,61	-0,49	-0,06	0,01
bs3vs12y5	0,23	-0,77	-0,04	-0,60	0,76	-0,28	0,50	0,27	0,19	0,84	0,84	0,68	0,76	-0,26	0,48	0,00
bs6vs12y1	0,27	-0,38	0,02	-0,02	0,51	-0,21	0,59	0,46	0,33	0,36	0,37	0,41	0,42	-0,67	-0,34	0,00
bs6vs12y2	0,22	-0,56	0,01	-0,17	0,61	-0,22	0,66	0,49	0,36	0,54	0,55	0,56	0,58	-0,67	-0,18	0,00
bs6vs12y5	0,12	-0,77	-0,02	-0,40	0,70	-0,17	0,70	0,51	0,40	0,74	0,75	0,69	0,74	-0,59	0,13	0,00
Depo%daily	-0,02	-0,03	0,04	0,28	0,36	0,14	0,57	0,58	0,43	-0,27	-0,25	-0,16	-0,16	-0,85	-0,76	0,00
MLF%	-0,12	-0,03	0,04	0,31	0,36	0,18	0,58	0,60	0,46	-0,29	-0,27	-0,14	-0,15	-0,81	-0,78	0,00
MRO%	-0,07	-0,03	0,04	0,30	0,36	0,16	0,58	0,59	0,45	-0,28	-0,26	-0,15	-0,16	-0,84	-0,77	0,00
Operations	0,65	0,77	0,25	0,53	-0,60	-0,36	-0,58	-0,56	-0,55	-0,47	-0,47	-0,43	-0,49	0,24	-0,39	0,00
MLF	0,11	-0,06	-0,03	0,14	0,15	-0,16	0,21	0,23	0,20	-0,01	0,00	0,05	0,05	-0,27	-0,30	-0,01
Depo	1,00	0,12	-0,15	0,04	-0,19	-0,44	-0,11	-0,25	-0,28	0,15	0,16	0,08	0,09	0,08	-0,12	0,08
Liquidity_and_SMP	0,12	1,00	0,05	0,71	-0,67	-0,13	-0,74	-0,60	-0,54	-0,80	-0,82	-0,69	-0,78	0,35	-0,53	-0,01
CA	-0,15	0,05	1,00	0,08	-0,04	-0,01	-0,02	0,01	0,01	-0,06	-0,06	-0,03	-0,05	-0,03	-0,09	-0,15
Reserves	0,04	0,71	0,08	1,00	-0,48	-0,25	-0,34	-0,23	-0,24	-0,61	-0,61	-0,36	-0,48	-0,10	-0,75	0,00
CBPP1	-0,19	-0,67	-0,04	-0,48	1,00	-0,48	0,46	0,34	0,27	0,64	0,63	0,49	0,54	-0,45	0,88	0,01
EUR/USD	-0,44	-0,13	-0,01	-0,25	-0,48	1,00	0,29	0,39	0,38	-0,21	-0,21	-0,17	-0,15	-0,14	-0,03	0,00
Eurobond2y	-0,11	-0,74	-0,02	-0,34	0,46	0,29	1,00	0,93	0,83	0,47	0,49	0,51	0,55	-0,84	-0,22	0,00
Eurobond5y	-0,25	-0,60	0,01	-0,23	0,34	0,39	0,93	1,00	0,96	0,27	0,28	0,37	0,38	-0,77	-0,25	-0,01
Eurobond10y	-0,28	-0,54	0,01	-0,24	0,27	0,38	0,83	0,96	1,00	0,25	0,26	0,37	0,37	-0,64	-0,14	-0,01
EurobondCDS5y	0,15	-0,80	-0,06	-0,61	0,64	-0,21	0,47	0,27	0,25	1,00	1,00	0,90	0,95	-0,04	0,70	0,01
EurobondCDS10y	0,16	-0,82	-0,06	-0,61	0,63	-0,21	0,49	0,28	0,26	1,00	1,00	0,89	0,94	-0,04	0,70	0,01
CDS 2y EURIBOR PANEI	0,08	-0,69	-0,03	-0,36	0,49	-0,17	0,51	0,37	0,37	0,90	0,89	1,00	0,98	-0,16	0,39	0,01
CDS 5y EURIBOR PANEI	0,09	-0,78	-0,05	-0,48	0,54	-0,15	0,55	0,38	0,37	0,95	0,94	0,98	1,00	-0,16	0,50	0,01
deficitzone	0,08	0,35	-0,03	-0,10	-0,45	-0,14	-0,84	-0,77	-0,64	-0,04	-0,04	-0,16	-0,16	1,00	0,47	0,01
debtzone	-0,12	-0,53	-0,09	-0,75	0,88	-0,03	-0,22	-0,25	-0,14	0,70	0,70	0,39	0,50	0,47	1,00	0,00
Monetary dummy	0,08	-0,01	-0,15	0,00	0,01	0,00	0,00	-0,01	-0,01	0,01	0,01	0,01	0,01	0,01	0,00	1,00

Appendix 2. Descriptive statistics of European Central Bank's actions over the sample period

	Depo%daily	*MLF%*	*MRO%*	*Operations*	*MLF*	*Depo*
Mean	0,77	2,31	1,54	6105,56	15,35	1107,35
Median	0,25	1,75	1,00	6183,22	2,29	858,80
Standard Deviation	0,96	1,00	0,98	1459,95	34,10	906,95
Kurtosis	1,98	2,96	2,39	-1,21	17,58	-0,57
Skewness	1,89	2,03	1,95	0,06	3,92	0,67
Jarque-Bera	661,41	916,90	757,99	54,31	13429,90	77,55
Minimum	0,25	1,75	1,00	1804,33	0,00	0,40
Maximum	3,25	5,25	4,25	9104,50	287,07	3842,60
Count	879	879	879	879	879	879

	Liquidity_ and_SMP	*CA*	*Reserves*	*CBPP*	*Monetary dummy*
Mean	2861,24	2152,32	2126,99	483,43	0,05
Median	3127,91	2158,12	2119,14	597,15	0,00
Standard Deviation	986,84	445,45	39,99	183,59	0,21
Kurtosis	-0,04	1,38	-0,65	0,07	16,59
Skewness	-0,84	-0,15	0,33	-1,24	4,31
Jarque-Bera	103,64	72,04	31,82	157,46	12655,10
Minimum	18,08	794,28	2060,96	0,66	0,00
Maximum	4172,17	3848,98	2210,56	611,44	1,00
Count	879	879	879	624	879

Appendix 3. Euribor panel banks data on CDS spreads with 2 year and 5 year maturities

Euribor panel banks' 2 year CDS spreads were available for	
Austria	Erste Bank der Österreichischen Sparkassen
	RZB - Raiffeisen Zentralbank Österreich AG
Belgium	Dexia Bank
	KBC
France	BNP - Paribas
	Crédit Agricole s.a.
	HSBC France
	Natixis
	Société Générale
Germany	Bayerische Landesbank Girozentrale
	Commerzbank
	Deutsche Bank
	Norddeutsche Landesbank Girozentrale
	WestLB AG
Ireland	AIB Group
	Bank of Ireland
Italy	Intesa Sanpaolo
	Unicredit
Luxembourg	Banque et Caisse d'Épargne de l'État
Netherlands	ING Bank
	Rabobank
	RBS N.V.
Portugal	Caixa Geral De Depósitos (CGD)
Spain	Banco Bilbao Vizcaya Argentaria
	Banco Santander Central Hispano
	Confederacion Española de Cajas de Ahorros
	La Caixa Barcelona
Other EU Banks	Barclays Capital
	Den Danske Bank
	Svenska Handelsbanken
International Banks	Bank of Tokyo - Mitsubishi
	Citibank
	J.P. Morgan Chase & Co.
	UBS (Luxembourg) S.A.
Number of banks	34

Euribor panel banks' 5 year CDS spreads were available for	
Austria	Erste Bank der Österreichischen Sparkassen
	RZB - Raiffeisen Zentralbank Österreich AG
Belgium	Dexia Bank
	KBC
Finland	Nordea
France	BNP - Paribas
	Crédit Agricole s.a.
	HSBC France
	Natixis
	Société Générale
Germany	Bayerische Landesbank Girozentrale
	Commerzbank
	Deutsche Bank
	DZ Bank Deutsche Genossenschaftsbank
	Norddeutsche Landesbank Girozentrale
	WestLB AG
Ireland	AIB Group
	Bank of Ireland
Italy	Intesa Sanpaolo
	Monte dei Paschi di Siena
	Unicredit
Luxembourg	Banque et Caisse d'Épargne de l'État
Netherlands	ING Bank
	Rabobank
	RBS N.V.
Portugal	Caixa Geral De Depósitos (CGD)
Spain	Banco Bilbao Vizcaya Argentaria
	Banco Santander Central Hispano
	La Caixa Barcelona
Other EU Banks	Barclays Capital
	Den Danske Bank
	Svenska Handelsbanken
International Banks	Bank of Tokyo - Mitsubishi
	Citibank
	J.P. Morgan Chase & Co.
	UBS (Luxembourg) S.A.
Number of banks	36

All inclusive list of panel banks: http://www.euribor-ebf.eu/euribor-ebf-eu/about-us.html

Data source: Bloomberg

Appndix 4. Unit root test results (augmented Dickey-Fuller test)

	Neither constant nor trend	Constant no trend	Constant trend	lags included		Neither constant nor trend	Constant no trend	Constant trend	lags included		Neither constant nor trend	Constant no trend	Constant trend	lags included
bs3vs6y1	-0,272903	-3,06516	-3,0751	18	Δbs3vs6y1	-6,15143	-6,18259	-6,17726	17	DLbs3vs6y1	-5,90615	-8,92175	-8,93338	18
bs3vs6y2	0,307273	-2,89749	-2,89749	18	Δbs3vs6y2	-6,21372	-6,28832	-6,28556	17	DLbs3vs6y2	-7,46795	-7,62542	-7,6862	14
bs3vs6y5	0,763179	-2,06946	-2,51218	11	Δbs3vs6y5	-9,20863	-9,32484	-9,3472	10	DLbs3vs6y5	-6,04801	-6,2727	-6,46232	17
bs1vs3y1	-0,851607	-2,52671	-2,98498	19	Δbs1vs3y1	-6,20113	-6,19988	-6,24499	20	DLbs1vs3y1	-6,4782	-6,49652	-6,55126	20
bs1vs3y2	-0,775068	-3,59227	-4,48495	19	Δbs1vs3y2	-6,69984	-6,69603	-6,71115	18	DLbs1vs3y2	-6,8836	-6,88708	-6,89466	18
bs1vs3y5	-0,661242	-3,35541	-3,39726	11	Δbs1vs3y5	-7,58947	-7,584	-7,57904	10	DLbs1vs3y5	-6,57681	-6,58056	-6,57712	17
bs3vs12y1	-0,691049	-2,30321	-2,27722	18	Δbs3vs12y1	-5,87363	-5,88925	-5,90484	17	DLbs3vs12y1	-10,2395	-10,4911	-10,4902	8
bs3vs12y2	0,00538029	-1,75292	-1,9536	18	Δbs3vs12y2	-6,0323	-6,07311	-6,09677	17	DLbs3vs12y2	-10,3764	-10,5517	-10,5467	8
bs3vs12y5	0,797399	-0,866782	-1,79447	18	Δbs3vs12y5	-6,43952	-6,54737	-6,5724	17	DLbs3vs12y5	-8,82392	-8,99813	-8,99594	11
bs6vs12y1	-0,986439	-2,04516	-2,01653	18	Δbs6vs12y1	-5,7542	-5,76356	-5,79686	17	DLbs6vs12y1	-29,8846	-29,9677	-29,967	0
bs6vs12y2	-0,315248	-1,40594	-1,56114	18	Δbs6vs12y2	-5,9758	-6,00043	-6,05926	17	DLbs6vs12y2	-4,74403	-5,07947	-5,11105	17
bs6vs12y5	0,797624	-0,540272	-0,9114	12	Δbs6vs12y5	-9,07855	-9,14147	-9,24025	11	DLbs6vs12y5	-6,78057	-7,15993	-7,15447	19
Depo %	-3,39538	-3,10177	-2,13376	20	ΔDepo%	-5,19637	-5,41049	-5,98734	19	DLDepo %	-5,66727	-5,68189	-6,0976	19
MLF %	-3,04702	-3,97232	-2,91591	20	ΔMLF%	-5,25701	-5,54877	-6,40914	20	DLMLF %	-5,31566	-5,52734	-6,26111	19
MRO %	-3,57672	-3,8722	-2,7073	20	ΔMRO%	-4,92523	-5,23271	-6,17157	19	DLMRO %	-5,35187	-5,52983	-6,28641	19
Operations excluding SMP	-0,270541	-1,6278	-2,91131	20	ΔOperations excluding SMP	-7,16546	-7,16168	-7,23071	20	DLOperations excluding	-4,88987	-5,82673	-5,97988	20
MLF	-4,59961	-5,28466	-5,33033	3	ΔMLF	-10,0337	-10,0323	-10,0296	13	DLMLF	-5,94457	-11,7087	-11,7631	15
Deposit facility	-0,669659	-2,2229	-2,19476	20	ΔDeposit facility	-7,42276	-7,45648	-7,45794	19	DLDeposit facility	-6,00258	-6,23137	-6,38075	20
Autonomous Factors and SMI	-0,899752	1,72587	-1,60987	17	ΔAutonomous Factors and S	-8,30707	-8,43318	-10,2701	16	DLAutonomous Factors a	-4,82697	-4,73663	-4,59367	20
Current accounts	-0,403707	-7,86079	-8,57016	20	ΔCurrent accounts	-12,6196	-12,6114	-12,6017	20	DLCurrent accounts	-5,06387	-9,17896	-9,69942	20
Reserve requirements	-0,703353	-0,822174	-2,49034	20	ΔReserve requirements	-7,31225	-7,34228	-7,37114	19	DLReserve requirement	-7,25141	-7,27984	-7,30965	19
CBPP	0,115851	-2,44572	-2,12607	18	ΔCBPP	-1,73593	-1,7971	-2,00962	17	DLCBPP	-4,96979	-4,84588	-4,85388	20
Eurobond 2y	0,323255	-0,225116	-0,753034	18	ΔEurobond 2y	-5,52172	-5,53532	-6,83915	17	DLEurobond 2y	-6,89545	-6,92382	-7,79583	15
Eurobond 5y	-0,274262	-1,64563	-1,50853	16	ΔEurobond 5y	-6,27698	-6,27252	-6,8856	15	DLEurobond 5y	-6,51655	-6,51925	-7,00826	19
Eurobond 10y	-1,50853	-2,09775	-2,31813	14	ΔEurobond 10y	-7,08706	-7,0829	-7,30941	13	DLEurobond 10y	-7,05777	-7,05555	-7,25122	13
EuroCDS 5y	2,01386	0,70269	-0,764236	19	ΔEuroCDS 5y	-6,34414	-6,65308	-6,80138	18	DLEuroCDS 5y	-5,37047	-5,70972	-5,72982	16
EuroCDS 10y	2,57674	1,25716	-0,269513	11	ΔEuroCDS 10y	-7,19893	-10,7056	-9,71221	14	DLEuroCDS 10y	-5,50293	-5,84287	-5,84505	16
CDS_2y_Euribor	1,02667	-0,358993	-1,10103	19	ΔCDS_2y_Euribor	-5,54808	-5,58783	-5,66598	18	DLCDS_2y_Euribor	-5,66611	-5,86572	-5,86106	20
CDS_5y_Euribor	1,07382	-0,282061	-1,33817	16	ΔCDS_5y_Euribor	-5,73369	-5,88536	-5,97572	15	DLCDS_5y_Euribor	-6,00057	-7,46804	-7,46633	15
Deficit	-0,686519	-3,09404	-2,96235	1	ΔDeficit	-3,33129	-3,33972	-3,45097	0	DLDeficit	-0,407288	-0,185889	-1,10531	0
Debt	1,04823	-2,73927	-1,53769	1	ΔDebt	-1,19995	-1,80662	-2,77371	0	DLDebt	0,155937	1,43956	0,602768	0
EUR/USD	-0,831945	-3,27146	-3,27027	12	ΔEUR/USD	-8,11695	-8,14138	-8,18107	11	DLEUR/USD	-8,06607	-8,07862	-8,10851	11
*Critical values (10% signifigance)	-1,6156	-2,5671	-3,1279		*Critical values (10% signifigance)	-1,6156	-2,5671	-3,1279		*Critical values (10% signifigance)	-1,6156	-2,5671	-3,1279	
*Critical values (5 % signifigance)	-1,9393	-2,8621	-3,4126		*Critical values (5 % signifigance)	-1,9393	-2,8621	-3,4126		*Critical values (5 % signifigance)	-1,9393	-2,8621	-3,4126	
*Critical values (1 % signifigance)	-2,5658	-3,4336	-3,9638		*Critical values (1 % signifigance)	-2,5658	-3,4336	-3,9638		*Critical values (1 % signifigance)	-2,5658	-3,4336	-3,9638	

*Mackinnon (2010)

Appendix 5. Descriptive statistics of relative changes in variables

***	*bs3vs6y1*	*bs3vs6y2*	*bs3vs6y5*	*bs1vs3y1*	*bs1vs3y2*	*bs1vs3y5*	*bs3vs12y1*	*bs3vs12y2*	*bs3vs12y5*	*bs6vs12y1*	*bs6vs12y2*	*bs6vs12y5*
Mean	0,004	0,003	0,002	0,001	0,001	0,001	0,006	0,003	0,002	0,236	0,030	0,006
Median	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Standard Deviation	0,059	0,040	0,030	0,045	0,035	0,031	0,108	0,060	0,042	4,108	0,329	0,104
Kurtosis	28,918	26,524	12,422	16,144	15,727	12,562	107,500	7,692	5,914	747,924	114,465	18,832
Skewness	2,514	2,357	1,227	1,172	1,096	0,338	6,052	0,702	0,489	26,548	9,008	2,241
Jarque-Bera	52,536	26242,800	5793,940	9618,930	9112,790	5717,670	423261,000	2207,910	1297,020	20334700,000	485662,000	13549,900
Minimum	-0,388	-0,213	-0,123	-0,289	-0,171	-0,190	-0,672	-0,346	-0,212	-0,992	-0,909	-0,500
Maximum	0,681	0,471	0,259	0,464	0,362	0,280	1,892	0,429	0,254	117,000	5,000	0,889
Count	878	878	878	878	878	878	878	878	878	878	878	878

***	*Depo%daily*	*MLF%*	*MRO%*	*Operations*	*MLF*	*Depo*	*Liquidity_excl_SMP*	*CA*	*Reserves*	*CBPP*	*EUR/USD*	*Eurobond2y*
Mean	-0,001	-0,001	-0,001	0,007	9,086	0,204	0,004	0,039	0,000	0,017	0,000	0,001
Median	0,000	0,000	0,000	0,000	0,000	0,037	-0,003	-0,022	0,000	0,000	0,000	0,000
Standard Deviation	0,050	0,015	0,021	0,132	72,756	2,198	0,152	0,390	0,002	0,120	0,008	0,028
Kurtosis	227,062	119,131	100,734	45,109	398,330	349,684	449,522	24,518	43,113	160,777	2,603	23,080
Skewness	6,283	-7,520	-4,014	4,413	17,956	17,933	19,124	4,684	-1,299	12,219	-0,076	-1,606
Jarque-Bera	1870390,000	521503,000	369313,000	76413,700	5592290,000	1870390,000	7361690,000	24929,900	67452,000	676753,000	244,584	19630,900
Minimum	-0,500	-0,222	-0,250	-0,612	-1,000	-0,996	-0,899	-0,564	-0,016	-0,003	-0,046	-0,331
Maximum	1,000	0,143	0,250	1,569	1751,500	47,528	3,747	3,087	0,015	1,870	0,041	0,119
Count	878	878	878	878	849	878	878	878	878	624	878	878

***	*Eurobond5y*	*Eurobond10y*	*robondCDS*	*EurobondCDS10y*	*DS 2y EURIBOR PANEL BANKS*	*CDS 5y EURIBOR PANEL BANKS*	*deficitzone*	*debtzone*
Mean	0,000	0,000	0,004	0,004	0,003	0,002	0,001	-0,001
Median	0,000	0,000	0,002	0,002	0,001	0,002	0,002	0,000
Standard Deviation	0,017	0,012	0,043	0,038	0,032	0,031	0,036	0,035
Kurtosis	3,632	2,190	4,500	4,632	10,626	13,130	743,300	829,912
Skewness	-0,271	-0,238	0,084	0,237	0,377	0,682	-26,516	-28,807
Jarque-Bera	486,019	180,584	731,117	782,002	4099,520	6296,610	18974500,000	23647800,000
Minimum	-0,115	-0,066	-0,274	-0,251	-0,213	-0,190	-1,000	-1,000
Maximum	0,067	0,040	0,219	0,195	0,248	0,242	0,029	0,001
Count	878	878	878	878	878	878	830	830

***Variables are relative changes

Appendix 6. OLS estimation results with six independent variables

Model 1: OLS, using observations 1-878
Dependent variable: bs3vs12y2

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0,00283948	0,00172358	1,6474	0,09983	*
Operations	0,0101758	0,0129947	0,7831	0,43380	
Depo	0,000236921	0,000782747	0,3027	0,76221	
EurobondCDS10y	0,260597	0,0486953	5,3516	<0,00001	***
Reserves	0,149206	1,06057	0,1407	0,88815	
EUR_USD	-0,550589	0,226809	-2,4275	0,01540	**
Eurobond2y	-1,13409	0,0617836	-18,3559	<0,00001	***

Mean dependent var	0,003309	S.D. dependent var	0,059945
Sum squared resid	2,224918	S.E. of regression	0,050541
R-squared	0,294003	Adjusted R-squared	0,289140
F(6, 871)	60,45280	P-value(F)	1,19e-62
Log-likelihood	1378,482	Akaike criterion	-2742,964
Schwarz criterion	-2709,520	Hannan-Quinn	-2730,173
rho	-0,092663	Durbin-Watson	2,184779

Model 2: OLS, using observations 1-878
Dependent variable: bs3vs12y5

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0,00216167	0,00123543	1,7497	0,08052	*
Operations	0,0140948	0,00931937	1,5124	0,13079	
Depo	2,63688e-05	0,00056111	0,0470	0,96253	
EurobondCDS10y	0,0605531	0,0344723	1,7566	0,07934	*
Reserves	0,125791	0,760615	0,1654	0,86868	
EUR_USD	-0,617746	0,162493	-3,8017	0,00015	***
Eurobond5y	-1,14535	0,0712427	-16,0767	<0,00001	***

Mean dependent var	0,002450	S.D. dependent var	0,041553
Sum squared resid	1,143174	S.E. of regression	0,036228
R-squared	0,245063	Adjusted R-squared	0,239863
F(6, 871)	47,12314	P-value(F)	3,93e-50
Log-likelihood	1670,817	Akaike criterion	-3327,634
Schwarz criterion	-3294,190	Hannan-Quinn	-3314,843
rho	-0,025729	Durbin-Watson	2,048597

Appendix 7. Correlation matrix (relative changes)

	bs3vs6y1	bs3vs6y2	bs3vs6y5	bs1vs3y1	bs1vs3y2	bs1vs3y5	bs3vs12y1	bs3vs12y2	bs3vs12y5	bs6vs12y1	bs6vs12y2	bs6vs12y5	Depo%daily	MLF%	MRO%	Operations	MLF
bs3vs6y1	1	0,951331	0,760447	0,231702	0,161845	0,106999	0,780935	0,844965	0,768172	0,283787	0,249697	0,456824	-0,00635	-0,01181	-0,0027	0,01236638	-0,01013
bs3vs6y2	0,951331	1	0,855772	0,223003	0,178698	0,13468	0,674232	0,816745	0,801442	0,158154	0,226372	0,445455	-0,0061	-0,00262	0,001863	0,01821855	-0,01256
bs3vs6y5	0,760447	0,855772	1	0,189206	0,181413	0,184524	0,509785	0,676862	0,782169	0,076675	0,18765	0,392753	0,007382	0,012681	0,026793	0,03505113	-0,01083
bs1vs3y1	0,231702	0,223003	0,189206	1	0,89184	0,591378	0,249306	0,227715	0,200887	0,155876	0,072029	0,09256	-0,0316	-0,12191	-0,10024	0,05443823	0,019704
bs1vs3y2	0,161845	0,178698	0,181413	0,89184	1	0,800249	0,158761	0,167626	0,176688	0,077418	0,035648	0,076793	-0,03308	-0,11328	-0,10945	0,05047989	0,012957
bs1vs3y5	0,106999	0,13468	0,184524	0,591378	0,800249	1	0,098787	0,125982	0,164744	0,015042	0,06367	0,08871	-0,01964	-0,05558	-0,06734	0,01872702	0,016012
bs3vs12y1	0,780935	0,674232	0,509785	0,249306	0,158761	0,098787	1	0,894224	0,740023	0,595943	0,431578	0,642422	0,012228	-0,00828	0,002134	0,014434	0,000189
bs3vs12y2	0,844965	0,816745	0,676862	0,227715	0,167626	0,125982	0,894224	1	0,923512	0,26512	0,457668	0,755077	0,002696	-0,00688	-0,00342	0,02843726	-0,00335
bs3vs12y5	0,768172	0,801442	0,782169	0,200887	0,176688	0,164744	0,740023	0,923512	1	0,128869	0,404322	0,75544	0,016554	0,01071	0,016864	0,0305962	-0,00764
bs6vs12y1	0,283787	0,158154	0,076675	0,155876	0,077418	0,015042	0,595943	0,26512	0,128869	1	0,113851	0,10726	0,001628	0,003108	0,003125	0,00243284	-0,002
bs6vs12y2	0,249697	0,226372	0,18765	0,072029	0,035648	0,06367	0,431578	0,457668	0,404322	0,113851	1	0,618248	0,003545	0,002174	0,002956	0,01340366	-0,00811
bs6vs12y5	0,456824	0,445455	0,392753	0,09256	0,076793	0,08871	0,642422	0,755077	0,75544	0,10726	0,618248	1	0,012705	0,005249	0,00896	0,02844189	-0,00671
Depo%daily	-0,00635	-0,0061	0,007382	-0,0316	-0,03308	-0,01964	0,012228	0,002696	0,016554	0,001628	0,003545	0,012705	1	0,659338	0,86458	-0,08097314	0,002119
MLF%	-0,01181	-0,00262	0,012681	-0,12191	-0,11328	-0,05558	-0,00828	-0,00688	0,01071	0,003108	0,002174	0,005249	0,659338	1	0,901342	-0,15903129	0,007903
MRO%	-0,0027	0,001863	0,026793	-0,10024	-0,10945	-0,06734	0,002134	-0,00342	0,016864	0,003125	0,002956	0,00896	0,86458	0,901342	1	-0,14738677	0,007028
Operations	0,012366	0,018219	0,035051	0,054438	0,05048	0,018727	0,014434	0,028437	0,030596	0,002433	0,013404	0,028442	-0,08097	-0,15903	-0,14739	1	-0,00203
MLF (in seconc	-0,01013	-0,01256	-0,01083	0,019704	0,012957	0,016012	0,000189	-0,00335	-0,00764	-0,002	-0,00811	-0,00671	0,002119	0,007903	0,007028	-0,00202835	1
Depo	0,030066	0,029188	0,091948	0,034688	0,032996	-0,00598	0,021854	0,029383	0,022672	-0,00316	0,00232	0,002828	-0,00608	0,002827	0,00123	0,11954315	-0,00522
Liquidity_excl_	-0,02822	-0,02228	-0,00577	0,00221	-0,01722	-0,01401	-0,01925	-0,02081	-0,01601	-0,00283	-0,00787	-0,01233	0,009002	0,013996	0,014411	-0,02076518	-0,00626
CA	0,005176	0,013123	0,032719	0,059354	0,041182	0,016868	0,012119	0,025651	0,030071	0,001496	0,015238	0,027739	-0,05451	-0,14878	-0,14811	0,88070405	-0,01181
Reserves	-0,00933	-0,01734	-0,02151	-0,0059	-0,00687	-0,04808	0,000536	-0,01325	-0,02033	0,000699	-0,00054	-0,00171	-0,21359	-0,16191	-0,18956	-0,01512421	-0,00376
CBPP	-0,00539	0,005447	0,014981	0,007437	0,039715	0,062393	-0,0277	-0,0348	-0,03952	-0,00904	-0,01711	-0,0276	-0,00555	-0,00396	-0,00436	-0,00466982	-0,01654
EUR/USD	-0,11946	-0,13761	-0,13612	-0,18585	-0,18386	-0,13137	-0,08333	-0,12049	-0,13472	0,027108	-0,0718	-0,08493	0,031018	0,033519	0,040861	0,01808766	-0,03993
Eurobond2y	-0,37673	-0,3596	-0,30077	-0,01018	0,014248	0,003625	-0,42876	-0,50171	-0,46573	-0,01535	-0,26627	-0,44189	0,014573	0,038291	0,025699	-0,0029879	0,035935
Eurobond5y	-0,36143	-0,35763	-0,31474	-0,08487	-0,05605	-0,0602	-0,41993	-0,49819	-0,46967	-0,02466	-0,26538	-0,41746	-0,00806	0,011871	-0,00229	0,02915423	0,007253
Eurobond10y	-0,29606	-0,29684	-0,24982	-0,06881	-0,03739	-0,03223	-0,33268	-0,40396	-0,383	-0,02903	-0,21241	-0,32885	-0,01255	-0,008	-0,01242	0,03724015	-0,00984
EurobondCDS5	0,083315	0,087631	0,073007	0,13769	0,123033	0,079324	0,076713	0,08377	0,047722	0,005835	0,03652	0,032285	-0,00075	-0,04372	-0,03783	0,02895046	0,04305
EurobondCDS1	0,093935	0,102517	0,093498	0,144873	0,136168	0,089349	0,093475	0,110291	0,085666	-0,00158	0,053316	0,059527	0,015174	-0,0439	-0,0265	0,02849538	0,053004
CDS 2y EURIBO	0,083685	0,115285	0,145355	0,165649	0,171368	0,147011	0,045996	0,082667	0,105485	-0,01839	0,016129	0,044729	-0,00446	0,00485	-0,01287	-0,00475656	0,061897
CDS 5y EURIBO	0,146935	0,176904	0,192453	0,155914	0,163903	0,149165	0,08044	0,135135	0,150812	-0,01746	0,029955	0,070003	-0,00807	-0,00819	-0,02312	-0,01282316	0,0617
deficitzone	0,015641	0,009831	-0,00554	-0,00922	-0,00253	0,00584	0,003476	0,001472	-0,00406	5,45E-05	-0,00418	0,002743	-0,01338	-0,0028	-0,01093	-0,00553448	0,000817
debtzone	0,005454	0,002053	-0,00398	-0,00794	-0,00405	0,000622	-0,00126	-0,00296	-0,00419	0,001674	0,001904	-0,00067	-0,00114	-0,00291	-0,00271	0,00174753	0,003317
Monetary dum	0,017162	-0,00611	-0,0189	0,050795	0,040958	0,051601	0,018504	0,003879	-0,01312	-0,00914	-0,00579	-0,00421	0,003819	0,013902	0,012231	-0,01738165	0,042526

	Depo	idity_excl_!	CA	Reserves	CBPP	EUR/USD	urobond2	urobond5	urobond1(	obondCD!	obondCDS	RIBOR PAN	RIBOR PAN	deficitzone	debtzone	onetary dumr
bs3vs6y1	0,030066	-0,02822	0,005176	-0,00933	-0,00539	-0,11946	-0,37673	-0,36143	-0,29606	0,083315	0,093935	0,083685	0,146935	0,015641	0,005454	0,017
bs3vs6y2	0,029188	-0,02228	0,013123	-0,01734	0,005447	-0,13761	-0,3596	-0,35763	-0,29684	0,087631	0,102517	0,115285	0,176904	0,009831	0,002053	-0,006
bs3vs6y5	0,091948	-0,00577	0,032719	-0,02151	0,014981	-0,13612	-0,30077	-0,31474	-0,24982	0,073007	0,093498	0,145355	0,192453	-0,00554	-0,00398	-0,019
bs1vs3y1	0,034688	0,00221	0,059354	-0,0059	0,007437	-0,18585	-0,01018	-0,08487	-0,06881	0,13769	0,144873	0,165649	0,155914	-0,00922	-0,00794	0,051
bs1vs3y2	0,032996	-0,01722	0,041182	-0,00687	0,039715	-0,18386	0,014248	-0,05605	-0,03739	0,123033	0,136168	0,171368	0,163903	-0,00253	-0,00405	0,041
bs1vs3y5	-0,00598	-0,01401	0,016868	-0,04808	0,062393	-0,13137	0,003625	-0,0602	-0,03223	0,079324	0,089349	0,147011	0,149165	0,00584	0,000622	0,052
bs3vs12y1	0,021854	-0,01925	0,012119	0,000536	-0,0277	-0,08333	-0,42876	-0,41993	-0,33268	0,076713	0,093475	0,045996	0,08044	0,003476	-0,00126	0,019
bs3vs12y2	0,029383	-0,02081	0,025651	-0,01325	-0,0348	-0,12049	-0,50171	-0,49819	-0,40396	0,08377	0,110291	0,082667	0,135135	0,001472	-0,00296	0,004
bs3vs12y5	0,022672	-0,01601	0,030071	-0,02033	-0,03952	-0,13472	-0,46573	-0,46967	-0,383	0,047722	0,085666	0,105485	0,150812	-0,00406	-0,00419	-0,013
bs6vs12y1	-0,00316	-0,00283	0,001496	0,000699	-0,00904	0,027108	-0,01535	-0,02466	-0,02903	0,005835	-0,00158	-0,01839	-0,01746	5,45E-05	0,001674	-0,009
bs6vs12y2	0,00232	-0,00787	0,015238	-0,00054	-0,01711	-0,0718	-0,26627	-0,26538	-0,21241	0,03652	0,053316	0,016129	0,029955	-0,00418	0,001904	-0,006
bs6vs12y5	0,002828	-0,01233	0,027739	-0,00171	-0,0276	-0,08493	-0,44189	-0,41746	-0,32885	0,032285	0,059527	0,044729	0,070003	0,002743	-0,00067	-0,004
Depo%daily	-0,00608	0,009002	-0,05451	-0,21359	-0,00555	0,031018	0,014573	-0,00806	-0,01255	-0,00075	0,015174	-0,00446	-0,00807	-0,01338	-0,00114	0,004
MLF%	0,002827	0,013996	-0,14878	-0,16191	-0,00396	0,033519	0,038291	0,011871	-0,008	-0,04372	-0,0439	0,00485	-0,00819	-0,0028	-0,00291	0,014
MRO%	0,00123	0,014411	-0,14811	-0,18956	-0,00436	0,040861	0,025699	-0,00229	-0,01242	-0,03783	-0,0265	-0,01287	-0,02312	-0,01093	-0,00271	0,012
Operations	0,119543	-0,02077	0,880704	-0,01512	-0,00467	0,018088	-0,00299	0,029154	0,03724	0,02895	0,028495	-0,00476	-0,01282	-0,00553	0,001748	-0,017
MLF (in seconc	-0,00522	-0,00626	-0,01181	-0,00376	-0,01654	-0,03993	0,035935	0,007253	-0,00984	0,04305	0,053004	0,061897	0,0617	0,000817	0,003317	0,043
Depo	1	-0,00777	0,083284	0,002402	0,010091	-0,0245	-0,02866	-0,02659	-0,02959	-0,01116	0,005956	0,028717	0,032052	0,023426	0,002113	-0,011
Liquidity_excl_	-0,00777	1	-0,04472	-0,00274	-0,00118	-0,00864	0,006073	0,002254	-0,02878	-0,01331	-0,02086	-0,0351	-0,04767	0,046147	0,050334	-0,005
CA	0,083284	-0,04472	1	-0,06912	-0,02051	0,011566	0,004524	0,026199	0,044663	0,033719	0,023843	-0,01242	-0,0153	-0,00107	0,006249	-0,033
Reserves	0,002402	-0,00274	-0,06912	1	0,000748	0,04277	0,002109	0,031949	0,042769	-0,07732	-0,07599	-0,07543	-0,05379	0,002664	-0,00077	0,004
CBPP	0,010091	-0,00118	-0,02051	0,000748	1	0,02649	0,010291	0,002917	0,000474	-0,0509	-0,05043	-0,04978	-0,04904	0,020908	0,006496	-0,025
EUR/USD	-0,0245	-0,00864	0,011566	0,04277	0,02649	1	-0,02797	-0,01119	-0,00702	-0,36064	-0,36789	-0,30806	-0,327	0,047532	0,05513	0,005
Eurobond2y	-0,02866	0,006073	0,004524	0,002109	0,010291	-0,02797	1	0,829387	0,657583	0,188687	0,15842	0,146234	0,111964	-0,00487	0,013736	0,016
Eurobond5y	-0,02659	0,002254	0,026199	0,031949	0,002917	-0,01119	0,829387	1	0,899369	0,058461	0,032419	-0,01883	-0,05595	0,009184	0,01975	0,008
Eurobond10y	-0,02959	-0,02878	0,044663	0,042769	0,000474	-0,00702	0,657583	0,899369	1	0,025976	-0,00767	-0,06779	-0,09906	0,020876	0,028156	0,032
EurobondCDS!	-0,01116	-0,01331	0,033719	-0,07732	-0,0509	-0,36064	0,188687	0,058461	0,025976	1	0,880942	0,556102	0,557735	-0,01093	-0,00391	0,045
EurobondCDS1	0,005956	-0,02086	0,023843	-0,07599	-0,05043	-0,36789	0,15842	0,032419	-0,00767	0,880942	1	0,570063	0,575446	-0,01414	-0,00849	0,028
CDS 2y EURIBO	0,028717	-0,0351	-0,01242	-0,07543	-0,04978	-0,30806	0,146234	-0,01883	-0,06779	0,556102	0,570063	1	0,871508	-0,00978	-0,009	0,011
CDS 5y EURIBO	0,032052	-0,04767	-0,0153	-0,05379	-0,04904	-0,327	0,111964	-0,05595	-0,09906	0,557735	0,575446	0,871508	1	-0,01342	-0,01734	0,011
deficitzone	0,023426	0,046147	-0,00107	0,002664	0,020908	0,047532	-0,00487	0,009184	0,020876	-0,01093	-0,01414	-0,00978	-0,01342	1	0,972926	0,007
debtzone	0,002113	0,050334	0,006249	-0,00077	0,006496	0,05513	0,013736	0,01975	0,028156	-0,00391	-0,00849	-0,009	-0,01734	0,972926	1	0,008
Monetary dur	-0,01119	-0,00503	-0,03308	0,004499	-0,02469	0,004516	0,015731	0,00817	0,032239	0,045103	0,027565	0,011336	0,010609	0,006881	0,007664	1

Appendix 8. Correlation between 3M vs. 12M Euribor basis swap spreads with 2 year and 5 year maturities including one to five leads and lags of explanatory variables

Basis	lead/lag	Depo%daily	MLF%	MRO%	Operations	(in secondary	Depo	uidity_and_SM	CA	Reserves	CBPP	EUR/USD	Eurobond2y	Eurobond5y	Eurobond10y	urobondCDS5y	urobondCDS10	URIBOR PANEL	URIBOR PANEL	deficitzone	debtzone	Monetary dummy
	-5	0,003	-0,064	-0,029	-0,003	0,015	-0,011	0,001	-0,004	-0,010	-0,030	-0,038	0,018	0,005	-0,007	0,042	0,048	-0,020	-0,015	0,006	0,007	0,033
	-4	0,079	0,011	0,069	0,017	0,031	0,071	0,016	-0,004	-0,080	-0,027	-0,051	0,010	-0,019	-0,037	0,038	0,018	-0,003	-0,055	0,026	0,029	-0,017
	-3	0,017	0,024	0,017	-0,016	0,021	0,090	0,023	-0,014	-0,046	-0,029	0,047	-0,041	-0,074	-0,088	-0,056	-0,045	-0,035	-0,056	0,025	0,026	0,063
	-2	0,055	0,052	0,072	0,036	-0,046	-0,034	0,003	0,039	-0,043	-0,012	-0,006	0,017	0,009	0,015	0,020	0,007	-0,006	0,009	0,002	0,001	-0,029
	-1	0,065	0,057	0,071	-0,006	0,033	0,082	-0,003	-0,018	-0,001	-0,031	-0,102	-0,053	-0,017	0,009	0,107	0,120	0,111	0,076	-0,015	-0,020	0,004
3vs12 2y	0	0,003	-0,007	-0,003	0,028	-0,003	0,029	-0,021	0,026	-0,013	-0,035	-0,120	-0,502	-0,498	-0,404	0,084	0,110	0,083	0,135	0,001	-0,003	0,004
	1	0,004	0,014	0,013	-0,015	-0,025	0,035	0,005	-0,018	-0,001	0,030	-0,002	0,025	0,027	0,031	0,042	0,020	-0,031	-0,034	-0,003	-0,010	-0,012
	2	0,007	-0,012	0,009	-0,012	-0,031	0,001	0,006	-0,023	-0,011	-0,061	-0,012	0,028	0,047	0,063	0,017	0,004	0,002	0,027	0,007	0,004	-0,011
	3	0,069	0,001	0,054	0,026	0,018	-0,048	0,003	0,020	0,025	-0,007	-0,019	0,015	0,020	0,013	0,015	0,019	-0,049	-0,033	0,044	0,042	0,022
	4	-0,041	-0,013	-0,035	-0,012	0,021	0,106	-0,006	-0,005	0,030	0,036	-0,012	0,057	0,035	0,038	-0,007	0,037	0,006	0,040	-0,002	-0,007	0,053
	5	-0,022	-0,009	-0,023	0,000	0,005	0,024	0,047	-0,007	0,072	-0,057	0,005	0,067	0,060	0,062	0,010	-0,015	-0,108	-0,103	0,019	0,015	0,015

Basis	lead/lag	Depo%daily	MLF%	MRO%	Operations	(in secondary	Depo	uidity_and_SM	CA	Reserves	CBPP	EUR/USD	Eurobond2y	Eurobond5y	Eurobond10y	urobondCDS5y	urobondCDS10	URIBOR PANEL	URIBOR PANEL	deficitzone	debtzone	Monetary dummy
	-5	0,002	-0,078	-0,037	0,004	0,011	-0,007	0,004	0,000	-0,013	-0,028	-0,023	0,034	0,021	0,006	0,008	0,015	-0,048	-0,043	0,002	0,007	0,038
	-4	0,082	0,018	0,080	-0,002	0,025	0,071	0,003	-0,024	-0,076	-0,023	-0,052	0,002	-0,015	-0,037	0,033	0,015	-0,015	-0,067	0,017	0,024	-0,017
	-3	0,022	0,032	0,028	-0,006	0,021	0,107	0,005	-0,022	-0,035	-0,039	0,038	-0,029	-0,060	-0,078	-0,064	-0,051	-0,031	-0,067	0,017	0,023	0,049
	-2	0,032	0,030	0,050	0,039	-0,032	-0,031	-0,016	0,038	-0,035	-0,009	0,011	0,018	0,018	0,030	0,030	0,020	-0,007	0,010	-0,004	0,000	-0,041
	-1	0,072	0,061	0,081	-0,005	0,027	0,076	-0,003	-0,015	-0,026	-0,041	-0,088	-0,066	-0,035	-0,012	0,102	0,113	0,120	0,078	-0,015	-0,016	-0,013
3vs12 5y	0	0,017	0,011	0,017	0,031	-0,008	0,023	-0,016	0,030	-0,020	-0,040	-0,135	-0,466	-0,470	-0,383	0,048	0,086	0,105	0,151	-0,004	-0,004	-0,013
	1	0,006	0,028	0,025	-0,016	-0,013	0,036	0,011	-0,018	-0,012	0,047	-0,018	0,004	-0,012	-0,003	0,037	0,013	-0,020	-0,015	-0,005	-0,006	-0,006
	2	0,000	-0,016	0,003	-0,010	-0,015	-0,024	0,009	-0,017	-0,012	-0,072	0,006	0,032	0,041	0,050	0,043	0,019	-0,001	0,012	0,003	0,003	-0,019
	3	0,071	0,001	0,062	0,018	0,005	-0,028	0,006	0,011	0,033	0,003	-0,022	0,006	0,002	0,005	0,027	0,040	-0,035	-0,010	0,036	0,039	0,031
	4	-0,038	-0,009	-0,037	-0,002	0,028	0,130	-0,007	0,006	0,020	0,049	-0,003	0,045	0,016	0,020	-0,013	0,022	-0,007	0,030	-0,005	-0,005	0,057
	5	-0,051	-0,021	-0,049	-0,007	0,007	0,028	0,035	-0,011	0,094	-0,072	0,023	0,077	0,066	0,058	0,018	-0,015	-0,112	-0,114	0,011	0,009	-0,003

Appendix 9. Lag length selection for Johansen's test

VAR system, maximum lag order 20

The asterisks below indicate the best (that is, minimized) values of the respective information criteria, AIC = Akaike criterion, BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	-15221,96370		35,571510	35,881549	35,690212
2	-14942,56342	0,00000	35,035072	35,616394*	35,257637*
3	-14863,97458	0,00000	34,966181*	35,818786	35,292609
4	-14825,32501	0,00610	34,990279	36,114169	35,420572
5	-14791,61952	0,04155	35,025889	36,421063	35,560045
6	-14759,60553	0,07330	35,065438	36,731895	35,703457
7	-14729,58062	0,13391	35,109617	37,047358	35,851501
8	-14681,11382	0,00005	35,110859	37,319883	35,956606
9	-14647,54150	0,04352	35,146779	37,627087	36,096389
10	-14599,55521	0,00007	35,149139	37,900731	36,202613
11	-14564,68741	0,02736	35,182043	38,204918	36,339381
12	-14532,26055	0,06410	35,220630	38,514789	36,481832
13	-14504,65664	0,25171	35,270446	38,835889	36,635511
14	-14474,03047	0,11248	35,313226	39,149952	36,782155
15	-14444,17402	0,14045	35,357797	39,465807	36,930590
16	-14413,46137	0,10963	35,400376	39,779669	37,077032
17	-14391,65369	0,69047	35,463687	40,114265	37,244207
18	-14343,50796	0,00006	35,465676	40,387537	37,350060
19	-14304,04374	0,00430	35,487878	40,681023	37,476126
20	-14232,81854	0,00000	35,436132	40,900560	37,528243

VAR system, maximum lag order 20

The asterisks below indicate the best (that is, minimized) values of the respective information criteria, AIC = Akaike criterion, BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	-14401,12270		33,660356	33,970394	33,779057
2	-14141,74197	0,00000	33,170528	33,751851*	33,393093*
3	-14058,09844	0,00000	33,089868*	33,942474	33,416297
4	-14025,14091	0,05372	33,127220	34,251109	33,557512
5	-13996,30287	0,18515	33,174163	34,569336	33,708319
6	-13960,65684	0,02044	33,205255	34,871711	33,843274
7	-13934,83272	0,37072	33,259215	35,196955	34,001098
8	-13889,33533	0,00025	33,267370	35,476394	34,113117
9	-13859,02018	0,12320	33,310874	35,791181	34,260484
10	-13812,81378	0,00018	33,317378	36,068969	34,370852
11	-13780,17398	0,05975	33,355469	36,378344	34,512807
12	-13753,27684	0,29590	33,406931	36,701090	34,668133
13	-13727,38118	0,36547	33,460725	37,026167	34,825790
14	-13704,03616	0,56727	33,520457	37,357183	34,989386
15	-13676,85215	0,27745	33,571251	37,679261	35,144043
16	-13650,11200	0,30629	33,623078	38,002372	35,299734
17	-13630,81914	0,85740	33,692245	38,342822	35,472765
18	-13584,13193	0,00014	33,697630	38,619491	35,582013
19	-13545,21284	0,00544	33,721101	38,914246	35,709348
20	-13473,86355	0,00000	33,669065	39,133494	35,761176

Appendix 10. Total outstanding amounts of over the counter euro denominated plain vanilla swaps in billions of USD (in right axis) with respect to Eurobond yields (in left axis)