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Euribor Evolution and Risk on Banks' Asset

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by

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Resumo

O presente estudo investiga o impacto das alterações da taxa de juro interbancária, Euribor, no risco dos activos bancários.

Com a recente crise financeira, o efeito da turbulência no mercado interbancário criou uma necessidade de explorar as forças que foram causa de vários fenómenos incomuns nesse mercado. Por um lado, a Euribor testemunhou valores anormalmente baixos, chegando mesmo a atingir valores negativos. Por outro lado, os *spreads* dos activos bancários dispararam.

Tendo como base a vasta revisão da literatura, foram utilizados dados da Euribor a três meses retirados da Thomson Datastream entre 2000 e 2015 e dados do índice iTraxx fornecidos pela Markit de forma a construir um modelo auto-regressivo com a possibilidade de quebras de estrutura (Bai e Perron, 1998; 2003a).

Concluiu-se que (i) a Euribor não é o principal instrumento de explicação para o comportamento dos *spreads* nos mercados financeiros; e que (ii) com o nosso modelo econométrico, não é possível obter inferência estatística sobre a previsão da Euribor adicionando a componente do risco bancário, iTraxx. É evidenciado na nossa análise o problema de co-breaking.

Palavras-chave: Euribor, Activo Bancário, Políticas Monetárias, Crise Financeira, iTraxx, Co-breaking.

Abstract

This study investigates how Euribor rate affects the risk on banks' assets. With the recent financial crisis, the effect of turbulence on interbank markets has created a need to explore forces that have caused multiple uncommon phenomena in markets. On the one hand, Euribor rate witnessed drastic values, specifically reached values below zero. On the other hand, the volatility of banks' risk spreads soared.

Considering the vast literature review, we use three-month Euribor dataset from Thomson Datastream between 2000 and 2015, and iTraxx dataset from Markit to construct an autoregressive model, addressing the possibility of structural breaks (Bai and Perron, 1998; 2003a).

We concluded that (i) the Euribor is not the main instrument to explain the behavior of spreads in the financial markets; and (ii) with our econometric model we are unable to obtain statistical inference to draw conclusions about Euribor predictions based on iTraxx series. The co-breaking problem stands out in our analysis.

Keywords: Euribor, Banks' Assets, Monetary Policies, Financial Crisis, iTraxx, Co-breaking.

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List of Abbreviations

ABS: Asset-Backed Securities

BCBS: Basel Committee on Banking Supervision

EBA: European Banking Authority

ECB: European Central Bank

EMMI: European Money Market Institute

ESMA: European Securities and Market Authorities

EU: European Union

FI: Financial intermediation

GRSS: Global Rate Set System Ltd.

ICE: Intercontinental Exchange

IMF: International Money Fund

MP: Monetary Policy

OECD: Organization for Economic Corporation and Development

USA: United States of America

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Introduction

With the recent financial crisis, the effect of turbulence on interbank markets has created a need to explore forces that have caused multiple uncommon phenomena in markets. On the one hand, Euribor rate witnessed drastic values, specifically reached values below zero. On the other hand, the volatility of banks' risk spreads soared.

The general field of interest in this thesis is the Euribor evolution and risk on banks' asset.

We believe that this theme is quite pertinent because (i) It covers two recent business cycles: an expansion between 2000 and 2007 characterized by rising demand that lead to a great optimism and hence lead to higher asset prices, easier finance and reduced worries about risk; and a recession after 2007 that brought new challenges both to banking sector and market regulators[1]. Many authors such as Lipsey and Chrystal (2011), compared the macroeconomic impact of this recession to the Great Depression.

(ii) After 2004, the securitization market was intensified, when financial institutions began marketing sophisticated derivative products at unprecedented levels (e.g. Asset-backed securities, Credit Default Swaps). Securitization was a financial innovation technique that changed the constraints facing banks, which allowed banks to increase their lending faster than their deposits were growing. This expansion period was linked to the housing boom in United States of America (USA) and to the apparently low risk on banks' assets.

(iii) In September 2008, Lehman Brothers collapsed in the USA and many other financial institutions went bankrupt. After Lehman Brothers defaulted,

[1] In the banking sector this period was associated to a balance-sheet recession.

monetary atmosphere experienced a dramatic change and suddenly interbank market become illiquid. At that time, the capital of banks had been badly eroded by their losses and they had become much more risk-averse, which resulted in a rise of spread on banks' assets.

(iv) Strict regulations were enhanced in banking markets in order to avoid new balance-sheet recession and also to control banks' risk. In fact, these regulations improved the banking sector's ability to absorb shocks arising from financial and economic stress. For instance, the Liquidity Coverage Ratio was one of the Basel Committee's key reforms to strengthen global capital and liquidity regulations with the goal to promote a short-term resilient of a bank's liquidity risk profile.

(v) As it is known low interest rates tend to stimulate demand, but in 2008-2010 recession that did not occur. The ECB reduced their refi-rate to unprecedented low levels, hence so did Euribor, as a response to the sovereign debt crisis in Eurozone, provoked, among others, by the housing crisis. In theory, this is similar to liquidity trap phenomenon which is a situation described in Keynesian economics and developed in the IS-LM model by Hicks.

(vi) The ECB had to operate in uncharged waters, characterized by low growth, below-target inflation and unusual low rates, as well as financial fragility and rising debt. In concrete, policymakers searched for other ways to stimulate economy with unconventional monetary policies (e.g. quantitative easing).

(vii) The role of the bank as the financial intermediary was intensified. Specifically, the transmission mechanism became more complex over time in light of the increasing interlinkages between the banking sector and the financial market, i.e. it is due to the interconnectedness of financial institution: banks between themselves, with derivative counterparties and with direct links to consumption/households and investment spending decisions.

All the motives described above reveal that the interbank market has grown in matter during 2000-2015, mainly because it has become the major promoter of economic and financial stability. Therefore, we believe that the study of Euribor rates is relevant and justified in order to investigate the risks on banks' assets, taking into account that Euribor is indexed to most financial products and follows the refi-rate.

Also, the effect of negative interest rates seems ambiguous. On the one hand, it allows jointly with other measures, rearrangements in banks' assets. On the other hand, it implies losses in banks' assets operations. We consider that financial stability collides with banks' regulation and this situation may adversely affect the future credit, threatening banks' solvency. From our research, only few studies focus on the impact of the Euribor rates. In fact, in financial literature, the empirical papers have consisted impacts of changes in the interbank rate but huge part deal with only American dollar interest rate derivatives.

The central contribution of this paper is to illustrate the Euribor pattern as a provider of a renewed justification for banks' spreads. The significance of the study gives us solid proofs about the importance of the Euribor behavior as a prediction instrument of the banks' risk.

The purpose of this thesis is to investigate how changes in the Euribor rate, which is the interbank rate, will affect the risk on banks' asset. Considering this, we are motivated by two objectives: first, explore the impact of the Euribor in banks' risk and from there, find out whether it is possible to make any forecast for Euribor. Secondly, investigate the causal connection in this relationship, that is, the power of the Euribor as an instrument with the ability to predict banking risk.

For the purpose of our analysis and to conduct a comprehensive study of our research questions, we collected two datasets on a daily basis: the three-month

Euribor rate in order to explore the impact of the Euribor on banks' risk and the multi-name CDS index with five years maturity, iTraxx, to access the prediction capacity of the banks' risk. The time window is 2000-2015 for Euribor data and 2004-2015 for iTraxx data[2].

We present an econometric time series model. In this model we use Bai-Perron procedure to test structural breaks. This test was developed by Bai and Perron (1998) in the analysis of multiple structural change models and was designed to admit several breaks whilst most common models related to structural changes were designed for the case of a single change. Santos and Oliveira's (2010) study of inflation persistence with impulse saturation break tests was the support of our investigation of structural breaks in Euribor and iTraxx data. By contrast, in order to address this issue, other statistics and econometric literatures collect announcement that may lead to breaks (e.g. Falagiarda and Reitz, 2015) or admit several exogenous control variables in the estimation model (e.g. Alter and Beyer, 2014), among others. A robust forecasting test is also computed in our empirical analysis. Furthermore, we are unaware of any studies of breaks in Euribor in the estimated windows. Also, the study of breaks in time series is more associated with inflation studies

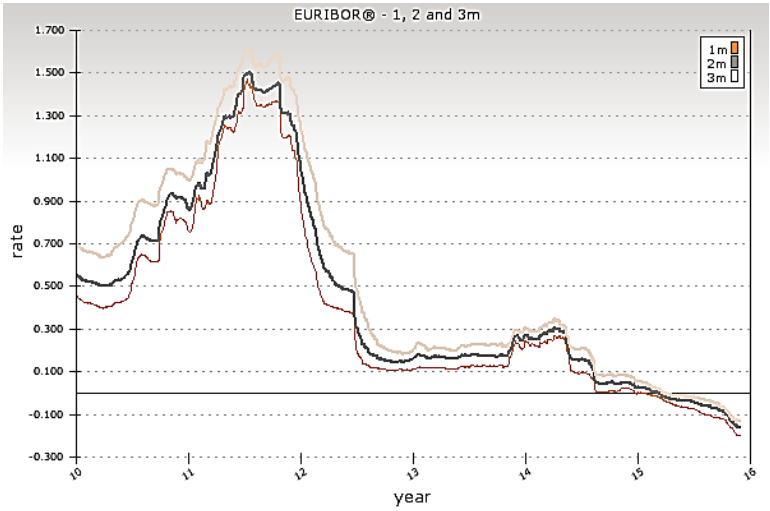
The remainder of this paper is organized as follows. Section 2 deals with literature review and extend from the first chapter to the fourth chapter, where we discuss studies related to our research. Section 2 corresponds to Chapter 5 and highlights the data, the methodology and presents our findings and discussions. The final section concludes the investigation carried throughout the writing of this paper.

[2] iTraxx data only became available after 2004.

Chapter 1
Euribor: History and Evolution

According to the information provided by the European Money Markets Institute (EMMI, formerly known as Euribor-EBF)[3], Euribor is a benchmark that allows the assessment of the average rate at which banks in the Eurozone lend unsecured funding in the euro interbank market[4] for a given period and in which is also considered the major euro interest reference rate. Over the years, its importance has risen in monetary policy (MP) decisions and in the European financial stability, being used as a reference in a wide range of financial instruments.

FIGURE 1 – Euribor rate evolution for three, two and one month



Source: EMMI, 2015

[3] EMMI is an international non-profit making association under Belgian law founded in 1999, it currently provides two indexes: Euribor and Eonia.

[4] The interbank Money market was created in 1977 in order to allow the redistribution of liquidity between the institutions of the banking system. While the interbank bond market was created in 1978 with the aim of rewarding the surplus liquidity of banks and it traded securities public debt and similar instruments (Barata, 1998).

Perceive from Figure 1, in the last four years, Euribor decreased till it reached a value approximate to zero. In April 2015, this downward trend assumed values below zero. In recent years, Euribor has been devalued as anticipation of the European Central Bank's (ECB) MP (Bernoth and Hagen, 2004), reflecting the regulators effort for the economic growth in the Eurozone. In this sense, Euribor shows itself susceptible to shocks in the economy, highlighting the regulators' indirect responsibility in the interbank market, e.g. much of the debt is indexed to Euribor and if the ECB induces rises in the reference rate, this may justify an increased likelihood of new problems in peripheral countries, which can deal with new bail-outs[5].

Several authors have studied the impact of MP announcements in the interbank market, for instances, Bernoth and Hagen (2004) studied the efficiency and the impact of ECB's policy announcements in the Euribor Futures Market, and Ricci (2015) revealed the impact of MP announcements on the stock price of large European banks during the financial crisis. On the another hand, Hirvelä (2012) gave evidences that corroborate the hypothesis of an impact and a significant correlation between ECB open market operations and Euribor basis swap spreads. To this, the Euribor effectiveness may be constituted as an indicator of transparency and clarity in the financial market (Bernoth and Hagen, 2004).

According to this perspective, the evolution of market interest rates reveals itself as a key-component for the transmission channel of MP. Therefore, such a quantitative assessment may be a natural complement to the wide range of financial market indicators already considered by policymakers. However, the effect of negative interest rates seems ambiguous. On the one hand, it allows, jointly with other measures, to rearrange the banks' asset, on the other hand, it implies losses in its asset operations.

[5] In periods of financial stress, banks should be capitalized by governments, increasing their tax liabilities.

In the following chapter, we develop this theme by illustrating Euribor rate's origin, main characteristics and its evolution within the time-window frame selected for this study.

1.1. Its Origin, principal characteristics and Evolution

Euribor was created alongside with the introduction of the single currency (Euro) to Europe in 1999. Its name, Euribor, stands for Euro Interbank Offered Rate and is a daily reference benchmark based on the average rate at which banks within the Eurozone lend unsecured funding in the euro interbank market for a given period (Ivanova and Gutiérrez, 2014). Euribor is constitued by a representative panel of European Banks[6] and is currently administrated by EMMI (www.euribor-rates.eu). The banks included in the panel have been selected to ensure that the diversity of the euro money market is adequately reflected. The Global Rate Set Systems Ltd. (GRSS) has been chosen as the screen service provider responsible for computing and publishing Euribor[7] (www.emmi-benchmarks.eu). This benchmark interest rate replicates the contributing bank's conviction about the cost at which a bank within the Eurozone would offer term deposits to another bank in the Eurozone (Marianne Ojo, 2014).

Current Euribor is calculated and published for the following eight maturities: 1 and 2 weeks; and 1, 2, 3, 6, 9 and 12 months. However, the present analysis focus on the 3-month duration due to, on the one hand, the interest payments on loans, mortgages and bonds are usually indexed to the 3-month

[6] The panel banks include the banks with the highest volume of business in the Eurozone money markets.

[7] A strict Code of Conduct sets out rules covering the criteria used to determine which banks may belong to the panel of banks, the obligations of the Panel Banks, tasks and the composition of the Steering Committee, which is responsible for overseeing Euribor.

Euribor rate and, on the other hand, the two of the most heavily traded products are 3-month Euribor Futures and options on 3-month Euribor Futures, derivatives on the 3-month Euribor (Rupert and Gutiérrez, 2010). Moreover, Euribor instruments were studied since they are the most liquid short rate contracts in Europe and hence have the best price picture (Tiganas, 2010), i.e., with the use of 3-month duration we are able to have a better picture of market expectations for the 3-month Euribor rate (Ivanova and Gutiérrez, 2014). These contracts are traded on the Intercontinental Exchange (ICE).

1.1.1 Euribor reform

The growing importance of Euribor requires adequate measures to preserve its integrity and credibility, through definition clarifications and further enhanced contribution processes and governance measures. Accordingly, EMMI is strongly committed to maintaining a robust governance and control framework for the administration of the Euribor benchmark, meeting global regulatory expectations and best practices (EMMI, 2015).

In order to achieve so, EMMI has, over the past years, implemented wide-ranging reforms related to its benchmark administration activities (governance, quality of the Benchmark, Quality of the Methodology, Accountability), aligned with ESMA[8]-EBA[9] recommendations.

Steven Maijoor, ESMA Chair, stated that:

> Euribor is a key global financial benchmark. The reforms undertaken by EMMI are a key prerequisite for ensuring confidence among rate submitters and final users of the benchmark. Beyond the immediate changes recommended by the EBA and ESMA, the international cooperation on reforming interbank benchmarks is progressing. Euribor should be ready to respond to these advances (www.eba.europa.eu).

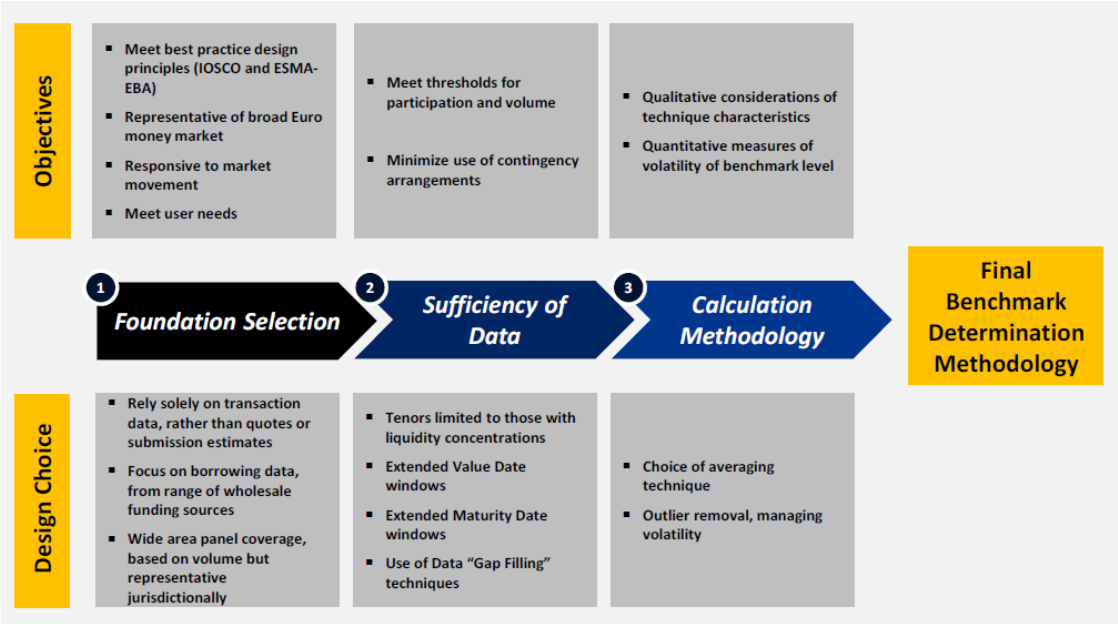
[8] European Securities and Markets Authority
[9] European Banking Authority

In this context, in 2014 EMMI initiated the "Euribor + Project" to develop and evaluate a transaction-based benchmark determination methodology for Euribor[10], clarifying the rate specification for the "rate at which banks of sound financial standing could borrow funds in the EU and EFTA[11] countries in the wholesale, unsecured money markets in euro" (EMMI, 2015). Accordingly, EMMI consider the Euribor rate should a) minimize the opportunities for market manipulation, b) be anchored in observable transactions wherever feasible, c) be robust in the face of market dislocation and should demonstrate confidence that they remain resilient in times of stress, resulting in a more robust Euribor benchmark. EMMI is intended to change the determination methodology on 4 July 2016 (EMMI, 2015).

1.1.2 Euribor Specification Methodology

The design of the transaction-based determination methodology for Euribor proceeded in three phases as described in the figure below.

TABLE 1 - Consultative Position Paper on the Evolution of Euribor



Source: EMMI, 2015

[10] Align with IOSCO Principles. http://www.iosco.org/library/pubdocs/pdf/IOSCOPD526.pdf

[11] EFTA – European Free Trade Association

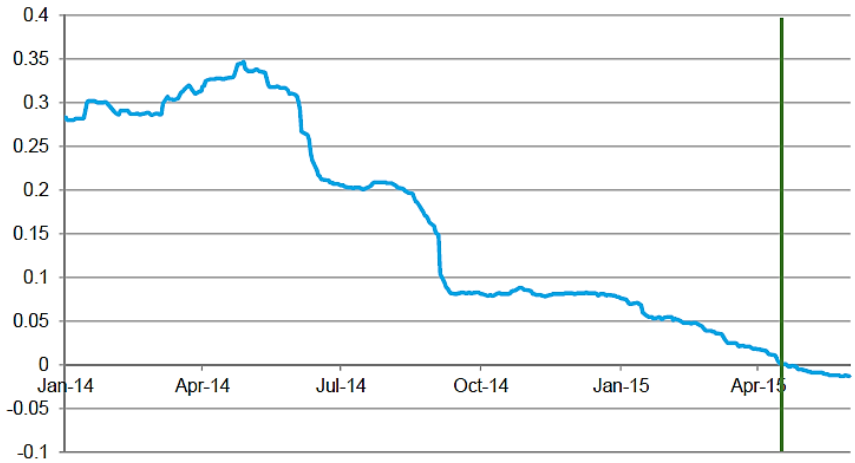
After implementing this methodology, the Euribor benchmark will be calculated for the following five tenors: 1 week and 1, 3, 6, and 12 months justified by the insufficient transactional volume[12] of the 2-week, 2-month and 9-month tenors. Also, EMMI envisages a Euribor panel consisting of banks that are active[13] participants in the euro money market.

With the introduction of the new methodology, we acknowledge the inevitable change in the level and volatility characteristics of Euribor, more precisely, with the new methodology we can expect an increased volatility but would be fully representative of the market reality. The transition plan from the current to the transaction-based determination methodology is shown in Table 1A in annex.

1.1.3 Initial market experience with negative Euribor

The 3-month Euribor has turned negative for the first time on April 21, 2015 (see figure 2). The negative values have impact both on the commercial side and financial side since financial products are mostly indexed to Euribor.

FIGURE 2 - Three-month Euribor rate



Source: ECB, 2015

[12] The sum of notional amounts of all eligible transactions which were used to derive the submission rate (volume-weighted average rate)

[13] Active refers to a bank that can prove to have borrowing activity in the interbank market, or positive outstanding amounts issued, or other unsecured wholesale short term instruments.

On the commercial side, three main alternatives may be identified for loans' stock: (i) the Euribor is floored at zero and hence the commercial spread is granted, (ii) the market rate (base rate + spread) is floored at zero and negative Euribor erode margins, (iii) no zero-floor where negative base rate may cause negative all-in market rate. For instance, Bank of Portugal clarifies that, with downward trend in Euribor, the spread needs always to be discounted (Banco de Portugal, 2015).

In the financial sector, as rates have been moving down, large investors have lengthen their credit limits (i.e. the tenor of their assets) in order to achieve positive returns and/or avoid negative rates. As market participants felt the possibility of having negative fixings for 3-month Euribor, they have been selling the basis swap, anticipating a higher inelasticity or stickiness of short term negative rates vs long term positive ones.

The effect of negative rates on interest rate options does not allow the use of the traditional pricing models (e.g. Black and Scholes) because these models are based on a lognormal distribution that does not allow negative rates. Implied volatility tends to infinity when forward rates approach zero. In order to cope with current market conditions, alternative models as Normal Gaussian Distribution have been used, this distribution allows rates to span the whole real axis (from –infinity to infinity). This way, market participants opted by using Displaced Lognormal Model[14] for swap options and a Normal Gaussian Model for Caps/Floors and Interest rate Futures' Options (www.ecb.europa.eu).

Another open issue is the legal topic where alternatives bear possible legal risks, as class actions may occur; banks may decide to opt for different solutions, causing reputational risks and new loans production need to be treated accordingly.

[14] The displaced lognormal model simply shifts the lognormal distribution to allow slightly negative rates.

Besides that, the downward trend improve the profitability of banks' financial margin, which means paying lower interest on deposits and resume lending, also banks are able to improve financial margins. However, the benefits may not compensate the current value of inflation.

Chapter 2
Great Financial Crisis

The build-up phase prior to a financial crisis has the same pattern as a boom in the business cycle[15]. Rising demand and employment lead to a great optimism and this in turn leads to higher asset prices, easier finance and reduced worries about risk. Higher asset prices encourage further buying by those seeking capital gains and many of these speculative purchases are funded by increasing debt (Lipsey and Chrystal, 2011). Thus, most financial crisis have their roots in a sustained period of economic growth and rising optimism. The recent financial crisis was no exception.

This crisis that started in 2007 had its origins in financial products created from mortgages in the USA, but rapidly spread from here to other countries and from financial markets to the real economy, for instance, securitization is of particular interest due to its role in the Credit Crunch[16]. As Hull (2012) stated, some financial institutions failed, many more had to be rescued by national governments which brings us to the conclusion that there can be no question that the first decade of the twenty-first century was disastrous for the financial sector.

Throughout this chapter, we give a brief explanation of the recent crisis and its main origins. For instance, we examine the nature of securitization and its role in the crisis. In the end of the chapter, we describe the interbank market reactions, focusing on the Euribor and Banks' asset.

[15] Fluctuations in economic activity that an economy experiences over a period of time. A business cycle is basically defined in terms of periods of expansion (the economy is growing in real terms) or recession (the economy is contracting).

[16] The crisis started in 2007 was associated with a Credit Crunch.

2.1 Credit Crunch

Over the period 2000-2007, banking activities over the world experienced rapid growth leading to an expansion of their balance sheets and therefore to an increase in their risk appetite. Moreover, in the financial sector, banks saw firms and consumers with growing incomes and they felt confident about lending to finance further expansion or property purchases. The belief in the wisdom of a specific regulator or government policy regime sustained the optimism [17] (Lipsey and Chrystal, 2011).

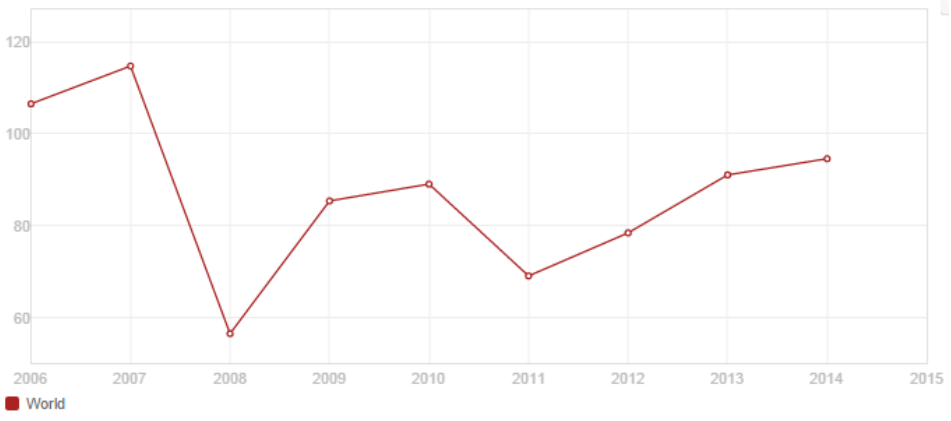
Specifically, in the USA the mortgage market watched an exponential growth leading to the American housing boom of the mid-2000s. The banks saw the great opportunity to expand their loans, mainly mortgages, rapidly and financing these loans by borrowing in the wholesale money markets (includes the interbank market). Securitization was a financial innovation technique that changed the constraints facing banks. In here, they could make a branch of loans and sell off the income stream from those loans in the form of a fixed-income investment instruments like a bond. Potential buyers would be attracted by the interest stream that they could get and with apparently low risk (Lipsey and Chrystal, 2011). Banks could lock in some profit on the deal and could then use the procedures to make even more loans which could also be potentially securitized. Hence, securitization allowed banks to increase their lending faster than their deposits were growing (Hull, 2012). Specifically, financial institutions began marketing sophisticated derivative products at unprecedented levels (e.g. Asset-backed securities (ABS) (see figure 1A in annex).

[17] This period was called "The great Moderation" owing to the apparent success of policymakers in keeping GDP close to potential and inflation under control (Lipsey and Chrystal, 2011).

To this, the relaxation of lending standards and the growth of subprime mortgages made house purchase possible for many families that had previously been considered to be not sufficiently creditworthy to qualify for a mortgage, in fact, the behavior of mortgage originators was influenced by their knowledge that mortgages would be securitized (Hull, 2012). The ABS market had become so large and so many banks were involved in both issuing these assets and trading them that the wholesale money markets took fright. Banks became very cautious about lending to each other on an unsecured basis[18] (see figure 2A in annex).

When the real estate market collapsed in July 2007 and once the financial crisis starts unfolding, these securities declined precipitously in value, jeopardizing the solvency of over-leveraged banks and financial institutions in the USA and Europe, and we assisted to a significant decrease of market valuation relative to GDP (Hoque, Andriosopoulos, Andriosopoulos, & Douady, 2015). As shown in figure 3, there was a significant decrease in market value relative to GDP leading up to the financial crisis[19] (see also figure 3A in annex).

FIGURE 3 - Market Capitalization to GDP (%)



Source: World Bank, 2015

[18] Secured lending involves the holding of some asset as security for the loan, whereas an unsecured loan can be worthless if a borrower defaults.

[19] A critical upset in a financial market (s) characterized by sharp declines in asset prices and the default of many financial and nonfinancial firms. (Burton and Lombra, 2006).

Lipsey and Chrystal (2011) consider that the critical point of the crisis was reached in September 2008 when Lehman Brothers collapsed in the USA[20] and both Royal Bank of Scotland and Lloyds Bank needed substantial injections of government funds in United Kingdom, mainly explained by the many financial institutions that found themselves in trouble when securitization market imploded in the USA (see figure 4A).

This contagious trend[21] quickly spread to other economies around the world, most notably in Europe.

2.2 Sovereign Debt Crisis in Europe

The European sovereign Debt crisis occurred during a period of time in which several European countries faced the collapse of financial institutions, high government debt and rapidly rising bond yield spreads in government securities. More precisely, the European sovereign debt crisis began at the end of 2009, when the peripheral Eurozone member states of Greece, Spain, Ireland, Portugal and Cyprus were unable to repay or refinance their government debt, or bail out their beleaguered banks without the assistance of third-party financial institutions such as the ECB, the International Monetary Fund[22] and the European Financial Stability Facility[23] (Nelson, Belkin, Mix, & Weiss, 2012).

With the increase fear of the excessive sovereign debt in 2010, lenders demanded higher interest rates from Eurozone states with high debt and deficit levels, making it harder for these countries to finance their budget deficits when faced with overall low economic growth. Some affected countries raised taxes

[20] Lehman Brothers was the country's fourth-largest investment bank.

[21] In this case, contagions are manifested as negative externalities diffused from the crashing of housing market in the USA.

[22] An international organization created with the purpose of standardizing global financial relations.

[23] An organization created by EU to provide assistance to member states with unstable economies.

and slashed expenditures in order to combat the crisis, which contributed to social upset within their borders and a crisis of confidence among their leadership, particularly in Greece.

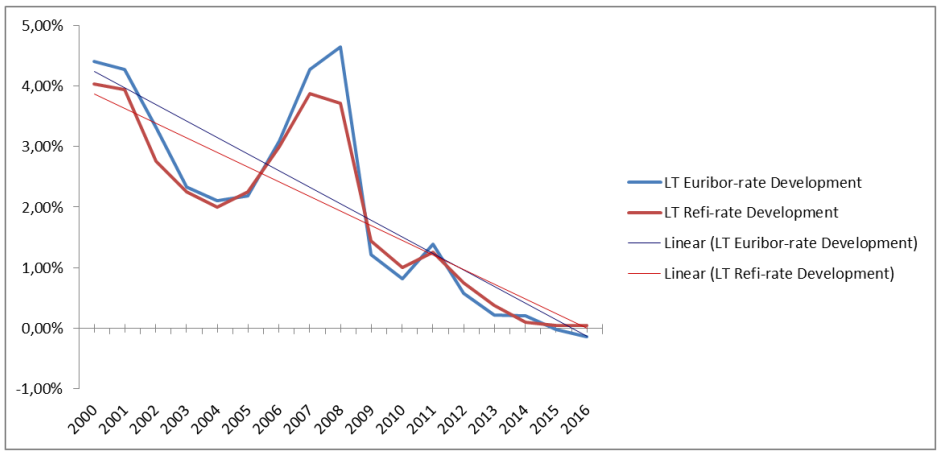
Focusing on the peripheral countries, this crisis came from two distinct situations: (a) the problems in financial institutions that led to government bailout which put the countries with difficulties; (b) and both the result of structural problems in Eurozone members (e.g. lack of competitiveness, lack of growth, and low level of savings) and a recurring need for debt issuance to support budget deficits. Following the Keynesian thought, some governments in the periphery of the Eurozone tried to counteract the breakdown of the economic cycle through public investment; an example was the case of the Portuguese government who created excessive indebtedness (Novais, 2014). Also, during this crisis, several of these countries had their sovereign debt downgraded to junk status by international credit rating agencies, worsening investor fears (Hirvelä, 2012). The credit crunch and the real estate market crisis described above also contributed to this crisis.

2.2.1 Euribor Evolution in times of Crisis

The following chart illustrates the evolution of the 3-month Euribor rate and the Refinancing rate[24] (refi-rate) as well as the respective linear trend since the build-up phase prior to a financial crisis until 15th January 2016. The values supporting figure 4 are respectively the average of each rate for each year.

[24] The key policy interest rate, main refinancing rate or minimum bid rate, is the interest rate which banks do have to pay when they borrow money from the ECB.

FIGURE 4 - Long-term rates development



Source: global-rates, 2016

As the chart above illustrates, the refi-rate imposed by the ECB has influence on the interest rates used in the interbank market. It proves to be a perfect correlation (99,19%) between the long-term (LT) development of the Refi-rate and the LT development of the Euribor rate. It is also evident that both rates shows a downward trend, reaching values close to zero and negative values for 3-month Euribor rate from 2015 onwards (see also FIGURE 1).

Refi-rate goes down in times of recession and vice-versa. So, when the European Sovereign Debt Crisis started in 2008-09, the ECB lowered the refi-rate with the purpose to stimulate the economy and a prolonged period of ultra-low interest rates took place. However, a prolonged period of very low interest rates can have unintended consequences in the financial sector: erosion of interest margins for financial institutions, incentive for excessive financial risk-taking, asset price inflation, etc. Cukierman and Izhakian (2014) highlights and supports the strong response of Euribor to changes in the ECB refi-rate.

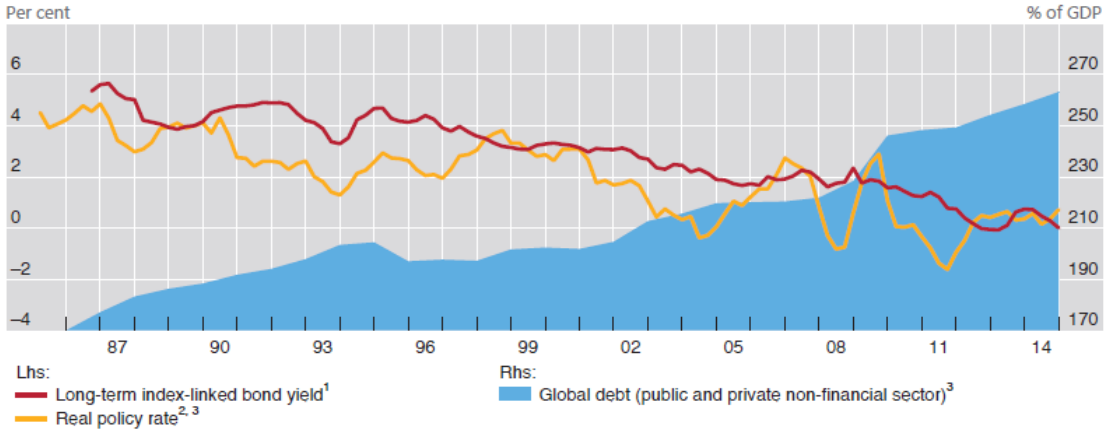
The BIS[25] Annual Report notes that

> the very low interest rates that have prevailed for so long may not be "equilibrium" ones, which would be conductive to sustainable and balanced

[25] Bank for International Settlement.

global expansion. Rather than just reflecting the current weakness, low rates may in part have contributed to it by fueling costly financial booms and busts. The result is too much debt, too little growth and excessively low interest rates [figure 5 shows that interest rates sink as debt soars]. In short, low rates beget lower rates (BIS, 2015b).

FIGURE 5 - Interest rates sink as debt soars



[1] From 1998, simple average of France, the United Kingdom and the United States; otherwise only the United Kingdom. [2] Nominal policy rate less consumer price inflation. [3] Aggregate based on weighted averages for G7 economies plus China based on rolling GDP and PPP exchange rates.

Source: BIS, 2015b

In fact, the level of refi-rate is no more that the price that banks pay to borrow funds from the ECB. This purchase price is an important factor for banks when setting the interest rates that they charge when they lend money. By raising or lowering interest rates the ECB can exercise indirect influence over the interest levels that the banks apply to interbank transactions, business loans, consumer loans, mortgages and savings accounts, amongst other assets. The ECB offers banks the facility to borrow money from it and banks make use of the lending facility when they are short of funds (www.global-rates.com). As Koulischer and Struyven (2014) concluded in their study about the Central Bank liquidity provisions and collateral quality, when the bank has a high level of quality collateral available, it borrows from the interbank market only. Nonetheless, when the amount or the quality of available collateral falls below a threshold, the commercial bank borrows from the central bank, which replicates

the observed shift from interbank markets to the central bank during the 2007-2013 financial crises.

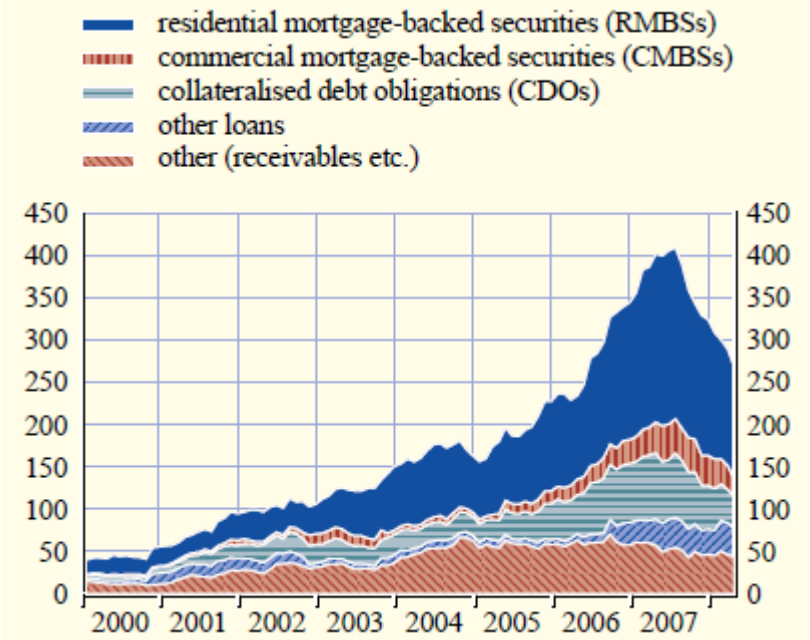
2.2.2 Banks' asset evolution in times of Crisis

In the few years prior to the financial market tensions, most balance sheet and profitability indicators for Eurozone banks showed a very positive picture[26]. Furthermore, during this period banks' profit and capital positions stood at relatively high levels. These developments were supported by a favorable macroeconomic environment and strong increases in asset prices. Consequently, banks' funding conditions were very favorable due to their low cost of financing and the strong demand for deposits and their marketable debt. In this respect, banks also benefited from an increasing ability to securitize their assets in an environment of ample liquidity and strong demand for credit products from non-bank investors searching for yield, which resulted in a surge in securitization of euro-denominated assets until mid-2007. Of course, these factors were in part the cause of a strong supply of bank credit and a progressive loosening in credit standards.

The figure below illustrates the issuance of euro ABS. As we can see, the growth of securitization markets in the Eurozone until the recent slowdown owing to the financial market tensions was remarkable. In fact, the issuance of euro ABS increased from around €50 billion in 2000 to almost €400 billion in mid-2007 (Lipsey and Chrystal, 2011).

[26] Banks' credit risk was very low; as measured either by indicators extracted from their financial statements.

FIGURE 6 - Issuance of euro ABS,



Description: Monthly data; 12-month moving sum
Source: Lipsey and Chrystal, 2011

We know that banks are involved in maturity transformation. This means that they borrow deposits that can be withdrawn on demand, and they make longer-term loans. Their assets are longer term than their liabilities (see figure 5A in annex). Therefore, this could cause problems if their depositors want their money back in a hurry, as banks cannot liquidate their loans quickly (Lipsey and Chrystal, 2011). This is why banks tend to manage this problem by holding liquid reserves and by using interbank market through which they can lend to each other when one bank is in need of short-term funds, while others have a surplus.

Hereafter, the crisis arrived and was grounded on financial assets and on excessive credit provision, specifically securitization[27]. This removed the loans from the banks' balance sheets and enabled them to expand their lending faster than they would otherwise be able to (Hull, 2012), and soon this crisis also

[27] Securitization was the process used by banks to create securities from loans and other income-producing assets.

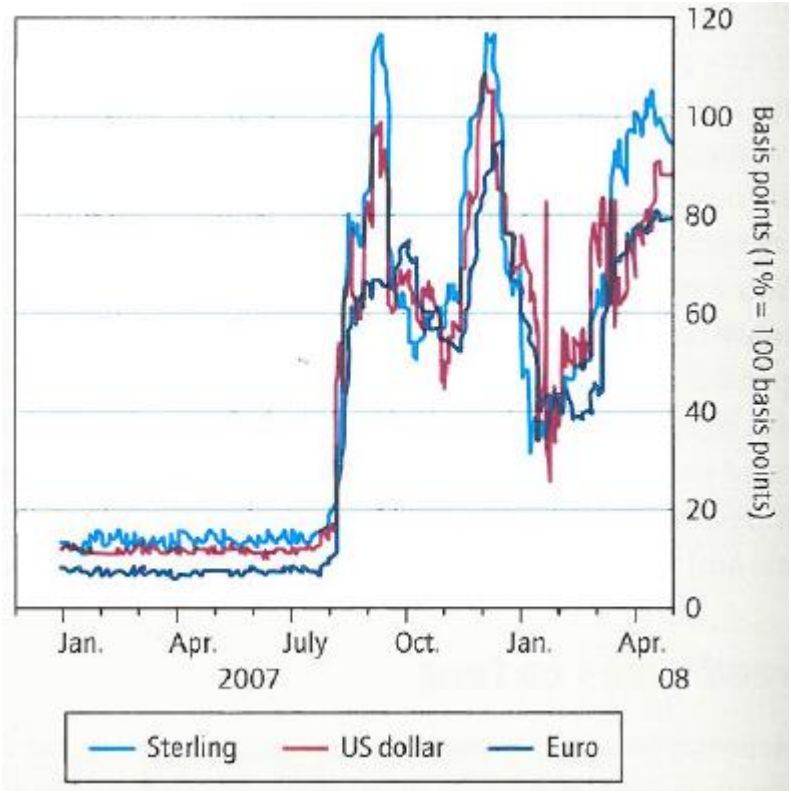
developed into a banking crisis, as a result, many banks were forced to close or to be restructured[28]. As mentioned in section 2.2, the peripheral economies of the Eurozone felt, with particular impact, the real estate and sovereign debt crisis, which exacerbated the banks' problem. Specifically, the portfolio of government bonds in bank assets experienced clear devaluations that led to a default risk for new banks' failures.

Figure 7 illustrates what happened to interest rates in the interbank market in United States, United Kingdom and Eurozone. The market froze and any trades that were done involved a substantial risk premium. Before the summer of 2007, interbank interest rates were a small margin above the official interest rates set by central banks. This small margin reflected the fact that bank loans to each other were unsecured and there was a very small risk that any of the major banks in this market might default (Lipsey and Chrystal, 2011). By 2008, the situation was totally different, the capital of banks had been badly eroded by their losses, they had become much more risk-averse and were reluctant to lend. Creditworthy individuals and corporations found borrowing difficult and credit spreads had increased dramatically[29] (Hull, 2012).

[28] Restructuring could involve a takeover by, or a merger with another institution, a change of management, a recapitalization or nationalization by the government, or some combination of these.

[29] The libor-OIS spread briefly reached 364 basis points in Oct'08, indicating an extreme reluctance of banks to lend to each other. The excess of the 3m-Libor interest rate over the 3m Treasury interest reached over 450 basis points in Oct'08 (normally it is between 30 and 50 basis points) (Hull, 2012).

FIGURE 7 - Interbank rates in United States, United Kingdom and Eurozone.



Source: Lipsey and Chrystal, 2011

As a matter of fact, in September 2008 there were even more serious events in the world money market. Several major banks found themselves in serious difficulty, requiring takeover by a stronger bank or government support (see section 2.1). The initial effect was greatest on USA interbank spreads but the USA markets fairly quickly came back into line with the others and they had similar movements after that. After Lehman Brothers defaulted, monetary atmosphere experienced a dramatic change and 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 (Hirvelä, 2012).

For instance, in the interbank market the same banks trade in several countries and so many of the world's major banks would have been counterparties of Lehman Brothers. What happened at the time of Lehman's

collapse was that nobody knew who else might be in trouble as a result of their exposure to Lehman and as a result of holding the same kind of faulty assets that Lehman held. So, all the banks trading in all the world's major money markets suddenly saw huge losses, and the rise in the interbank lending spread reflected the resulting risk premium charged by lenders. If the bank defaulted it would default on loans in all currencies that it traded. Hence, it made sense that the interest rates in all these markets moved together in this period (Lipsey and Chrystal, 2011). We noted that, once the banks find that they are in trouble, they become more cautious about lending to almost everybody. Consequently, as soon as the investors know about the events in the money markets and the resulting collapse in stock markets, they also start investing cautiously and seek to move funds away from risky investments toward much safer assets. The result of this general upsurge in caution is that interest rates on a wide range of assets tend to rise. This affects the cost of business borrowing and even the cost of some government borrowing. In many European countries the interest rate which has to be paid for a short term loan or mortgage (short term fixed interest rate period) does follow the Euribor. Once the Euribor increases, the interest which has to be paid increases as well and vice versa[30].

In order to do so, financial institutions faced a discouraging scenario, partly due to liquidity and capitalization problems, but also due to the values that would have to be recorded in impairments[31]. In addition, banks were also holders of significant portions of sovereign debt, leading to a successive effect of depressive spiral. With the fall of market value of sovereign bonds, the value of assets held by banks was reduced (see figure 3), further increasing the need

[30] When someone decides to opt in for a mortgage based upon an adjustable interest rate (also known as a floating rate or variable rate mortgage), it is announced beforehand that he or she will pay the Euribor rate plus a fixed commission, for example Euribor+1%.

[31] Due to the drop of the real estate value contracted as collateral for loans to borrowers that were unable to discharge his financial obligations.

for capitalization. This increased the probability of government bailouts, which resulted in a deterioration of the sovereign debt quality.

In sum, banks are paying a price for the crisis. As we will evidence in chapter 3, new legislation and regulation also reduced their profitability. For example, capital requirements are being increased, liquidity requirements were introduced, OTC derivatives are being more carefully regulated and new taxes have been introduced (Hull, 2012).

Chapter 3
Monetary Policy and risk on banks' asset

The global financial crisis has put the spotlight on Central Banks using their balance sheets as backstops to the financial system. In fact, the recession that accompanied the Great Financial Crisis was a balance sheet recession [32], associated with the bust phase of the financial cycle (BIS, 2015a).

The ECB's specific nonstandard MP responses in the main phases of the crisis, which mutated from a global financial crisis to a sovereign debt crisis in the Eurozone and was later intertwined with strain in the banking system (www.ecb.europa.eu). As we know, business cycles have been around for a long time, and few authors doubt that some cyclical variation in aggregate activity is inevitable. However, the 2008-10 downturns would most likely have been much worse without aggressive policy interventions from policymakers (Lipsey and Chrystal, 2011).

Aiming to contextualize the interest of this work and to align with the recent crisis, we are going to comprise a review of the existing literature about interventions in Money Market. In addition, we are also going to highlight the relevance of unconventional MP in the interbank market behavior. Beyond that, understanding the macroeconomic impact of nonstandard MP measures during the recent financial crisis is a challenging task, which makes us consider pertinent and important explore the interaction of nonstandard measures with financial intermediation (FI), especially through the banking sector (Giannone, Lenza, Pill, & Reichlin, 2011).

[32] Balance sheet recessions commonly coincide with permanent output losses and weak recoveries. The permanent output losses after the financial bust reflect, to a considerable extent, the fact that output growth was unsustainable during the preceding boom.

The monetary authorities in most currency zones, as the case of the Eurozone, set the interest rate[33] and let the money stock adjust to demand, this is called Monetary Policy (MP). MP involves changing interest rates in order to influence the economy (Barbosa, 2012). Low interest rates tend to stimulate demand, but in 2008-10 recession interest rates were so low that reached their lowest peak, making it impossible for them to continue lowering even further.

Accordingly, in 2009 and 2010, the markets were recovering from the financial shocks of 2007-08, when the sovereign debt crisis started to take hold, leading to further reduction in market valuation (see figure 3). At this time, the ECB found itself in contingency to depart from their statutory objective of inflation control, when from the end of 2010 the housing crisis had become into a sovereign debt crisis in Eurozone. In the aftermath of the crisis, even in countries where the effect of the real estate bubble burst was less clear, Central Banks have had to operate in uncharted waters, characterized by low growth, below-target inflation and unusually low interest rates, as well as financial fragility and rising debt (Caruana, 2016), in concrete, policymakers looked for other ways to stimulate economy. One new policy they adopted was called Quantitative Easing, described in section 3.2.1.

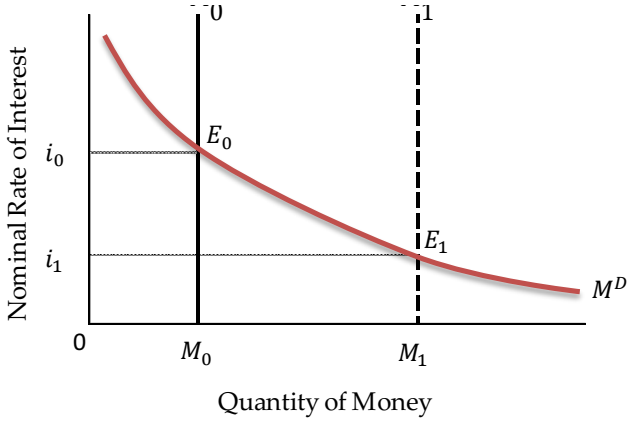
3.1 Standard Monetary Policy Intervention

One way to control the monetary system is directly altering the money supply by buying and selling securities, especially government bonds. The Central Bank is always present in the interbank market, but if Central Bank does not take any measure, money circulates without changes. Regardless of this, each time Central Bank enters into transactions by buying or selling

[33] Taylor Rule is used by the ECB to set the nominal interest rate.

securities, it changes the amount of money supply by increasing or decreasing it[34], in other words, Central Bank buys (or sells) government securities when it wants to expand (or contract) the money supply. If the bank bought bonds, issuing currency, the rate of securities decreased[35]. Conversely, if the rate goes up, the Central Bank withdraws currency into circulation (Barata, 1998). This exemplifies the classical macroeconomic theory: how the interest rates would adjust to clear the money market for a given level of the money stock and given money demand curve?

FIGURE 8 - Mechanics in monetary market



Description: The initial money supply is shown by the vertical line M_0^S, and the demand for money is shown by the negative sloped curve M^D. The initial equilibrium is at E_0, with corresponding interest rate i_0. The monetary authorities choose to lower the interest rate i_0 to i_1. In order to achieve this they must generate an increase in the money supply, from M_0^S to M_1^S. The new equilibrium is at E_1. Starting at E_1, with M_1^S and i_1, it can be seen that a decrease in the money supply to M_0^S would be required to achieve an increase in the interest rate from i_1 to i_0 (Lipsey and Chrystal, 2011).

A change in the refi-rate requires the money supply to change. So, if the authorities wished to relax MP they could do so by increasing money supply. If they did this, there would initially be an excess supply of money, holders of this

[34] The money supply is done in Open Market.

[35] Increased demand for bonds raised the price and the fee is equal to the interest divided by the price of securities.

money would demand more bonds, and via the process this would raise the price of bonds and lower the interest rate (Lipsey and Chrystal, 2011).

In sum, Martin Wolf wrote for the Financial Times that the simplest form to understand the intervention of the ECB is the Keynesian view:

> the short-run equilibrium in the economy is determined by the intersection of the real and monetary forces. The former determine equilibrium interest rates, which the Central Bank then seeks to deliver. Yet, in seeking to deliver the monetary conditions needed for equilibrium between savings and investment at high levels of activity, the Central Bank has to encourage credit growth. However, that credit growth might be, and in recent decades has been, highly destabilizing, because it requires massive leveraging, particularly of property assets, and leads to financial booms and busts (October 8, 2015).

As an example, rising global interest rates could prompt a new credit crunch in emerging markets, as businesses that have ridden the wave of cheap money to load up on debt are pushed into crisis. Thus, for an effective and smooth MP, it is important that interest rate expectations are in line with Central Bank policy intentions (Bernoth and Hagen, 2004).

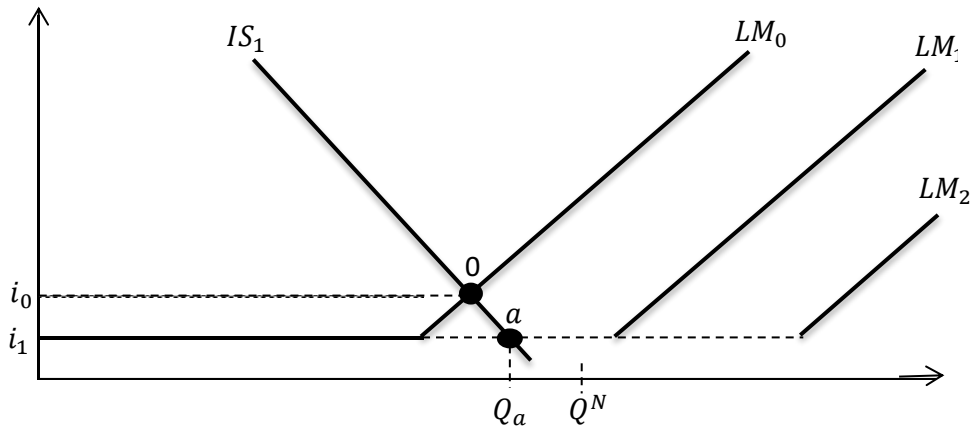
In this sense, with the Euribor downward trend, several measures are being taken in the Eurozone countries.

3.1.1 Liquidity Trap

As already mentioned, a standard MP intervention involves the authorities changing the interest rate at which they will lend to the money markets. For an economy in recession, a MP reaction intended to stimulate the economy would involve lowering the interest rate. However, there is the possibility that after the interest rate drop to a certain level, liquidity-preference may become virtually obsolete in the sense that almost everyone prefers cash to holding a debt which yields so low the interest rate. In this event, policymakers would have lost effective control over the interest rate (Keynes, 1936). Hicks pays

special attention to this theory in his IS-LM[36] model, adding that to a sufficiently low level of short-term interest rate, the demand for liquidity becomes perfectly elastic (Barbosa, 2012), as illustrated in figure 9. Specifically, Paul Krugman said that "recent demand-side events have been very much what people using IS-LM would have predicted (and did)" (www.krugman.blogs.nytimes.com).

FIGURE 9 - Liquidity trap



In fact, this is what we are facing in the Eurozone and the problem was known as liquidity trap[37]. It arises when interest rates are so low that nothing else can be done to stimulate spending via even lower rates. Even if the government were simply to print more money and give it to people[38] in a genuine liquidity trap this does not necessarily increase spending, as people can simply save the money, i.e. financial assets will be no longer attractive since they will not have any remuneration and holding money will have no opportunity cost, so any MP passing through stimulating production through monetary expansion is fruitless (Barbosa, 2012).

[36] General Equilibrium Model (Walras law) which includes the (1)Market for Goods and Services, (2) Money Market and (3) Financial Asset Market. Walras law: If two of the three markets are in equilibrium, the third market is in equilibrium too.

[37] Liquidity trap is a phenomenon associated with economies dangerously close to a zero interest rate.

[38] In practice, the monetary authorities would not usually literally print Money and spend it; rather they would buy long-term government debt with high-powered Money. This increases the liquidity of both the public and the banks with possible positive effects in spending.

3.2 Breaking Standard Monetary Policy

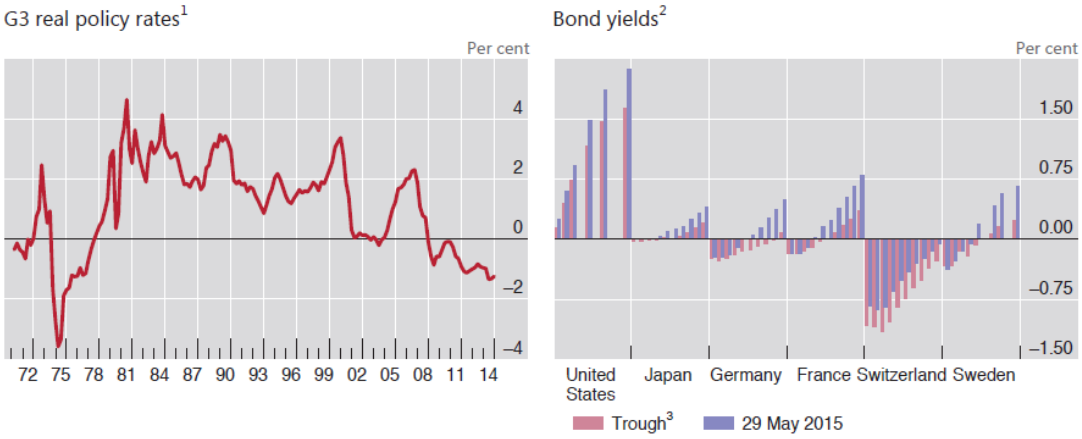
The ECB's found itself in contingency to depart from their statutory objective of inflation control by responding decisively to challenges posed by global financial crisis, reducing key policy interest rates to unprecedented low levels.

The problem then faced was that policymakers thought it necessary to stimulate aggregate demand further, clearly they could not do more by lowering interest rates and a new challenge arises: when interest rates have already been pushed down as low as they can go, what can policymakers do then in order to stimulate aggregate demand? Not much with interest rates. According to BIS Annual Report, interest rates have never been so low for so long (Figure 10, right panel). They are low in nominal and in real[39] terms and low against any benchmark. "Between December 2014 and end-May 2015, on average around $2 trillion in global long-term sovereign debt, much of it issued by euro area sovereign, was trading at negative yields" (BIS, 2015a). At their trough, French, German and Swiss sovereign yields were negative out to a respective 5, 9 and 15 years. Such yields are unprecedented. Policy rates are even lower than at the peak of the Great Financial Crisis in both nominal and real terms (BIS, 2015a).

Such low rates are only the most obvious symptom of a broader malaise, despite the progress made since the crisis. Global economic growth may now be not far from historical averages but it remains unbalanced. Debt burdens are still high, and often growing, relative to output and incomes. The economies hit by a balance sheet recession are still struggling to return to healthy expansion. In several others economies, financial imbalances show signs of building up, in the form of strong credit and asset price increases, despite the absence of inflationary pressures (BIS, 2015a).

[39] Inflation-adjusted.

FIGURE 10 - Real policy rates and bond yields



[1] Nominal policy rate less consumer price inflation excluding food and energy. Weighted averages for the euro area (Germany), Japan and the United States based on rolling GDP and PPP exchange rates. [2] Yield per maturity; for each country, the bars represent the maturities from one to 10 years. [3] For the United States, 30 January 2015; for Japan, 19 January 2015; for Germany, 20 April 2015; for France, 15 April 2015; for Switzerland, 23 January 2015; for Sweden, 17 April 2015.

Description: Left panel: real policy rates, right panel: bond yields
Source: BIS, 2015a

So, ECB introduced a number of nonstandard MP measures that are unprecedented in nature, scope and magnitude with the aim to safeguard the primary objective of price stability and ensure an appropriate MP transmission mechanism. Falagiardo and Reitz (2015) concluded that, in light to traditional transmission channels, the ECB nonstandard measures, aimed to improving the functioning of the interbank markets, may influence government bond spreads via banks' balance sheets.

3.2.1 Quantitative Easing

Given the difficulty of proceeding with conventional measures allied with the phenomenon of Liquidity Trap, the Central Banks decided to conduct unorthodox interventions. On the one hand, ECB started to act in markets with longer maturities through the acquisition of securities with longer maturities and, on the other hand, the ECB extended the purchase of securities in addition to the Treasury sphere for the private securities sphere. Thus, these measures contributed to the Euribor decline.

This massive acquisition of unconventional assets is known as Quantitative Easing (QE)[40] and was obtained *quid pro quo* by expansion of the monetary base and entailed a significant expansion of the central bank balance sheet. This bond buying program was started in March 2015 and provides extend until at least September 2016, until inflation Eurozone recover the tendency compatible with the statutory objective of 2%[41] and consist of purchasing 60 billion per month of assets in the Eurozone. In Portugal, in addition to this purchase that includes government bonds, also includes programs implemented in October 2014 of covered bonds purchase program[42] and ABS purchase program [43](Jornal de Negócios, 2015). Although the findings published by Jornal de Negícios, Paul Krugman argue that "euro area is much more deeply depressed than generally acknowledged, and that the ECB's attempt to get inflation back up close to 2% is a much more daunting challenge, than anyone seems to acknowledge" (www.krugman.blogs.nytimes.com).

The figure below illustrates the Eurosystem evolution in the internal liquidity management, specifically the Total Assets/Liabilities ratio. The outstanding volume of assets purchased was offset in liabilities by a similar expansion in the monetary base. This way, it is possible to realize the purpose of injecting liquidity into the market and the restoration effort in the normal credit flows.

[40] Involves the central bank buying large amounts of assets with money created for this purpose by the central bank itself and it is a form of open market operations.

[41] Monetary authorities' reactions are well described by the Taylor Rule: interest rates are raised when inflation exceeds target and when GDP exceeds potential, and vice versa.

[42] https://www.ecb.europa.eu/press/pr/date/2014/html/pr141002_1_Annex_2.pdf?0ba2a520b8a2b7ad8ff6bfb99333ba25

[43] https://www.ecb.europa.eu/press/pr/date/2014/html/pr141002_1_Annex_1.pdf?c4144e9908c29df066a053246f81d1ff

FIGURE 11 - Total assets/liability

Source: ECB, 2016

Clearly, MP is essential in a crisis for stabilizing financial system, but in the wake of a balance sheet recession, where weak demand may not be the only problem, monetary easing cannot be the only answer (Caruana, 2016).

3.3 The role of banks in the monetary policy transmission mechanism

The purpose of the liquidity operations by the ECB is to smooth impacts of financial shocks in interbank markets and to secure that MP decisions are transmitted into Eurozone economy (Hirvelä, 2012). Nevertheless, the transmission mechanism has become more complex over time in light of the increasing inter-linkages between the banking sector and the financial markets (ECB, 2008). The impact of the credit market tensions have shown that during periods of stress the securitization and credit derivatives markets could come to a standstill. The pressure on banks' profitability and balance sheets has been

driven mainly by revaluation adjustments of their marketable assets and rising costs related to credit hedging activities rather than by outright losses on their loan portfolios (ECB, 2008). Simultaneously the impacts of the ECB's MP were endangered, the ECB decided to increase maturities of its main refinancing operations as the demand for longer maturities boosted in illiquid interbank markets. In order to achieve this, the interbank refinancing rates increased, which caused banks to ask intensively central bank money (Hirvelä, 2012).

Banks are important players in the euro area financial system and facilitate the flows of financial assets from sabers to those with investment and consumption needs. They are the main collectors of funds from and providers of finance to the nonfinancial corporate and households sectors. The money and credit market tensions observed since mid-2007 have highlighted the importance of closely monitoring the role of banks in the MP transmission mechanism. Hence, a clear understanding of the role of banks in the MP transmission mechanism is essential.

Lipsey and Chrystal, (2011) notice four possible channels for QE to affect aggregate demand: in addition to the interest rates channels, there are also a money supply, asset prices and confidence channels. Falagiarda and Reitz (2015) reflect about the unconventional channels of MP, they study the signaling channel that emphasize the role of expectations of private agents, and the portfolio rebalancing channel according to which purchases carried out by a central bank imply a rebalancing of investors' portfolios. They conclude that by purchasing a particular security, the monetary authority reduces the amount of that security held by private agents usually in exchange of risk-free reserves. As a result, the asset prices increases and the interest rate fall, creating more favorable conditions for economic recovery through the traditional monetary transmission mechanisms.

This section describes the channels through which banks may play a part in monetary transmission. Given the existing literature about this topic, our study will focus in three MP transmission channels: Interest rate channel, Credit channel and Risk-taking channel.

3.3.1 Monetary Policy transmission Channels

Owing to the relatively large share of bank loans and deposits in total financial assets and liabilities in the Eurozone, the bank interest rate pass-through is a key element of the interest rate channel. The impact of this channel may vary with the amplitude and speed with which bank interest rates on loans and deposits are adjusted when policy rates change. It should be noted that the bank interest rate pass-through itself depends on a multitude of factors, such as the degree of competition among banks and financial market development, but also the balance sheet situation of banks and their borrowers (ECB, 2008), in which respect it can arguably also be viewed in relation to the credit channel (discussed below).

3.3.1.1 Interest Rate Channel

The interest rate channel previously introduced in section 3.1 has an important role as a transmission channel (Mishkin, 1996).

In fact, MP normally affects short-term interest rates (see figure 4). So, it may be expected that the increasing degree of market-based pricing of bank loans has made bank interest rates more sensitive to changes in refi-rates via the latter's effect on market interest rates. In 2008, ECB noted a stronger and faster bank interest rate pass-through from changes in policy rates for banks which are more active in securitization and derivatives markets (ECB, 2008). Nowadays, with injections in the money market from the ECB, interest rates

tend to decrease with influence in the investment and expense (see figure 8). However, the interest rate channel may have in the process been strengthened.

3.3.1.2 Credit Channel

The existence of a credit channel depends, on the one hand, on the extent to which banks can easily substitute other funding sources for deposits and, on the other hand, on the extent to which bank borrowers are able to find alternative funding sources to bank financing (ECB, 2008). With respect to the later, in particular, small and medium-sized enterprises and households could have difficulties in finding sources of external financing other than bank loans and hence largely depend on the ready availability of bank credit to fund their investment and consumption.

The "narrow" credit channel (bank lending channel) operates via the effect of a MP change on the liability side of banks' balance sheet, which may induce the adjustment of bank assets, including loans, i.e. MP induced reduction of banks' reserve holdings could lead to a contraction in loan supply if banks either are not fully able to substitute other sources of funding for deposits (e.g. because of their size or capital position) or have insufficient liquidity buffers. Part of the bank credit channel is related to banks' capital positions, in the sense that MP can induce banks to adjust their loan supply by affecting capital positions.

The "broad" credit channel (balance sheet channel) relates to the balance sheet position of banks' borrowers. MP may, via the impact on real interest rates, which affect disposable income, firm cash flow and (via the asset price channel) collateral values, change the net worth of borrowers and hence banks' willingness to supply loans. It thus may alter the external finance premium[44] facing bank borrowers.

[44] The external finance premium is the difference between the cost to the borrower of external versus internal funds.

Covering the period of booming securitization and derivatives activities that took place before the financial crisis already described, it has apparently led, under normal circumstances, to a change in bank lending dynamics, possibly leading to a more muted reaction of bank loan supply to MP changes. First, the sale securitization, in which the underlying assets are removed from the originating bank's balance sheet, has provided banks with an additional funding source. This is likely to have reduced sensitivity of banks loan supply to changes in MP rates and, *ceteris paribus*, weakened the bank lending channel. Also, by transferring credit risk off balance sheet, securitization may help originating banks to obtain capital relief, which in turn may free up funds for additional provision of loans as well as reduce the possibility of balance sheet constraints in the face of MP changes. At the same time, it has been argued that this more risk-sensitive framework potentially amplifies the pro-cyclical nature of bank lending and thus may lead in certain periods to a reduction of loan supply. Lastly, the use of structured credit products gave advances in the bank risk management systems. Notably, the combination of the credit risk modelling techniques and credit derivatives has allowed an improved allocation and dispersion of banking book risk at the portfolio level, which in turn may have enhanced banks' ability to expand their balance sheets. However, with the recent crisis, this channel has weakened even with the unconventional MP.

3.3.1.3 Risk-taking Channel

It is important to highlight that MP, by affecting collateral values, asset prices and cash flows, may also affect the risk perception and risk tolerance of banks and hence the overall risk-taking behavior in the economy.

Alongside this, it has been suggested that MP, by affecting asset prices, may drive a wedge between actual returns and some institutional investors' nominal

return targets, which may induce these investors to *search for yield*[45] across a wider array of assets. For instance, it could be the case that the environment of low interest rates observed in recent years has led some institutional investors to invest increasingly in credit-related assets, which has allowed banks to increasingly fund themselves by selling loans in the secondary market, hence potentially boosting their ability to supply new loans (ECB, 2008). Gaston Gelos (2015) said "In recent years, factors such as investors' higher risk appetite and low interest rates have been masking growing underlying fragilities in market liquidity" (www.theguardian.com).

This channel can work in the dimension of the financial risk-premia. For example, as financial assets are claims to future payments, their prices can be interpreted as reflecting the expectation of these payments, discounted to the present. The discount factors used for this exercise can be understood as reflecting interest rates on different maturities augmented by premia, whose size will differ according to the "riskiness" of the respective asset. Hence, riskier assets will trade at a lower prices or, alternatively, offer a higher return to the investors. This decomposition of assets prices and returns implies that changes in MP rates may have an impact on their values, by changing the outlook for future payments or by changing the risk-free component of the discount factor, but also by impacting on the required risk premium. Thus, for any part of the transmission mechanism that operates via changes in asset values and interest rates (which affect investment and spending decisions) potential amplifying or attenuating effects stemming from changing risk premia have to be taken into account.

An important question is how, in particular, the emergence of securitization and structured credit products has, by transforming the traditional bank

[45] *Search for yield* is often used as a general concept to represent an increased risk taking in exchange for higher expected return during periods with relatively low interest rates.

business model and bringing new investors to the credit markets, influenced the financial system and the ways it interacts with MP. Similarly, more market-based pricing may have reinforced the incentive structures driving banks and institutional investors, potentially leading to more extreme risk-taking behavior. These considerations point to a strengthening of the risk-taking channel.

Chapter 4
Risks on Banks' Assets

The ECB intervention wants to address the fragility of banking systems and restore the confidence in the financial markets[46] (ECB, 2008).

Aït-Sahalia, Andritzky, Jobst, Nowak, and Tamirisa (2012) examine the impact of macroeconomic and financial sector policy announcements on interbank credit and liquidity risk premia during recent crisis, concluding that policy interventions were associated with a reduction in interbank risk premia, most significantly for recapitalization programs. Similarly, Cukierman and Izhakian (2014) concludes that the impact of macroeconomic and financial sector policy announcements were associated with a reduction in interbank credit and liquidity risk premia[47]. In contrast, Hryckiewics (2014) found that in general government interventions have a negative impact on banking sector stability with a significant increase in risk.

Thereby, studying the risks that reveal the fragility in the banking system is a difficult task that deserves attention.

According to Saunders and Cornett (2007), the five major risks related to banks' assets that are continuously impacting a financial intermediation (FI) manager's decision-making process and risk management strategy are described in the table below.

[46] ECB argue that it is extremely important a sufficient high level of credit market transparency and supervision to ensure that market participants have confidence in the quality of the balance sheets of banks and other FI.

[47] The introduction of government guarantees has a larger immediate effect on interbank risk premia than asset purchases programs, because guarantees instantaneously transfer risks from banks' balance sheets to the sovereign.

TABLE 2- Higher risks for Banks' assets

Credit Risk	The risk that promised cash flows from loans and securities held by FIs may not be paid in full.
Liquidity Risk	The risk that a sudden and unexpected increase in liability withdrawals may require a FI to liquidate assets in a very short period of time and at low prices.
Interest Rate Risk	The risk incurred by a FI when the maturities of its assets and liabilities are mismatched and interest rates are volatile.
Market Risk	The risk incurred in trading assets and liabilities due to changes in interest rates, exchange rates, and other asset prices.
Insolvency Risk	The risk that a FI may not have enough capital to offset a sudden decline in the value of its assets relative to its liabilities.

Source: Saunders and Cornett (2007)

In addition to the risks described above, bank management also must deal with problems of asymmetric information, adverse selection, and moral hazard (Burton and Lombra, 2006). This chapter focuses on the credit and liquidity risks and give some evidences about how fully understand the moral hazard problem is extremely useful in this topic.

In this sense, before explaining the methods used in the empirical analysis of the present study, it is essential to evidence the underlying risks in the banking sector. Since during the recent crisis Euribor basis swap spreads have increased significantly (Hirvelä, 2012), highlight how Euribor basis swap spreads[48] is affected by risks such as credit, liquidity, and other risks is also a remarkable issue.

A range of literature investigates the potential risks annexed to the developments in the euro interbank market after the financial market crisis. Most of them focus, on the one hand, in variations in the credit and liquidity risks and, on the other hand, systematic, idiosyncratic and volatility risks

[48] Euribor basis swap spreads should trade in flat in order to no-arbitrage condition to hold.

associated with macroeconomic factors. In addition, a big part of that literature also refers the problem of moral hazard in the banking sector.

In this chapter, we introduce the problem of moral hazard to explain how risks may arise in the FI, specifically banks. Secondly, we describe the risks in the banks' assets. Ultimately, we explain how derivatives, such as CDS, contribute to measure relevant risks in order to address in the empirical methodology.

4.1 Moral hazard in Financial Intermediation

The moral hazard concept provides a framework for understanding the principles that FI managers must follow to minimize banks' risks. The moral hazard problem is a concern in the design of an international framework for financial stability. It is the risk (hazard) that the borrower might engage in activities that are undesirable (immoral) from the lender's point of view because they make it less likely that the loan will be paid back (Mishkin and Eakins, 2006), in other words, the moral hazard problem refers to the reduction in market discipline experienced by FIs that stems from deposit insurance[49]. Increases in moral hazard go hand-in-hand with deposit insurance, e.g. deposit insurance encourages FIs to make riskier loans because depositors do not keep as close tabs on how the bank is managing their funds as they would if their deposits were not insured (Burton and Lombra, 2006).

Several literatures reveals that systemic interventions measures result in a collective moral hazard problem and this problem arises because if some banks gamble, others will tend to follow, leading to correlated risk across the banking

[49] Deposit insurance is considered as one of the tools in the regulator's disposal for preventing the credit crisis from spreading further in the financial system, see section 3.2.

sector. Hoque et al. (2015) exposes that moral hazard problem increase in the banking sector by deposit insurance encourages banks to take on excessive risk, in other words, deposit insurance is negatively related to bank stability and systemic risk. Vasquez and Federico (2015) evidences that bank risk-taking in the run-up to the crisis was associated with increased financial vulnerability, suggesting that bank decisions regarding the associated liquidity and capital buffers were not commensurate with the underlying risks, resulting in excessive hazard to their business continuity. With a more volatile economy, increase the fluctuations in the value of a bank's assets and, hence, increase. This way, risk taking caused by moral hazard problem was one reason that so many banks failed.

On another perspective, the problem of moral hazard may exist if market participants believe that the effects of a failure would be so catastrophic that a taxpayer bailout would be inevitable. As financial flows across national borders increase, excessive risk-taking[50] may occur if financial participants think that international financial organizations such as IMF will bailout a country in crisis by acting as a lender of last resort or encouraging policies that prevent currency devaluation. Also, the existence of large firms could result in a moral hazard problem if market participants believe the firms are "too big to fail"[51] (Burton and Lombra, 2006). Cukierman and Izhakian (2015) developed a micro-founded general equilibrium model used to investigate the impact of uncertainty about the likelihood of government bailouts and conclude that lower ex-ante bailout uncertainty is conductive to higher leverage, which in turn raises moral hazard and makes the economy more vulnerable to ex-post increases in bailout uncertainty. In the line, Hryckiewicz (2014) find the increased role of the government in the banking sector might encourage politicians to act in self-

[50] See section 3.3.1.3.

[51] The failure of a large bank would be resolved by finding a buyer for the institution.

interest, leading to inefficiency and poor performance of affected institutions. Therefore, this problem will encourage excessive risk-taking[52] and policymakers should strive to find the right balance of restrictions for reducing systemic risk without decreasing efficiency.

4.2 Banks' Regulations

Shocks to banks' risk are important in the light of the erratic behavior of the interest rate spreads in banks' external finance. In the light of the sharp rise in interest rate spreads and bank failure rate during the crisis, Jin and Zeng (2014) views banks risk as a kind of systemic risk and as a promising candidate for driving forces of economic fluctuations. The sensitivity of bank stock returns to changes in the refi-rate target and MP adjustment are an important risk exposure for banks (Yang and Handorf, 2010). Dungey and Gajurel (2015) identify systemic risk and idiosyncratic risk as the principal channels of contagion in the banking market during the crisis.

To minimize this contagion of risk, regulatory and accounting rules are important determinants of bank behavior. To the purpose, the Basel Committee on Banking Supervision (BCBS)[53] was developed to make banking policy guidelines; its mandate is to strengthen the regulation, supervision and practices of banks worldwide with the goal of enhancing financial stability (www.bis.org). For instance, securitization by transferring credit risk off balance sheet help originating banks to obtain capital relief[54], this was an issue under the Basel I capital adequacy framework, as securitization was often

[52] Higher average expected return induces investors to accept more risk.

[53] The bank capital regulation is set by the BCBS. The Basel Committee is the primary global standard-setter for the prudential regulation of banks and provides a forum for cooperation on banking supervisory matters. (www.bis.org)

[54] See chapter 2.

perceived as a means for banks to arbitrage on the level of required regulatory capital by transferring better-quality assets off balance sheet while retaining the riskier loans. In addition, the introduction of Basel II increased the importance of the perception, pricing and management of risk for the behavior of banks (ECB, 2008). In continuity, the Basel III which is a comprehensive set of reform measures was constructed (see table 1AA). These measures aim to i) improve the banking sector's ability to absorb shocks arising from financial and economic stress, whatever the source; ii) improve risk management and governance; iii) strengthen banks' transparency and disclosures also, the reform target both the bank-level and regulation which will help raise the resilience of individual banking institutions to periods of stress and the macro-prudential (BCBS, 2015). The Basel III focus on capital using two key ratios: Liquidity Coverage ratio (LCR) and Net Stable Funding Ratio (NSFR).

Regarding the effectiveness and design of these regulations, Hoque et al. (2015) agree on the importance of the regulatory restrictions and supervision, concluding that more restrictions on banks increase the stability of global banks and reduce the systemic and idiosyncratic risks. Still, the BCBS has been widely criticized for failing to meet its banking safety objectives during the credit crunch (Cathcart, El-Jahel, & Jabbour, 2015).

One way to address moral hazard, where banks have an incentive to hold too little collateral, is to require banks to keep sufficient levels of quality collateral during booms[55], as with the Basel III LCR requirements (Koulischer and Struyven, 2014). The introduction of this leverage ratio with Basel III is a constraint on liquid assets and maturity mismatch and establishes a strong connection between liquidity creation and financial stability (Vasquez and Federico, 2015). The LCR is one of the Basel Committee's key reforms to

[55] While collateral policy loosening allows repairing the transmission of MP in crises, it is ineffective for tightening during booms, when collateral is abundant.

strengthen global capital and liquidity regulations with the goal of promoting a short-term resilient of a bank's liquidity risk profile. It does this by ensuring that a bank has an adequate stock of unencumbered high-quality liquid assets that can be covered into cash easily and immediately in private markets to meet its liquidity needs for a 30 calendar day liquidity stress scenario. Dermine (2015) illustrates the LCR with an analogy:

> consider water, it is like estimating how much water you need to drink every day under stress for the next 30 days, so you have to stock enough water in your house to last at least a month, which makes you independent for that period of time. This has also an effect in terms of your profitability: the higher your liquidity, the lower your expected return (Dermine, 2015).

Specifically, the LCR ensures that a portfolio of contingent liquid asset can fund a cash outflow lasting 30 days in a stress scenario; its objective is to both ensure that permanent assets are funded with stable assets and limit the risk of bank run imposing constraints on maturity mismatch and the holding of liquid assets. Also, it will improve the banking sector's ability to absorb shocks arising from financial and economic stress (Dermine, 2015). The minimum requirement is 60% nowadays, but the BCBS designed a graduated approach to ensure that the LCR can be introduced without disruption to the orderly strengthening of banking systems or the ongoing financing of economic activity. The minimum LCR requirement begin at 60% rising in equal annual steps of 10 percentage points to reach 100% on 1 January 2019. Consider this, a floor on leverage, an unweighted leverage ratio, is often justified by simplicity and transparency, the avoidance of gaming the system that reduce the probability of moral hazard problem, robustness to estimation errors or the need for banks to have enough capital in case the economy deteriorates. However, a strict application of a LCR with 100% backing by safe liquid assets will eliminate bank runs but also negate

an important function of banks, the creation of liquid claims on illiquid assets (BCBS, 2013).

Conversely, the NSFR requires banks to maintain a stable funding profile in relation to their on- and of-balance sheet activities, thus reducing the likelihood that disruptions to a bank's regular sources of funding will erode its liquidity position in a way that could increase the risk of its failure and potentially lead to broader systemic stress. Take into consideration that banks have to avoid a mismatch risk within one year. Borrowing in a short term and lending in the long term could create an interest rate risk because you have to refinance your liabilities with a new rate while your assets are fixed (Vasquez and Federico, 2015) (See figure 5A in annex).

4.3 Risks incurred by financial institutions

With the increasing volatility of interest rates that occurred in recent years, FI became more concerned about their exposure to interest-rate risk, which is related to liquidity and credit risks. FI can manage interest-rate risk by modifying their balance sheets and by making use of new financial instruments.

4.3.1 Liquidity Risk

Liquidity creation is an essential role of banks and establishes a strong connection between liquidity creation and financial stability. Vasquez and Federico (2015) contribute measuring structural liquidity and leverage in bank balance sheets in a way consistent with the formulations of the NSFR and the LCR. The findings suggest that the marginal stability gains associated with stronger liquidity and capital cushions do not appear to be large for the average bank, but seem substantial for the weaker institutions, at the same time, the

smaller banks were more susceptible to failure on liquidity problems, while the large cross-border banking groups typically failed on insufficient capital buffers.

Liquidity risk arises when the FI's liability holders demand immediate cash for the financial claims they hold with an FI or when holders of off-balance sheet loan commitments suddenly exercise their right to borrow. In addition to an unusual or unexpected need for cash, a lack of confidence by liability holders in an FI may lead liability holders to demand larger withdrawals than usual. As a consequence, FIs may have to sell some of their less liquid assets to meet the withdrawal demands of liability holders. Serious liquidity problems may eventually result in a "run" in which all liabilities claimholders seek to withdraw their funds simultaneously from an FI because they fear that it will be unable to meet their demands for cash in the near future. This turns the FI's liquidity problem into a solvency problem and can cause it to fail.

4.3.2 Credit Risk

The policymakers regulate the amount of capital that banks are required to hold, which influence banks' credit[56]. If the ECB requires more reserves, banks have to decrease the amount of money they can borrow and thus lowers money supply in the economy. The rate of legal reserve is a strong weapon because reserves are an essential element in credit process (Barbosa, 2012). The credit view is unique in its emphasis on the health of the financial sector as a critically important determinant of the efficacy of MP and FIs play a critical role in the allocation of credit in the economy because they are the primary source of credit for consumers and businesses that do not have direct access to capital markets (BCBS, 2012).

[56] The law requires banks to have a certain percentage of their deposits in reserves.

Credit risk arises because of the possibility that promised cash flows on financial claims held by FIs, such as loans and bonds, will not be paid in full. However, one of the advantages that FIs have over individual investors is their ability to diversify credit risk exposures by exploiting the law of large numbers in their asset investment portfolios. Diversification across assets, such as loans exposed to credit risk, reduces the overall credit risk in the asset portfolio and thus increases the probability of partial or full repayment of principal and/or interest. In particular, diversification reduces individual idiosyncratic credit risks[57], while still leaving the FI exposed to systematic credit risk[58]. (Saunders and Cornett, 2007) (See figure 6A in annex).

4.4 CDS as a measure of risk

The main overall concern of bank regulators is to ensure that a bank's capital reflects the risk it is bearing. The traditional approach was to specify minimum levels for balance sheet ratios such as equity/total assets. However, this has become inappropriate in recent years due to derivatives contracts such as swaps and options, which do not appear on the balance sheet, have begun to account for a significant proportion of the total risk. New schemes proposed by the BIS appeared. In these, each on- and off- balance sheet item is assigned a weight reflecting its relative credit risk (Hull, 1993).

Nowadays, derivatives contracts are the main instruments used by investors to efficiently hedge risk and speculate on perceived market uncertainty. Several authors use the CDS as a measure of risk in their analysis. As an example, Augustin (2013) use the long-term risk for CDS spreads to evaluate the

[57] The risk of default for the borrowing firm associated with the specific types of project risk taken by that firm.

[58] The risk of default associated with general economy-wide or macro-conditions affecting all borrowers.

aggregate macroeconomic uncertainty and domestic risk. Aït-Sahalia et al. (2012) consider CDS as a composite measure of bank-specific default risk and as a measure of market perceptions of macroeconomic prospects and financial stability. So, CDS may be an alternative system-wide measure of credit and liquidity. While the ECB (2009) consider the market price of the premium of the CDS an indication of the perceived risk related to the reference entity.

As a matter of fact, over the past two decades the CDS market has become one of the leading indicators of an entity's default risk and the primary hedging and trading tool for credit risk (Vogel, Bannier, & Heidorn, 2013). For instance, CDSs can be used to hedge the credit risk of on-balance sheet assets (e.g. corporate bonds on ABS by acquiring CDS protection on them) (ECB, 2009).

4.4.1 Credit Default Swap

A Credit Default Swap (CDS) is a credit derivative contract between two parties where the buyer of the swap makes periodic payments to the swap's seller up until the maturity date of a contract in exchange for a commitment to a payoff if a third party defaults (ECB, 2009), for instance, in the event that the debt issuer defaults or experiences another credit event, the seller will pay to the buyer the security's premium as well all interest payments that would have been paid between that time and the security's maturity date. To this, a CDS protects bondholders and lenders against the risk that the borrower will default. The lender's insuring counterparty takes on this risk in return for income payments. In this respect, it is important for the insuring counterparty to fully assess the swaps risk/return feature to ensure it is receiving fair compensation vis-à-vis the level of risk (Hull, 2012). The mechanics of an index CDS are slightly different from that of a single-name CDS. For an index CDS, the swap payment continues to be made by the protection buyer. However, the amount of the quarterly swap premium payment is reduced. This is because the

notional amount is reduced as a result of a credit event for a reference entity (Fabozzi, 2013).

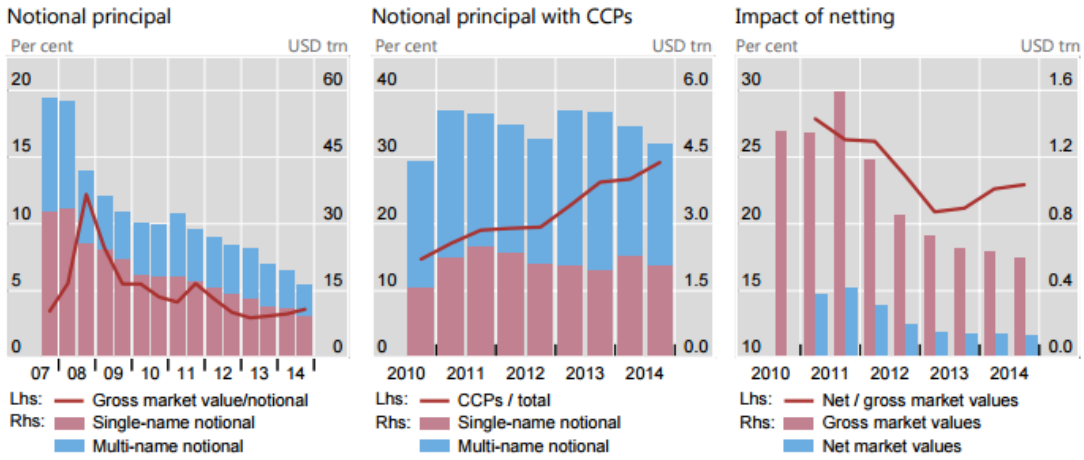
However, as Warren Buffet wrote, Central banks and governments have so far found no effective way to control, or even monitor, the risks posed by these contracts. In his view, "derivatives are financial weapons of mass destruction, carrying dangers that, while now latent, are potentially lethal" (Buffet, 2002).

Besides that, a CDS provides a very pure measure of default risk by isolating the default probability of the underlying name and the ability of participants to buy and sell credit in liquid, standardized markets serving to transfer the risk that a certain individual entity or credit defaults from the protection buyer to the protection seller in exchange for the payment of a regular fee. In case of default, the buyer is fully compensated by receiving e.g. the difference between the notional amount of the loan and its recovery value from the protection seller. The CDS spread is the insurance premium [59] for protection against default, where the premium is set such that the CDS has a value of zero at the time of origination (ECB, 2010).

Index CDS and single name CDS are both relatively recent products that have seen a rapid growth in the past twelve years. However, following the crisis, the total outstanding notional has decreased due to multiple reasons, some being economic related like the level of the interest rates, other being structural, in particular its standardization in 2009 and the compression runs (ESMA, 2014). While in 2007 credit derivatives had come close to surpassing foreign exchange derivatives as the second largest segment in the global OTC derivatives market, notional amounts have since declined more or less steadily as figure 12 below, in left-hand panel, shows. The market value of CDS also continued to decline (right-hand panel) (BIS, 2015a).

[59] In basis points per annum as a fraction of the underlying notional.

FIGURE 12 - CDS: Multi-name and single-name evolution



[1] At half year-end (end-June and end-December). Amounts denominated in currencies other than US dollars are converted to US dollars at the exchange rate prevailing on the reference date.

Description: Single-name is referred to CDS that protect only one entity while multi-name is referred to CDS that protect a bunch of entities at the same time.
Source: BIS, 2015a.

Murphy and Murphy (2012) by constructing a vector autoregressive approach using market-quoted yield and spread data from the highly liquid CDS, evidence that liquidity risk factor shocks have been the dominant drivers of the variation in swap spreads over this period. Aït-Sahalia et al. (2012) consider the CDS as a bank-specific measure of default risks that may be an alternative system-wide measure of credit and liquidity risks. Socio (2013) decompose the Euribor spread into a credit and liquidity risk component and evaluate their relative importance during the crisis, to do this, the author derive the credit risk component from CDS of the banks included in the Euribor panel using the 5-year CDS, which is the most liquid maturity and best reflects credit risk.

What concerns to risk-taking channel[60], the strengthening of MP transmission through this channel due to the changing role of banks may be illustrated in the CDS market. For example, it has been found that changes in MP affects CDS spreads, as predicted by both the balance sheet channel and the risk-taking

[60] See section 3.3.1.3.

channel. An easing of MP would be expected to lower the CDS spreads, which would make it less costly for banks to hedge their credit risk and hence may allow them to originate riskier loans (as they would then be able to off-load the loans more easily). Adrian and Shin (2007) note a positive link between asset prices and (mainly investment) banks' risk-taking. Hence, the developments toward more market-based pricing of bank balance sheets implies a higher volatility of liabilities in the sense that banks tend to increase leverage when asset prices increase and reduce it when they decline, which in turn may lead to amplified effects on the real economy of MP changes.

Chapter 5
Empirical Analysis

We are motivated by two objectives: first, explore the impact of the Euribor on banks' risk and from there, find out whether it is possible to make any forecast for Euribor. Second, investigate the causal flow in this relationship, that is, the power of the Euribor as an instrument with prediction capacity of the banking risk.

In this closing chapter, we outline our data and econometric methodology and, finally, we present our findings and discuss their implications for the debate of the present study. We describe first the general data structure. Then, by using time series analysis, we present the correcting tools to answer each investigation question.

5.1 Data and Econometric Methodology

5.1.1 Data Description

For the purpose of our analysis and to conduct a comprehensive study of our research questions, we collect two datasets. We collect time series data on three-month Euribor rate in order to explore the impact of the Euribor in the banking risk and, eventually, to forecast Euribor behavior and, we regard multi-name CDS index, iTraxx, for European financial institutions with high risk spreads on debt with five year maturity, to access the prediction capacity of the banks' risk. Both aggregate time units of the financial data are at a daily basis.

The current and historical time series data of the three-month Euribor rate was provided by Thomson Datastream with a sample size of 3914 observations. The data window goes from 07 November 2000 until 06 November 2015. This length of time is chosen to add the changes in volatility in the interbank market before and after the credit crisis that developed from mid-2007. We choose year 2000 as our starting point to cover the period 2000-2007 where banking activities over the world experienced rapid growth leading to an expansion of their balance sheets and therefore to an increase in their risk appetite that led, after 2007, to a Great Recession in the global financial market, as described in chapter two.

To create time series information on the banks' risk we used as data source the Markit[61], which administers the CDX indices and the iTraxx indices (BIS, 2015a). We cover the European corporate credit called iTraxx Europe with five years maturity. Aligned with the research of Socio (2013), the 5-year multi-name CDS are selected since they represent the most active index CDS. Also, we noticed in the literature review described along the present paper that, in general, the authors use single-name CDS as a bank-specific measure to access the bank's risk. However, as in our analysis we want to absorb the banks' risk as a whole and not for a single bank, the use of a multi-name index CDS, which is a CDS written on a standardized basket of reference, seems to be more efficient to address our empirical analysis. This data sample covers the period between 29 June 2004 and 13 March 2015 and corresponds to 2740 observations. The data only begins at year 2004 due to the fact that multi-name CDS is a relatively recent index that appeared with the phenomenon of the securitization[62].

[61] Markit Group Ltd. is a London-based global organization that provides financial information services, including the determination of index products (multi-name CDS contracts with constituent reference credit and a fixed coupon).
[62] See section 2.2.

Assuming the two different data windows, we consider having a problem to regress the variables in the same model.

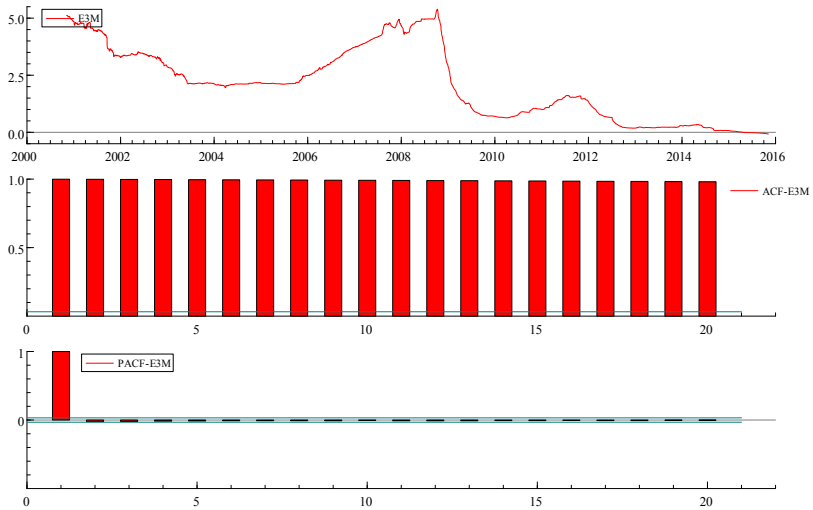
5.1.2 Models and Testing Approach

We are interested in investigating whether Euribor impacts banks' risk. In the starting point, we do a preliminary analysis by investigating the stationarity from the time-series dimension of the three-month Euribor rate data. In a second phase, we estimate parameters in potential models and we select the best model. Afterwards, we use the best model to forecast three-month Euribor rate.

5.1.2.1 Preliminary Analysis: Euribor data

In the first phase, we examine the three-month Euribor rate data and we use autocorrelation function (ACF) and partial autocorrelation function (PACF) to identify potential models. For a stationary process, the autocorrelation [63] between any two observations only depends on the time lag h between them.

FIGURE 13 - Three-month Euribor data



Description: Top panel: a time plot; middle panel: The ADF of the data; bottom: The PACF of the data

[63] Autocorrelation is the linear dependence of a variable with itself at two points in time.

The top panel represents the three-month Euribor rate as a percentage during the reference period. Looking at the top panel, it is manifested a potential nonstationary problem arising from the three-month Euribor rate. The nonstationary problem is justified by the downward trend until 2005 that turns to positive until 2009, dealing with a sharp decline afterwards to abnormal low values. Figure 1 also evidences this pattern.

The middle panel presents the ACF for the time series. This procedure was to verify the presence of unit root[64] in the series using the ADF test. The non-decreasing nature of the bars suggests an unit root process. In the horizontal axis we have twenty lags that, by default, represent twenty days. Therefore, the correlation today and in twenty days remain unchanged the unit root nature, in other words, we suspect the series have a stochastic trend. So, the ACF anticipates the possibility of the process being autoregressive with unit root.

In the bottom panel it is shown the PACF for this series. The PACF is the correlation between two points in time after removing any linear dependence on variables. In a sense, the PACF provides a cleaner picture of serial dependencies for individual lags. For an autoregressive model (AR), the PACF shuts off past the order of the model. By shuts off we intend that in theory the partial autocorrelations are equal to zero beyond that point. Put another way, the number of non-zero partial autocorrelations gives the order of the AR model. The order of the model is the most extreme lag of h used as a predictor. Note that the first lag value is statistically significant, whereas partial autocorrelations for all other lags are not statistically significant. This suggests a possible AR (1) model for the three-month Euribor data. Combining with the conclusion given by ACF, we infer an AR (1) model with unit root.

[64] An unit root is a feature of processes that evolve through time, which can cause problems in statistical inference involving time series models.

However, the top panel raises a red flag for the possibility of structural breaks in time series.

5.1.2.2 Modeling three-month Euribor rate as AR (1) with unit root

Following our suspicions about the presence of an AR (1) with unit root, consider the autoregressive model with drift:

$$\boldsymbol{y_t = \mu + \rho y_{t-1} + \varepsilon_t} \quad , \quad t = 1,2, \dots, T \qquad \text{(Equation 1)}$$

where $y_0 = 0$ is the initial value; $\boldsymbol{\rho}$ is a real number, and $\{\boldsymbol{\varepsilon_t}\}$ is a sequence of independent normal random variables with mean zero and variance σ^2.

Let 3914 observations $\boldsymbol{y_1, y_2, \dots, y_{3914}}$ be generated by the model above, where properties of the regression estimator of $\boldsymbol{\rho}$ are obtained under the assumption that $\boldsymbol{\rho = \pm 1}$.

The following estimation output was obtained using the ordinary least squares (OLS) from the previous model.

TABLE 3 - Results of regression Euribor

	Coefficient	**Std. Error**	**t-value**	**t-prob**	**Part.R^2**
E3M_1	0,999727	0,0001456	6865.	0,000	0,9999
Constant	-0,000756395	0,0003814	-1,98	0,0474	0,0010

Sigma	0,0143434	**RSS**	0,804826286
R^2	0,999917	**F(1,3912)**	4,713e+007 [0.000]**
Adj. R^2	0,999917	**log-likelihood**	11060,1
nºof observations	3914	**nºof parameters**	2
mean (3M)	2,09211	**se(E3M)**	1,57419

If $\boldsymbol{|\rho| = 1}$, the time series is nonstationary and the variance of y_t is $t\sigma^2$ and the model discloses shocks with permanent effects. The regression estimator $\boldsymbol{\rho}$ of the three month Euribor rate in $\boldsymbol{y_{t-1}}$ is 0,999727, which is in fact ≈ 1. When $\rho \approx 1$ we believe it is equal to one, because in time series models estimated by OLS are linked to an estimator $\boldsymbol{\rho}$ with positive skewness. Hence, the estimation

output reveals a further confirmation that the series of the three-month Euribor rate is an AR (1) with unit root.

It must be taken into account that the OLS estimator $\boldsymbol{\rho}$ is biased because AR (1) suggests the existence of one explanatory variable lagged, which is therefore endogenous in any autoregression. However, this bias has an order in such a small probability that keeps the consistency of the estimator that asymptotically is unbiased.

5.1.2.3 Testing three-month Euribor rate as AR (1) with unit root

In this section we use the equation (1.1) to make an unit root test to confirm the nonstationarity. Specifically, we consider the Dickey-Fuller (DF) and the Augmented-Dickey Fuller (ADF) tests, where H_0 is an unit root and H_1 is stationary.

The unit root null hypothesis against the stationary alternative corresponds to: $H_0: \rho = 1$ against $H_1: \rho < 1$.

Following are the results of the DF and ADF Unit Root Tests.

TABLE 4 - Euribor data: results of DF ad ADF tests

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
2	-1,38	0,99982	0,0127	13,95	0,0000	-8,729	
1	-1,47	0,99981	0,0130	28,87	0,0000	-8,681	0,0000
0	-1,88	0,99973	0,0144			-8,488	0,0000

As shown by the displayed output, the sample value for the test statistic observed (-1.88) is, in absolute value, lower than the critical values (-2.86 and -3.44 for significance levels of 5% and 1%, respectively), which enables to accept the null hypothesis. The statistic test observed for one and two lags also allows the acceptance of the unit root null hypothesis, which corresponds to the ADF test. In fact, what the results show is that $H_0: \rho = 1$ is never rejected for the three-month Euribor rate series. It can thus be concluded that, for the

conventional levels of significance, there is statistical evidence that the variable is nonstationary and the three-month Euribor rate is AR (1) with unit root.

However, as figure 13 top panel suggested, there is a possible spurious unit root due to structural break in series and a problem may arise in our time series.

5.1.2.4 Special Events

Consider a one-time change in the mean of the series, a so-called break; this is one large shock with a permanent effect that may bias the results towards an unit root. Now consider our Euribor time series with red flags for multiple structural breaks. According to Perron result (1989), if we break structures that are not modelled, it is possible to detect the existence of a spurious regression problem, i.e., it is concluded the existence of unit roots, but that does not take into account the structural breaks. Thus, it was developed the Bai-Perron (2003) structural break test in which multiple structural breaks can be automatically detected from data. On the one hand, the test does not require a fixed number of breaks in contrast to other tests less sophisticated that only admit one break. On the other hand, the test does not choose the observations/dates, i.e. if there are too many unknown breaks, then it just assumes the parameter to be time varying.

In technical issues, for a given number of observations it is possible to admit a maximum of breaks, for instance, if we assume five breaks it will only admit five or less breaks. In a simple matter, the Bai-Perron test (1998; 2003) investigates all the observations in our data in order to find structural break. We admit that the break can exist in the independent term μ, which is the most common type of break structure that usually corresponds to a level shift.

This model does not use conventional distributions, for instance, Bai-Perron (2003) proposed a test for $\boldsymbol{\ell}$ versus ($\boldsymbol{\ell}$ +1) breaks, labelled sup$F_t(\boldsymbol{\ell}$ +1$|$ $\boldsymbol{\ell}$). This method amounts to the application of ($\boldsymbol{\ell}$ +1) tests of the null hypothesis of no

structural change versus the alternative hypothesis of a single change. The test is applied to each segment containing the observations $\widehat{T_{i-1}}$ to $\hat{T}_i$ ($i = 1, \ldots, (\ell+1)$). We conclude for a rejection in favor of a model with (ℓ+1) breaks if the overall minimal value of the sum of squared residuals (over all segments where an additional break is included) is sufficiently smaller than the sum of squared residuals from the ℓ breaks model. The break date hence selected is the one associated with this overall minimum. In addition, the Bai-Perron procedure deals with the problems of heteroskedasticity[65] and autocorrelation[66]. In particular, the estimator they use is the one used by Andrews (1993) to correct the test results. Nevertheless, the procedure is too complex to detail here[67].

In this way, we use the Bai and Perron (1998; 2003a) test in order to consider structural breaks in the three-month Euribor series. In order to obtain a better overall assessment, we provide the Bai-Perron estimated confidence intervals for the break dates.

TABLE 6 - Regimes identified in Bai-Perron: Euribor data

Period
07/11/2000 – 03/02/2003
04/02/2003 – 21/04/2006
22/04/2006 – 09/10/2008
10/10/2008 – 23/12/2011
24/12/2011 – 06/11/2015

TABLE 5 - C.I. for break dates with Bai-Perron testing

C.I. for break dates 95%
04/02/2003 – 21/04/2006
22/04/2006 – 09/10/2008
10/10/2008 – 23/12/2011
24/12/2011 – 06/11/2015

Table 6 highlights the five regimes suggested with the Bai-Perron method, whilst table 5 provides the confidence intervals (C.I.) for each of the estimated break dates. In table 5, we report results for 95% confidence level. By default,

[65] Heteroskedasticity occurs when the variance of the unobserved error is not constant.

[66] Autocorrelation happens when the error term at one date is correlated with the error term in the previous date.

[67] For further information see Bai and Perron (2003b).

the test allows for a maximum number of five breaks, employs a trimming percentage[68] of 15% , and uses the 0,05 significance level for the sequential testing.

The confidence intervals are not symmetric around the break date point estimate, but that was to be expected, since it is a property of Bai-Perron method (Santos and Oliveira, 2010).

Thereby, the sequential test results indicate sufficient empirical evidence to conclude, at the significance level $\alpha = 0{,}05$, that there is at least four breakpoints in the sample. We performed a conversion of Euribor reference observations to standard dates for estimation and comparison; the four observations correspond to the dates 23/12/2011; 9/10/2008; 21/4/2006; 4/2/2003. So, by means of using the sup$F_t(\ell +1 \mid \ell)$ statistic, for ℓ ranging from one to five, sup$F_t(5|4)$ is smaller than any critical value at any significance level considered, leading us not to reject the hypothesis of four breaks vs. the alternative of five breaks. In conclusion, we declare that the Bai-Perron method suggests four break dates identifying five regimes in the data[69].

By comparing the model with figure 13, until the first break date 14/2/2003, which is the default regime, the series shows a downward trend. In the first regime (S1) between 14/2/2003 and 21/4/2006 the three-month Euribor rate stabilizes in 2,5%. After 21/4/2006 until mid-2008 (S2), it illustrates an upward trend that reaches 5%. During 10/10/2008 to 23/12/2011 (S3) the three-month Euribor rate presented a sharp decline. The 24/12/2011 to 06/11/2015 (S4) regime experiences the lowest Euribor rate percentage across the sample, stabilizing in an ultra-low percentage level.

[68] Trimming factor $\epsilon = h/T$, where h is the minimum regime length.

[69] The numbers of regimes have to be equal to the number of breaks +1.

In fact, the break dates actually make sense. On 9 October 2008 (S3), we assisted to the collapse of the Lehman Brothers and other financial institutions[70]. From 2012, we assisted both to the second Greece rescue that imposed losses on creditors and to the particularly visible MP that rescued the banks with bailout programs. Subsequently (S4) the refi-rate was already at the lower possible level and so the Euribor downward trend stopped. The impact of the unconventional MP adopted was practically zero in the refi-rate that was already in low levels, consequently, the shocks in the Euribor rate were not pronounced. After 2006 (S2), the mortgage credit started to become too bulky in the USA and the ECB statutory objective of the inflation control dealt with increases in the refi-rate. Some shocks reveal that structural breaks may be associated with events impossible to estimate. In conclusion, results seem to point in the direction that structural break test is leading to similar conclusions as the mainstream literature, while, at the same time, it is providing economically meaningful break dates.

5.1.2.5 Euribor model reformulation

Consider now an extension version of the initial model (equation 1), where we add four breaks as explanatory dummy variables which take the value one if we are in the respective regime and take the value zero otherwise. The purpose of this extension version is to conclude if the breaks inclusion in the model will change the nature of the model: an unit root model.

TABLE 7 - Dummy variables

D_variable	Regime
S1	14/02/2003 – 21/04/2006
S2	22/04/2006 – 09/10/2008
S3	10/10/2008 – 23/12/2011
S4	24/12/2011 – 06/11/2015

[70] See section 2.1.

Each of these dummy variables is equivalent to a new explanatory variable. Note that if we had used five dummy variables for the five regimes, we would encounter the problem of multicollinearity[71]. Instead, we used one less the number of regimes. For example, the coefficient associated with S1 is a measure of the effect between the first regime (14/2/2003 – 21/4/2006) compared to the default regime (7/11/2000 – 3/2/2003).

The following output was estimated from the extension model, including the four dummy variables:

TABLE 8 - Results of regression Euribor including dummy variables

	Coefficient	**Std. Error**	**t-value**	**t-prob**	**Part.R^2**
E3M_1	0,99795	0,0002188	4560	0,0000	0,9998
Constant	0,0060918	0,0007631	7,98	0,0000	0,0160
S1	-0,00122243	0,0006534	-1,87	0,0614	0,0009
S2	0,00439307	0,001051	4,18	0,0000	0,0044
S3	-0,00849964	0,0007002	-12,1	0,0000	0,0363
S4	-0,00656998	0,0009732	-6,75	0,0000	0,0115

Sigma	0,0140308	**RSS**	0,769342865
R^2	0,999921	**F(1,3912)**	9,85e+006 [0.000]**
Adj. R^2	0,999921	**log-likelihood**	11148,4
nºof observations	3914	**nºof parameters**	6
mean (3M)	2,09211	**se(E3M)**	1,57419

The regression estimator of persistence would be $\boldsymbol{\rho} \approx 1$, which is actually the same obtained with the simple model. Regardless the breakpoints, the results conclude hereby that we continue to have an AR (1) with unit root. In addition, the extension model also permits validate the Bai-Perron test because the breaks are individually significant, so the dates found for breaks are statistically feasible. The conclusion shows evidence of persistence even considering regime shifts and validates the use of the robust forecasting device to prove useful in forecasting the present time series.

[71] Multicollinearity refers to the existence of an exact linear relationship among some or all explanatory variables of a regression model.

This way, the regression analysis resulting in the extension model is used to forecast the Euribor rates, which has in essence an unit root model. This model normally is associated with a Robust Forecast Model.

5.1.2.6 Forecasting Assessment

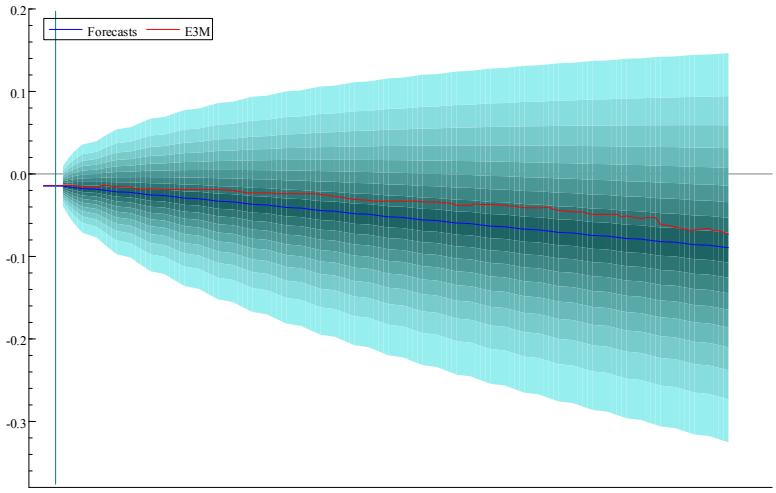
Now, the objective is to forecast three-month Euribor rate for 100 days after 6 November 2015 where none of the explanatory variables values will be known. The variables will all have to be forecast for 100 days. Since explanatory variables have to be predicted before the forecast variable can be predicted, it is important to get robust forecasts for these explanatory variables; the Robust Forecast model predicts considering a level shift break.

Regression analysis is a powerful method and the most commonly used approach to model the effect of explanatory variables on the forecast variable. Accordingly, if we are consider the estimation results using dummies obtained from the Bai-Perron test, we select the following regression to apply the Robust Forecast Model.

$$\boldsymbol{y_t} = \underset{}{0{,}0061} + \underset{}{0{,}998}\boldsymbol{y_{t-1}} - \underset{(0{,}00022)}{0{,}0012}\boldsymbol{S1} + \underset{(0{,}00065)}{0{,}0044}\boldsymbol{S2} - \underset{(0{,}00105)}{0{,}0085}\boldsymbol{S3} - \underset{(0{,}00070)}{0{,}0066}\boldsymbol{S4} \quad (0{,}00097)$$

The density forecasts for 100 days are represented graphically as a set of prediction intervals with different probability coverages. The resulting chart has become known as a “fan chart” and is shown below.

FIGURE 14- fan chart



Description: Predictions for three-month Euribor data

The fan chart has the following features. There are an equal number of blue bands on either side of the central band. Each pair of bands covers 10% of the distribution. To illustrate the uncertainty in the predictions, blue bands were drawn alongside the solid line prediction and the bands become lighter as the distance from the prediction line increases.

The forecast method re-estimates the model with less 100 observations. With those 100 observations, the model tries to predict the three-month Euribor rate for the respective 100 days, in other words, the model will compare the gap between the predicted estimation with 100 observations and the estimation with all observations, $Euribor(real) - Euribor(estimated)$.

In the fan chart, the solid red line corresponds to the difference between $Euribor(real) - Euribor(estimated)$. On the one hand, the solid red line is always below zero suggesting a tendency of upward prediction, i.e. the estimated Euribor rate is higher in comparison with the true rate. On the other hand, the solid red line is almost always aligned with the darker blue area; this implies a likely capability of correctly forecast Euribor.

In the initial range, we can say with 95% of confidence that the difference between the observations and predictions is zero. However, as uncertainty increases with the forecast horizon, we could also vary the shading over time. The shading of this chart emphasizes a much less certainty about the more distant values for three-month Euribor rate than about the values corresponding to earlier dates. The red line is no longer in the darker blue but would be in 90% confidence interval.

The fan chart reveals the forecast quality. For instance, if the red line were in a lighter area, the quality allowance would be much lower. Yet, as the prediction for the distant period has 90% of probability to be correct, the evaluation of the fan chart suggests fairly high probability of the quality in the forecast explanatory variables.

5.1.2.7 Euribor relationship model with banks' risk

In this section we want to address our second investigation question, that is, the Euribor power as an instrument with prediction capacity of banks' risk. In order to examine this question, we are considering using the data from spread iTraxx Europe with five year maturities[72] .

In here, we follow the similar structure used to answer the first research question. We start by a preliminary analysis, then we use DF and ADF to address the best model in our analysis and, finally, we tries to evidence the Euribor relationship model with the bank risk.

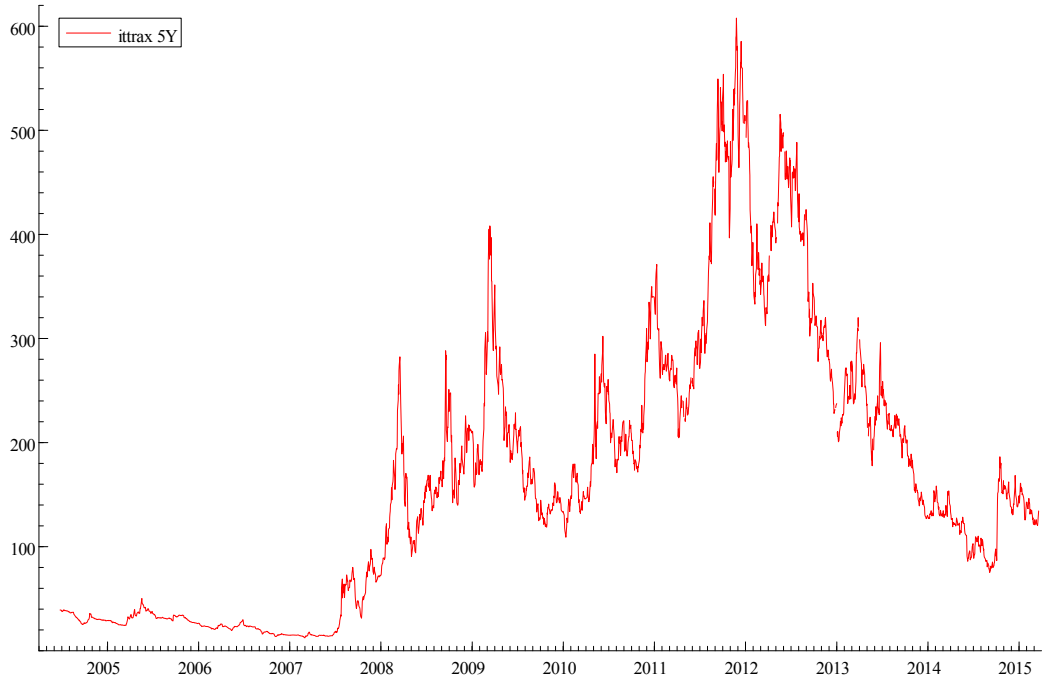
5.1.2.8 Preliminary analysis: iTraxx data

The statistical analysis of the daily data for spreads iTraxx results in the following chart and enables to collect information about the characteristics of the data. As was done for three-month Euribor data, by using a preliminary

[72] See section 5.1.1. Data description.

analysis we may find some suspicions about stationarity and the presence of possible regime shifts.

FIGURE 15 - iTraxx data



Description: Time plot

The chart shows the spreads of multi-name CDS in basis points (1 bp=1/10000). As indicated in the chart, the new statistics illustrate the importance and existence of highs and lows in credit after 2007, which can be justified by the increased volatility in interbank market as a product of the financial crisis that unfolded in that date and was intensified afterwards[73]. Specifically, it shows a heightened credit risk between 2007 and 2012. After 2012, a downward trend took place explained by the ECB's aggressive interventions in the banking sector. In fact, Mário Dragi (2012) noted that "during his mandate, the ECB is prepared to do whatever it takes to preserve the euro" (www.dn.pt) by using policies of liquidity trap and credit risk transfer from banks to ECB in order to reduce the banking risk. Also, the plot

[73] See chapter 2.

evidence that the higher index spread implies lower credit quality of entities in multi-name CDS, in other words, when chart above reaches the highest value there is a reliable dependence between bank and counterparty. We suspect a stochastic process in this financial series, which means an unit root process.

5.1.2.9 Testing AR (1) with unit root

In order to investigate if the iTraxx data is unit root, we use the equation 1 which is an AR (1) with drift.

We proceed with DF and ADF tests as we have done previously but now we use the iTraxx series. The unit root test is then carried out under the same characteristics and the same hypothesis used for Euribor data.

TABLE 9 - iTraxx data: results of DF ad ADF tests

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
2	-1,812	0,99639	7,685	-1,706	0,0881	4,081	
1	-1,906	0,99621	7,690	7,551	0,0000	4,081	0,0881
0	-1,536	0,9969	7,814			4,113	0,0000

These results confirm the main features already identified in figure 15 and suggest an unit root process. The DF and ADF tests do not reject the null hypothesis of an unit root in the iTraxx series for the 5% and 1% level of significance, so an evidence of unit root was found. However, as we done before, we must verify if the root is spurious, precisely by accessing the possibility of structural breaks.

5.1.2.10 iTraxx model Reformulation

Aligned to what was done for Euribor date, we use Bai-Perron tests to investigate the possibility of structural breaks in the iTraxx series.

From the output of the Bai-Perron test summary not here reported (see table 2AA in appendix), the test statistic reveals no break points in iTraxx series,

probably due to trimming factor (Santos and Oliveira, 2010). Respectively, in the study of structural breaks, we test of one break versus zero breaks of the null hypothesis of no structural change versus the alternative hypothesis of a single change. We conclude for not reject the null hypothesis of zero versus one break because the one break date of the sum of the squared residuals is not sufficiently smaller. Hence, the iTraxx series does not reveal any structural break, which may deal with modelling problems when adding the Euribor to explain the banking risks.

5.1.2.11 Modelling Problems

We have some evident modelling problems by regressing Euribor to explain the risks on the banks' asset.

The three-month Euribor rate series is integrated of order 1 with multiple breaks whilst iTraxx series is integrated without breaks. This reveals a co-breaking problem and thus, standard inference cannot be made in a joint model (Hendry and Massmann, 2007). The co-breaking approach is an alternative approach to avoiding systematic forecast failure by seeking to model the changes that occur, in other words, this approach eliminates deterministic shifts across linear combinations of variables (Clements and Hendry, 2001).

Also, the number of observations of each data is different. We have more observations for Euribor than for iTraxx data because the last one only began to be compiled in 2004. If it were possible to construct a regression model, it would only be necessary to use the same time window (2004-2015) by dropping the first variables in Euribor data. As co-breaking failure makes impossible to construct a joint model, we don't need to do those data adjustments.

Therefore, the co-breaking problem evidences that Euribor is not a determinant of financial iTraxx.

5.2 Empirical Findings and Discussions

This study conducts a thorough examination of two research questions linked to Euribor rate. First, examine the Euribor impact in the banks' risk and second, access the Euribor quality as an instrument of banks' risk prediction.

The first step of our empirical analysis was the construction of a valid model using three-month Euribor rate. We began by carrying out unit root tests which suggest an AR (1) with unit root process; the evidences are in figure 13. Our analysis is then guided by equation 1, our baseline model.

In the process we note that the sample we use, which includes crisis periods, may induce to potential regime changes and inconsistencies in the estimation. In this matter, we used Bai-Perron test to investigate the null hypothesis of ℓ breaks versus the alternative hypothesis of (ℓ +1) breaks, until five breaks. Table 5 exhibits the results of Bai-Perron test revealing four breaks. So, the baseline model was spurious in the sense that we have an AR (1) unit root process with structural breaks. In fact, the break dates match, on average, with macroeconomic events. The first regime (S1) is supported by figure 7 in section 2.2.2, which reveals the stable pattern before 2007, where interbank interest rates where a small margin above the refi-rates set by central banks. The second regime (S2) evidence the rising optimism in the financial market, conducted mainly by securitization as illustrated in figure 6 in section 2.2.2. The decline in the third regime (S3) is supported with the literature review in section 2.1 Credit crunch, which explains in detail this time window. Actually, the critical point of the financial crisis was in September 20008 when Lehman Brothers collapsed in the USA and both RBS and Lloyds Bank needed substantial injections of government funds in United Kingdom, mainly explained by the many financial institutions that found themselves in trouble when the securitization market imploded. This regime also covers the Sovereign Debt

Crisis in Europe that started at the end of 2009, when the peripheral Eurozone members Greece, Spain, Ireland, Portugal and Cyprus were unable to repay or refinance their government debt (see section 2.2). In the last regime (S4), the ECB lowered the refi-rate to stimulate the economy and a prolonged period of ultra-low rates took place, which explains the steady pattern. A similar pattern is also documented in intraday interest rate, which is affected by changes of the spread between the three month Euribor and the Eonia swap rates (Baglioni and Monticini, 2013).

In order to control these special events, we re-estimate our baseline model addressing structural breaks. Once the four structural break dates are identified, we then re-estimate the model including the four break dates as dummy variables. The quantitative assessment of the extensive model is presented in table 8. The test statistic concludes persistence of an unit root process even considering regime shifts.

The second step was addressing the risk component in the model. This way, we used data from spread iTraxx Europe with five year maturity. By taking the same procedures used in Euribor series, we also concluded that iTraxx series is AR (1) with stochastic process. Figure 15 illustrates low spread values between 2004 and 2007. In fact, as we described in chapter two, in this period, banking activities over the world experienced rapid growth, leading to an expansion of their balance sheets and therefore to an increase in their risk appetite. Also, in that time, there was a very small risk that any of the major banks in the market could default. Financial crisis supports the increase in banks' risk between 2007 and 2012, where banks became very cautious about lending to each other on an unsecured basis. After 2012, the ECB was committed to restoring confidence and the proper functioning of the financial market leading to reductions in the iTraxx spreads. However, the Bai-Perron test reveals no breaks for this data.

Consequently, a co-breaking problem arises when we want to join the two models. To this, we cannot make inferences in the Euribor because of the no co-breaking.

It follows that the factors which may induce breaks in Euribor are not relevant to induce breaks in iTraxx spreads, i.e. in the bank trust. So, the major conclusion is that Euribor is not the principal instrument to explain the volatility in banks' spreads. FIs' risks are mainly affected by other sources, e.g. MP extra regulatory rate, like QE. The ECB interventions are omitted and weigh more on banking risk than the resulting loss with the decline of the three-month Euribor rate. In fact, our findings are consistent with Alter and Beyer (2014), who documented the impact of different ECB's MP in the spreads. The authors conclude the refi-rate policy, which is strongly correlated with Euribor[74], is not statistically significant to explain the banks' spread volatility. Ricci (2015) concludes that banks are more sensitive to unconventional MP than changes in refi-rate, the author evidence that monetary relief decisions and market liquidity decisions have more impact on banks' risk than interest rate policies. Aït-Sahalia et al. (2012) also conclude that policy interventions were associated with a reduction in interbank market, most significantly for recapitalization programs. Adversely, Murphy and Murphy (2012), by using market-quoted yield and spread data from the highly liquid CDS and OIS markets, provide compelling empirical evidence that the LIBOR[75] rate have a great level of influence over the banks' risk. However the last two econometric studies are considering LIBOR rate instead of Euribor rate and they do not cover the co-breaking issue.

In addition, we tough that a careful forecast analysis were strongly recommended to do. Although forecasts are inherently uncertain, quite often

[74] See figure 4.
[75] LIBOR – London Interbank Offered rate.

the associated uncertainty and risks are not duly acknowledge and quantified, we addressed a forecast study of our empirical analysis. Outline this analysis is important because the forecasting models in the presence of structural breaks suggest a number of implications that can be confronted with data. If a deterministic shift is suspected, or confirmed as in our case for Euribor data, the methods that are not robust to such a shift are likely to have performed poorly.

Therefore, the forecasting ability of the extensive model is then tested using Robust Forecast Model as described in section 5.1.2.6. As a result, fan-chart validates the model ability to produce reliable forecasts for Euribor with 90% of confidence, in other words, it is possible to predict Euribor with at least 90% of confidence.

Concerning the join model, forecasts standard inference cannot be made by adding banks' risk component in Euribor. By insert iTraxx spreads, we fail to know the error probability. To know the error distribution it would be required the existence of co-breaking. Consequently, the band for the error which would correspond to a prediction of 90% of confidence will be unknown. Hence, forecasts of three-month Euribor based on iTraxx series lack statistical inference. The forecast quality for Euribor is not improved with the financial iTraxx.

Conclusion

Euribor is not the principal instrument to explain the volatility in banks' spreads. This suggests that FIs' risks are mainly affected by other sources, e.g. MP extra regulatory rate. The ECB interventions are omitted and weigh more on banks' risk than changes in short-term Euribor rate. Our findings are consistent with other econometric studies (e.g. Alter and Beyer, 2014; Ricci, 2015; Aït-Sahalia et al., 2012). Also, forecasts standard inference cannot be made by adding banks' risk component in Euribor, meaning that the forecast quality for Euribor is not improved with the financial iTraxx.

In this article, we have developed an empirical application of the structural break test Bai and Perron (1998; 2003a). We have used the break test in the context of searching for a break both in the three-month Euribor series and iTraxx series. Finding such breaks is shown to be fundamental to preclude spurious unit root findings. Using the break dates suggested by the Bai-Perron test we were able to find a congruent representation for Euribor dynamics over the sample period. The same did not occur in the iTraxx series, where Bai-Perron test evidence no breaking points. We conclude that the factors which may induce breaks in Euribor are not relevant to induce breaks in iTraxx spreads, i.e. in banks' trust.

Nevertheless, we were aware that choosing to apply a structural break test over similar tests, as well as the possibility to use different metrics for forecast error to robust our findings, could reveal limitations in our study.

Lastly, since the econometric framework analyzed was for a specific case, it would be interesting to implement the same econometric procedure to other economic variables besides Euribor to infer about the main indicator for risks on banks' assets. Also, and besides on the findings collected throughout the

present thesis, we believe that the use of sub-periods could give the possibility of co-breaking.

Bibliography

Adrien, T. & Shin, H. S. 2007. ***Liquidity and Leverage.*** European Central Bank.

Aït-Sahalia, Y., Andritzky, J., Jobst, A., Nowak, S., & Tamirisa, N. 2012. Market response to policy initiatives during the global financial crisis. ***Journal of International Economics***, 87: 162 – 177.

Alter, A. & Beyer, A. 2014. The dynamics of spillover effects during the European sovereign debt turmoil. ***Journal of Banking and Finance***, 42: 134 – 153.

Augustin, P. 2013. ***The Term Structure of CDS Spreads and Sovereign Credit Risk.*** Working Paper, October 2012.

Baglioni, A. & Monticini, A. 2013. Why does the interest rate decline over the day? Evidence from liquidity crisis. ***Journal of Financial Services Research***, 44 (2): 175 – 186.

Bai, J. & Perron, P. 2003a. Computation and analysis of multiple structural change models. ***Journal of Applied Econometrics***, 18: 1 – 22.

Bai, J. & Perron, P. 2003b. Critical values for multiple structural change tests. ***Econometrics Journal***, 6: 72 – 78.

Banco de Portugal. 2015. ***Taxas de juro em contratos de crédito com consumidores e empresas***. Circular letter n.26/2015/DSC, March 30.

Bank for International Settlement, 2015a. ***OTC derivatives statistics at end-December 2014***. Statistical release, Monetary and Economic Department, April 2015.

Bank for International Settlement. 2015b. ***85th Annual Report***, June 28.

Barbosa, P. A. 2012. ***Macroeconomia***. Lisboa: Fundação Calouste Gulbenkian.

Basel Committe on Banking Supervision. 2012. ***Models and tools for macroprudential analysis.*** Bank for International Settlements, May 2012.

Basel Committee on Banking Supervision. 2013. ***Basel III: The liquidity coverage ratio and liquidity risk monitoring tools***. Bank for International Settlements, January 2013.

Basel Committe on Banking Supervision. 2015. ***Guidance on the application of the core principles for effective banking supervision to the regulation and supervision of institutions relevant to financial inclusion.*** Consultive Document, Bank for International Settlement, December 2015.

Bernoth, K. & Hagen, J. 2004. The Euribor futures market: Efficiency and the impact of ECB policy announcements. ***International Finance***, 7 (1): 1 – 24.

Buffet, W. 2002. Warren Buffet on derivatives. ***www.fintools.com.*** http://www.fintools.com/docs/Warren%20Buffet%20on%20Derivatives.pdf.

Burton, M. & Lombra, R. 2006. ***The Financial System and the Economy: Principles of Money Market*** (4th ed.). Mason: Thomson South-Western.

Caruana, J. 2016. ***Persistent ultra-low interest rates: the challenges ahead***. Closing speech at the Bank of France, Bank for International Settlements, January 12.

Cathcart, L., El-Jahel, L., & Jabbour, R. 2015. Can regulators allow banks to set their own capital ratios? ***Journal of Banking and Finance***, 53: 112 – 123.

Clements, M. P. & Hendry, D. F. 2001. ***Forecasting non-stacionary Economic time series***. Massachusetts: The Mit Press.

Cukierman, A. & Izhakian, Y. 2015. Bailout uncertainty in a microfounded general equilibrium model of the financial system. ***Journal of Banking and Finance***, 52: 160 – 179.

Dermine, J. 2015. Basel III leverage ratio requirement and the probability of bank runs. ***Journal of Banking and Finance***, 53: 266 – 277.

Diário de Notícias. 2012. Draghi garante que fará tudo para salvar o euro. ***www.dn.pt***. http://www.dn.pt/economia/interior/draghi-garante-que-fara-tudo-para-salvar-o-euro-2687960.html, June 26.

Dungey, M. & Gajurel, D. 2015. Contagion and banking crisis – International evidence for 2007 – 2009. ***Journal of Banking and Finance***, 60: 271 – 283.

ECB (2016) monetary policy statistics, available in http://sdw.ecb.europa.eu (2015/01/07; 21H 14).

ECB Montly Bulletin. 2008. ***The role of banks in the monetary transmission mechanism***. European Central Bank Publication, August 2008.

European Central Bank. 2009. ***Credit Default Swaps and counterparty risk***. August 2009.

European Money Market Institute. 2015. ***Consultative position paper on the evolution of Euribor***. Consultant paper, October 30.

European Securities and Market Authority. 2014. ***Clearing Obligation under EMIR***. Consultant paper no. 2, July 11.

Fabozzi, J. F. 2013. ***Bond Markets, Analysis, and Strategies*** (8th ed.). London: Pearson Education Edition.

Falagiarda, M. & Reitz, S. 2015. Announcements of ECB unconventional programs: Implications for the sovereign spreads of stressed euro area countries. ***Journal of International Money and Finance***, 53: 276 – 295.

Fontana, A. & Scheicher, M. 2010. ***An analysis of euro area sovereign CDS and their relation with government bonds***. Working paper no. 1271, European Central Bank, December 2010.

Giannone, D., Lenza, M., Pill, H., & Reichlin, L. 2011. ***Non-standard monetary policy measures and monetary developments***. Working paper no. 1290, European Central Bank, January 2011.

Global-rates (2016) refi-rate historical data, available in ***www.global-rates.com***.

Hendry, D. F. & Massmann, M. 2007. Co-Breaking: Recent advances and a synopsis of the literature. ***Journal of Business and Economic Statisticsn***, 25 (1): 33 – 51.

Hirvelã, J. 2012. ***Euribor Basis Swap Spreads estimating driving forces.*** Helsingford: Aalto University School of Economics.

Hoque, H., Andriosopoulos, D., Andriosopoulos, K., & Douady, R. 2015. Bank regulation, risk and return: Evidence from the credit and sovereign debt crises. ***Journal of Banking and Finance***, 50: 455 – 474.

Hryckiewicz, A. 2014. What do we know about the impact of government interventions in the banking sector? An assessment of various bailout programs on bank behavior. ***Journal of Banking and Finance***, 46: 246 – 265.

Hull, J. 1993. ***Options, Futures, and Other Derivatives Securities*** (2nd ed.). Toronto: Prentice-Hall, Inc.

Hull, J. 2012. ***Options, Futures, and Other Derivatives Securities*** (8th ed.). Toronto: Prentice-Hall.

Ivanova, V. & Gutiérrez, M. J. 2014. Interest rate forecasts, state price densities and risk premium from Euribor options. ***Journal of Banking and Finance***, 48: 210 – 223.

Jin, Y. & Zeng, Z. 2014. Banking risk and macroeconomic fluctuations. ***Journal of Banking and Finance***, 48: 350 – 360.

Jorge, R. P. 2015. O que é o "Quantitative Easing" que o BCE vai implementar? ***www.jornaldenegocios.pt***.

http://www.jornaldenegocios.pt/economia/politica_monetaria/detalhe/o_que_e_o_quantitative_easing_que_o_bce_vai_implementar.html, January 22.

Keynes, J. M. 1936. The General Theory of Employment, Interest and Money ***marxists.org.*** https://www.marxists.org/reference/subject/economics/keynes/general-theory/.

Koulischer, F. & Struyven, D. 2014. Central bank liquidity provision and collateral quality. ***Journal of Banking and Finance***, 49: 113 – 130.

Krugman, P. 2015. Liquidity trap, temporary and permanent. ***www.krugman.blogs.nytimes.com***. http://krugman.blogs.nytimes.com/?s=liquidity+trap, November 2.

Lipsey, R. & Chrystal, A. 2011. ***Economics*** (12th ed.). New York: Oxford University Press.

Mishkin, S. F. 1996. ***The channels of monetary transmission: lessons for monetary policy.*** Working paper 5464, National Bureau of Economic Research, Massachusetts.

Mishkin, S. F. & Eakins, G. S. 2006. ***Financial Markets & Institutions*** (5th ed.). United States of America: Pearson International Edition.

Murphy, F. & Murphy, B. 2012. A vector-autoregression analysis of credit and liquidity factor dynamics in US LIBOR and Euribor swap markets. ***Journal of Economics and Finance***, 36 (2): 351 – 370.

Nelson, M. R., Belkin, P., Mix, E. D., & Weiss, A. M. 2012. ***The Eurozone Crisis: Overview and issues for congress***. Report for Congress, Congressional Research Service, September 26.

Novais, J. 2014. ***A decomposição do risco no mercado dos Credit Default Swaps***. Porto: Universidade Católica Portuguesa.

Ojo, M. 2014. Libor, Euribor, and the Regulation of Capital Markets: A review of the Efficient Market Hypothesis. ***Wiley Online Library***, 23: 119 – 124.

Ricci, O. 2015. The impact of monetary policy announcements on the stock price of large European banks during the financial crisis. ***Journal of Banking and Finance***, 52: 245 – 255.

Rupert, V. & Gutiérrez, M. J. 2010**.** ***A quantitative mirror on the Euribor market using implied probability density functions***. Working paper no. 1281, European Central Bank, December 2010.

Santos, C. & Oliveira, M. 2010. Assessing French inflation persistence with impulse saturation break tests and automatic general-to-specific modelling. ***Applied Economics***, 42 (12): 1577 – 1589.

Saunders, A. & Cornett, M. 2007. ***Financial Markets and Institutions*** (3rd ed.). New York: McGraw-Hill.

Segoviano, M. Jones, B. Lindner, P. & Blankenheim, J. 2013. ***Securitization: Lessons learned and the road ahead***. IMF Working paper, Monetary and Capital Markets Department, November 2013.

Socio, A. 2013. The interbank market after the financial turmoil: Squeezing liquidity in a "lemons market" or asking liquidity "on tap". ***Journal of Banking and Finance***, 27: 1340 – 1358.

Theguardian. 2015. IMF warns of new financial crisis if interest rates rise. ***www.theguardian.com.*** http://www.theguardian.com/business/2015/sep/29/imf-warns-new-financial-crisis-interest-rates-rise, September 29.

Tiganas, O. 2010. ***Risk modeling and pricing of Euribor futures and options using the Ho-Lee model***. Stockholms: Royal Institute of Technology.

UniCredit. 2015. Initial market experience with negative 3-month Euribor rates. ***www.ecb.europa.eu***. https://www.ecb.europa.eu/paym/groups/pdf/mmcg/20150617/Item_1c_Initial_market_experience_w_negative_3-month_Euribor_rates.pdf?7a6aba7ab4a84ef6dd4972923131715a, June 17.

Vasquez, F. & Federico, P. 2015. Bank funding structures and risk: Evidence from the global financial crisis. ***Journal of Banking and Finance***, 61: 1-14.

Vogel, H., Bannier, C. E., & Heidorn, T. 2013. ***Functions and characteristics of corporate and sovereign CDS***. Working paper, July 2013.

Wolf, M. 2015. Reasons for low rates is real, monetary and financial. ***www.ft.com.*** http://www.ft.com/intl/cms/s/0/516a3548-615b-11e5-a28b-50226830d644.html#axzz3xQqPkgpr, October 8.

Worldbank (2015) development indicators for financial sector, available in ***www.worldbank.org***.

Yang, J. & Handorf, C. W. 2010. State dependency of bank stock reaction to federal funds rate target changes. ***The Journal of Financial Research***, 33 (3): 289 – 315.

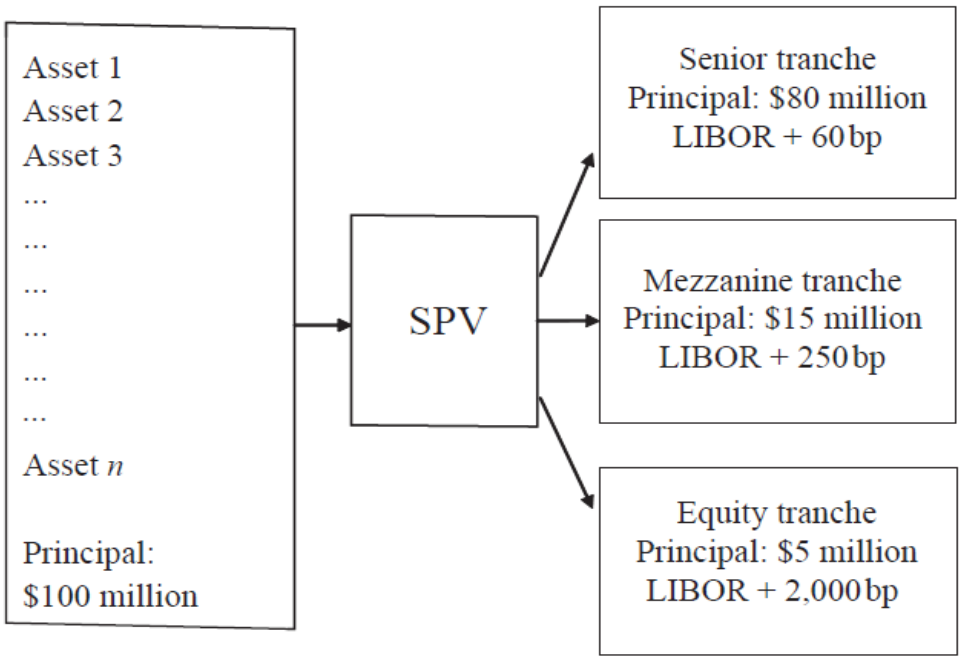
Annex

TABLE 1A
Transaction-based determination methodology

Workstream	Objectives
Benchmark Framework	• Elaborate the Euribor specification in order to facilitate a Seamless Transition • Develop the revised Euribor Code of Conduct to reflect the new Determination Method
Transaction-based Methodology	• Finalize the transaction-based determination methodology
Infrastructure	• Develop the specification of the infrastructure and the daily operations, including the data collection methodology and revised policy and procedural documentation
Transition Execution	• Implement the revised methodology and the new Administrator and Calculation Agent infrastructure
Communication Program	• Provide transparency to stakeholders on all aspects of the transition in order to allow stakeholders to adopt arrangements to mitigate potential migration issues.

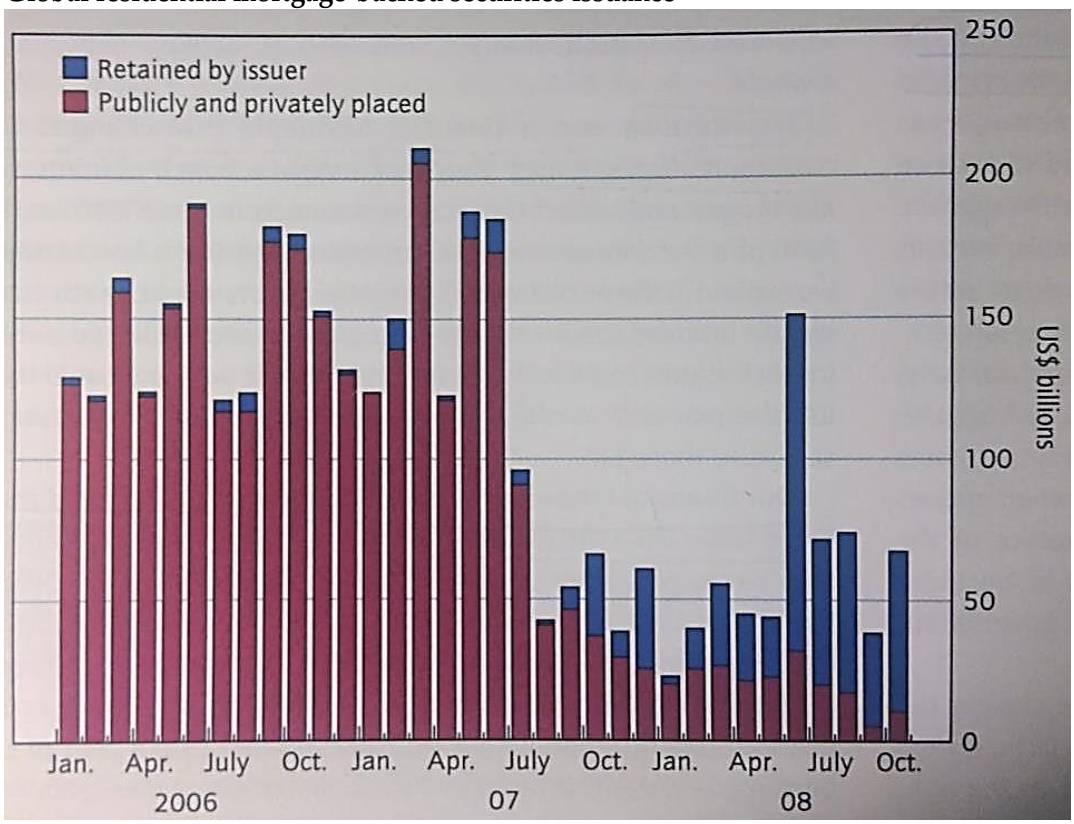
Source: EMMI, 2015

FIGURE 1A
An asset-backed security (simplified)



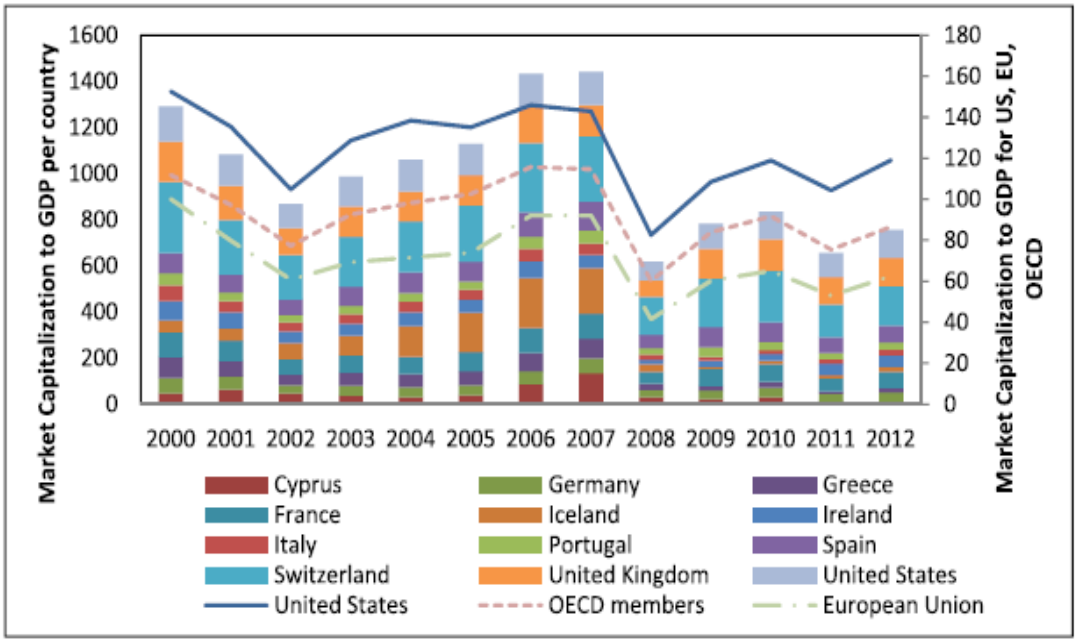
bp = basis points (1bp = 0,01%)
Source: Hull, 2012

FIGURE 2A
Global residential mortgage-backed securities issuance



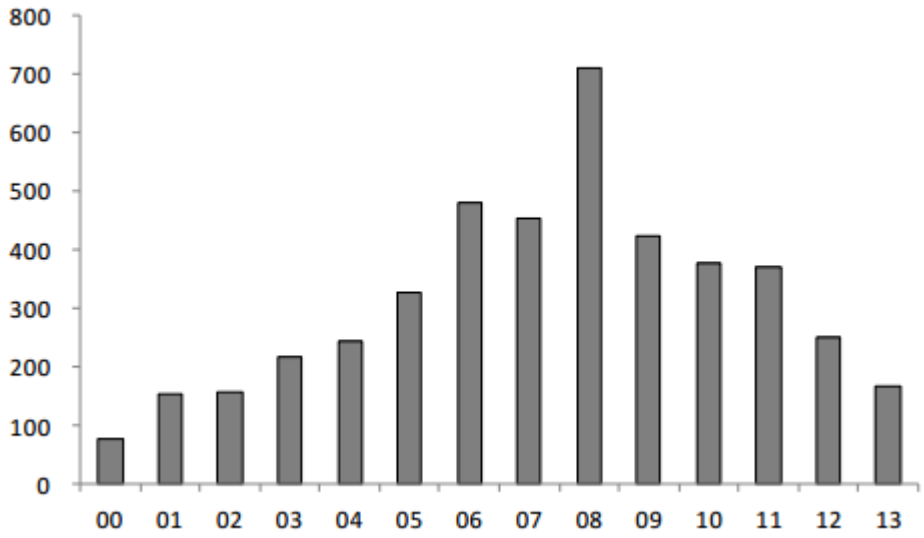
Jan 2006 – Oct 2008
Source: Lipsey and Chrystal, 2011

FIGURE 3A
Market Capitalization to GDP for USA, EU and OECD



Hoque et al., 2015

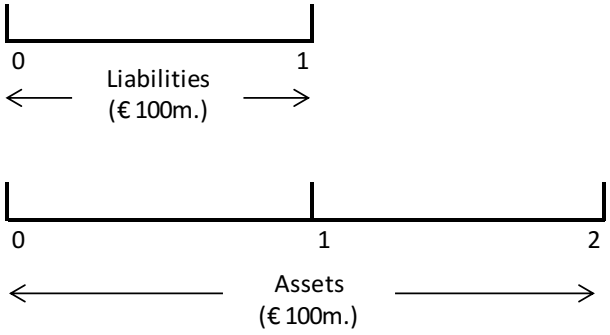
FIGURE 4A
Annual Securitization Issuance in Europe



In billions of euro
Source: IMF Working Paper, 2013

FIGURE 5A
Interest rate risk example

Consider an FI that issues $100 million of liabilities with one year to maturity to finance the purchase of $100 million of assets with a two-year maturity. We show this in the following time lines:



Suppose that the cost of funds (liabilities) for the FI is 9 percent per year and the interest return on the assets is 10 percent per year. In the second year the profit is uncertainty. If interest rates rise and the FI can borrow new one-year liabilities at only 11 percent in the second year, its profit spread in the second year is actually negative; that is, 10 percent – 11 percent = -1 percent, or the FI loses $1 million (-0.01x100m.). The positive spread earned in the first year by the FI from holding assets with a longer maturity than its liabilities is offset by a negative spread in the second year.

Impact of an Interest Rate Increase on an FI's Profit when the maturity of assets exceeds the maturity of liabilities.
Source: Saunders and Cornett, 2007

FIGURE 6A
Credit risk example

Consider an FI with the following balance sheet:

Balance Sheet (in millions €)			
Cash	20	Deposits	90
Gross Loans	80	Equity (net worth)	10
	100		100

Suppose that the managers of the FI recognize that 5$ million of its 80$ million in loans is unlikely to be repaid due to an increase in credit repayment difficulties of its borrowers. Eventually, the FI's managers must respond by charging off or writing down the value of these loans on the FI's balance sheet. This means that the value of loans fall from 80$ million to 75$ million, an economic loss that must be charged off against the stockholder's equity capital or net worth (i.e., equity capital falls from 10$ million to 5$ million). Thus, both sides of the balance sheet shrink by the amount of the loss:

Balance Sheet after loan loss (in millions €)				
Cash		20	Deposits	90
Gross Loans	80		Equity after charge	5
Less: Loan loss	-5			
Loans after charge-off		75		
		95		95

Top table: Balance sheet before loan loss; lower table: Balance sheet after loan loss.
Source: Saunders and Cornett, 2007

Appendix

TABLE 1AA
Measures reforms of Basel III

Basel I	The first accord was the Basel I. It was issued in 1988 and focused mainly on credit risk by creating a bank asset classification system grouped a bank's asset's into 5 risk categories. It was a set of international banking regulations put forth by the BCBS, which set out the minimum capital requirements of financial institutions with the goal of minimizing credit risk. Banks that operate internationally were required to maintain a minimum amount (8%) of capital based on a percent of risk-weighted assets.
Basel II	Basel II attempts to integrate Basel capital standards with national regulations, by setting the minimum capital requirements of financial institutions with the goal of ensuring institution liquidity. The purpose of Basel II was to create standards and regulations on how much capital financial institutions must have put aside in order to reduce risks associated with banks investing and lending practices.
Basel III	A comprehensive set of reform measures designed to improve the regulation, supervision and risk management within the banking sector. The BCBS published the first version of Basel III in late 2009, giving banks approximately three years to satisfy all requirements. Largely in response to the credit crisis, banks are required to maintain proper leverage ratios and meet certain capital requirements. Basel III is part of the continuous effort made by the BCBS to enhance the banking regulatory framework. It builds on the Basel I and Basel II documents, and seeks to improve the banking sector's ability to deal with financial and economic stress, improve risk management and strengthen the banks' transparency. A focus of Basel III is to foster greater resilience at the individual bank level in order to reduce the risk of system wide shocks.

TABLE 2AA
Bai-Perron test for iTraxx

Dependent Variable: ITTRAX_5Y
Method: Least Squares with Breaks
Date: 02/24/16 Time: 17:30
Sample (adjusted): 2 2740
Included observations: 2702 after adjustments
Break type: Bai-Perron tests of L+1 vs. L sequentially determined breaks
Break selection: Trimming 0.15, Max. breaks 5, Sig. level 0.05
No breakpoints selected

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.432975	0.274681	1.576282	0.1151
Non-Breaking Variables				
ITTRAX_5Y_1	0.997730	0.001308	763.0108	0.0000

R-squared	0.995384	Mean dependent var	164.3703
Adjusted R-squared	0.995382	S.D. dependent var	130.9036
S.E. of regression	8.895668	Akaike info criterion	7.209746
Sum squared resid	213658.9	Schwarz criterion	7.214114
Log likelihood	-9738.367	Hannan-Quinn criter.	7.211326
F-statistic	582185.4	Durbin-Watson stat	1.683080
Prob(F-statistic)	0.000000		