ALMA MATER STUDIORUM – UNIVERSITÀ DI BOLOGNA

DOTTORATO DI RICERCA IN
MERCATI E INTERMEDIARI FINANZIARI

Ciclo XXV

Settore concorsuale: 13/B4
Settore scientifico-disciplinare: SECS-P/11

A JOURNEY THROUGH THE CAPITAL STRUCTURE OF THE BANKING SECTOR: EMPIRICAL EVIDENCE FOR EUROPE FROM 2008 TO 2012.

Tesi presentata da: FRANCESCO GIULIANI

Coordinatore del Dottorato: Chiar.mo prof. Giuseppe Torluccio
Relatore: Chiar.mo prof. Giuseppe Torluccio

Esame finale anno 2014

INDEX

INTRODUCTION

The period elapsing from 2008 to 2012 has been scrutinized by practitioners and academia for the extraordinary volatility experienced by financial markets, for a perceived fragility of the banking sector, for one of the most active interventions of policy makers and for the recessions experienced by many countries. Many refer to this period as a Financial Crisis and dispute on the many causes that may explain it.

In this work we will analyze the evolution of the liability side of the balance sheet for the banking sector throughout these years. We will try to derive some conclusion on specific components of the capital structure such as senior and subordinated debt; we will also address the question of the adequacy of equity for the single financial institutions in light of the perceived fragility of financial markets.

Current times rely on measures of capital adequacy based on the definition of regulatory capital and regulatory ratios: this work will propose a different metric which is more market oriented and less accounting dependent.

Any journey during these fascinating years could not avoid reserving a major role to the protagonist of the financial crisis: systemic risk. This theme has not only attracted the attention of the most renowned authors in academia but urged the intervention of the most influential policy makers to avoid the collapse of the financial system.

Why a journey though the capital structure of the banking sector?

Banks have been quite challenged by recent years of financial turbulence: they have suffered an amount of losses and experienced a scarcity of liquidity such as to trigger the implementation of monetary policies and bail out programs to re-establish an ordinary evolution of financial markets.

The evolution of the value of assets (via financials) does not testify these moments of financial difficulties, due to their representation via an accounting metric that privileges a long term view, thus disregarding a theoretical fair value consistent with times of high risk aversion. This has produced a reading of the capital via accounting measures progressively at odds with the market cap of the financial institutions. The financial sector has experienced therefore a major reduction of the ratio market capitalization/tangible book value; this thesis also proposes how to address the striking difference between the accounting value of the tangible book with respect to the valuation expressed by the market.

Hence this work investigates the behavior of the liability side of the banking sector, given that debt and equity are usually quoted in regulated market; when the value of debt is too illiquid, then the author avails himself of the CDS values, introducing assumptions that will be specified below.

This journey through the capital structure of the banking sector will trigger an in-depth analysis of the questions

- Do CDS levels reflect a risk of default specific of the financial institution or they also reflect a scarcity of liquidity which may be experienced by the system? If so, does monetary policy matter for the purpose of the evolution of CDS?
- What happens when the market has no appetite for the subscription of senior issuance?
- Does volatility of debt matter?
- How does the volatility of debt compare with the volatility of equity?
- If we abandon a regulatory metric of capital how do we determine if the market estimates that the capital structure of a bank is sound enough for the amount of risk it bears on the assets?

We will list below few themes which will be of central importance in the following chapters.

Analysis of CDS levels

The analysis of the levels of senior debt would be quite difficult given that the financial crisis was characterized by periods with no appetite for fresh senior issuance underwriting and that most of the banks placed their senior debt to their own retail. Therefore financial senior debt has reduced the volumes exchanged on the secondary market and is most of the times regarded as an illiquid asset class, especially if issued by a financial institution affected by a multiple downgrade during the financial crisis.

For this reason we analyze the levels of CDS, not only because daily data is available, but also because, being them quoted by major market players, they reflect a risk estimated by institutional players; on the other hand debt is also subscribed by retail, thus resulting in a pricing biased by players with limited information. Hence the analysis of CDS will exclude such bias.

We will implicitly assume that the value of debt will be par when it yields Euribor + CDS: subsequent higher level of the CDS (widening) will represent a drop in value of the debt and viceversa.

The analysis of debt via its cds levels will prove useful when analyzing the volatility and a comparison with the one experienced by equity. This will allow an insight on the perceived soundness of the capital structure (second part of this work).

Systemic Risk

This concept will be widely explored in the second part of this work, dedicated more generally to the theme of capital structure of financial institutions. We will propose a new definition of systemic risk, centered on the idea that a volatile debt makes the refinancing mechanism of the banking sector volatile, thus generating a financial instability of systemic relevance. This intuition will also prove valuable to address the intuition of endogenous risk, as proposed by Danielsson and recalled in the second part of the thesis.

Although better addressed in the second part of this work, systemic risk will also be the implicit topic in the first part of the work, given that CDS levels will be explained via variables that are not firm specific. Although only in the second part of the work we will strive to provide a definition for systemic risk, the empirical consideration that CDS levels of financial issuers may be explained by common variables corroborates the idea that risk is driven mainly by system variables and not only by idiosyncratic ones.

In the second part of the work we will build on these intuitions and we will not limit the analysis to CDS levels (in their role to summarize the evolution of senior debt), but we will also include equity to assess if it is consistent with the risk/volatility of the assets.

Mark to Market vs Accounting Value

Before the latest financial crisis the world was expericing a regime of lower volatility, especially when dealing with Fixed Income Markets. Defaults were hardly perceived as systemic and International Accounting Standards made a special effort to introduce rules to align the values of the financial assets to a logic of Mark to Market rather than historical cost. Such effort led to the introduction of the so called "Financial Assets", whereas "Loans and Receivables" would (still) be evaluated at the historical levels.

Needless to say, this effort has introduced a higher degree of transparency for some of the assets of the bank: this was traded off against a higher variability of equity reserves: the latter reduce while the financial assets experience a drop in value.

The extraordinary volatility of the financial assets experienced during recent years has proved hardly sustainable for some banks, reporting an unprecedented volatility of capital reserves. This accounting volatility of the equity component of the balance sheet triggered the reaction of regulators, allowing to suspend the mark to market computation of some financial assets, for the purpose of computing regulatory capital. Exploring the terms and consequences of these norms would be beyond the scope of this work; this serves as an introduction to the striking difference between market capitalization of a bank and the value of its tangible book via balance sheet reading.

We summarize the evolution of the ratio market capitalization/tangible book for various financial European institutions in the appendix. Such comparison motivates the conclusion that the market has grown a sense of skepticism towards the regulatory and accounting reading of balance sheets. The introduction of a new metric which may address the concern of the market and provide guidance on how to manage the balance sheet of the bank (without accounting bias) is introduced in the second section of this work.

Volatility

Accounting and regulatory guidelines do not give a crucial role to volatility: yet an investor or a regulator should find this information very relevant for the purpose of evaluating a financial institution.

The most relevant capital measure from a regulatory point of view, Tier 1 capital, does not give volatility a crucial role: the main framework rotates around the accounting model as a representation of Assets and Liabilities values, according to a certain set of rules, at specific dates.

Recent turbulent times have shown instead that the most volatile times have been accompanied by a series of stress tests conducted to address the capital strength of the banking sector; Liquidity of financial institutions was particularly scrutinized due to the reluctance from the market to subscribe senior debt during the periods of highest volatility. In this introduction we are being very vague in relation to the concept of volatility: the author aims at motivating the importance of this input in managing the bank, from a liquidity and capital point of view; The second part of this thesis will specify variables apt to resemble the composition of assets and the volatility of such variables will be analyzed in detail.

This introduction motivates why capital management is ultimately about dealing with risk and measuring the adequacy of equity to represent a sizable buffer against the joint volatility of assets. When the risk of the assets explains poorly the variations in value of equity and it has a satisfactory explanatory power on debt, then senior issuance is no longer functioning as term liquidity provider only: as a consequence the bank may experience liquidity shortages. We will build on this intuition and on the subtle difference between solvency and illiquidity in the second and third chapter.

APPENDIX

Divergence of Accounting versus Market Value

TABLE 1: EVOLUTION IN TIME OF THE RATIO MARKET CAPITALIZATION/ TANGIBLE BOOK

Countries	19-Apr-10	19-Jul-10	18-Oct-10	24-Jan-11	15-Apr-11	13-Jul-11	28-Oct-11	23-Jan-12	16-Apr-12	17-Jul-12	22-Oct-12
Austria	142.8%	122.2%	212.7%	138.9%	85.2%	114.0%	83.2%	70.9%	70.8%	76.3%	84.6%
Benelux	149.9%	116.1%	117.2%	102.9%	99.1%	80.9%	69.8%	48.7%	61.9%	71.5%	85.4%
France	126.4%	100.7%	104.6%	112.8%	112.5%	84.6%	58.6%	56.8%	50.2%	48.1%	71.1%
Germany	90.0%	86.1%	90.0%	84.2%	76.3%	64.5%	51.7%	46.8%	49.1%	38.1%	47.2%
Greece	112.6%	91.2%	96.3%	79.2%	36.1%	48.4%	24.0%	20.0%	21.6%		
Iberia	166.6%	148.6%	139.9%	132.8%	126.3%	104.2%	92.3%	90.8%	78.4%	67.1%	90.4%
Italy	119.4%	103.4%	94.6%	93.2%	94.9%	59.1%	54.1%	45.9%	38.6%	37.9%	46.7%
Nordics	145.0%	143.9%	150.8%	149.5%	146.8%	117.7%	113.7%	107.7%	109.6%	120.3%	116.4%
Switzerland	245.2%	214.0%	207.3%	205.5%	195.1%	167.1%	135.0%	126.3%	118.8%	97.7%	110.4%
UK	150.1%	137.5%	131.0%	130.2%	118.0%	98.7%	86.2%	91.7%	89.3%	90.1%	92.7%
UK ex HSBC, STAN	110.3%	98.7%	96.0%	94.5%	87.1%	66.9%	56.9%	58.6%	55.7%	48.7%	62.3%

CHAPTER 1:
A FRAMEWORK FOR LIQUIDITY MANAGEMENT AND THE EVOLUTION OF SENIOR DEBT DURING 2008-2013.

Motivation

Since 2007 policy makers have been facing unprecedented times, which required their intervention in more than one occasion and sometimes jointly across different monetary areas. Liquidity within the banking system has played a crucial role in recent years: the banking system saw the intervention of regulators and sovereign states across the whole capital structure (in guaranteeing senior debt issuance and in subscribing shares/ subordinated debt). Debt, be it sovereign or private, is scrutinized in its sustainability and correction measures are being taken by sovereign states and by the banking system in a common aim of deleverage.

This study analyzes the crucial role of liquidity in a deleverage process and finds that under certain conditions central banks can no longer rely on an efficient transmission mechanism of their monetary input through the banking system. Rather than considering the latter a transmission tool, central banks try to preserve liquidity at critical level for the survival of the banking system.

Ultimately this work provides an answer to how important liquidity is for the purpose of explaining CDS levels in an economy characterized by a financial crisis, credit deterioration and deleverage.

For the avoidance of doubt this study will never adopt the term “Liquidity” to denote efficiency in the financial market with respect to the price of one particular instrument, but will always refer to the portion of the monetary base readily available to the banking system, as a cash reserve or for the purpose of redeeming debts.

Related Literature

This study contributes to, at least, two strands of literature.

The first one is represented by the field of studies investigating the determinants of CDS spreads, with a focus on the recent years of financial turbulence. The main contribution of this work is in the emphasis of the role of liquidity, meant as degree of cash availability, in explaining the evolution of CDS whose reference entities are Banks. Many other factors are identified by literature: Dieckmann and Plank (2010) find evidence that government CDS of various countries find explanatory variables in the country's domestic financial system and the state of the world financial system (represented via variables respectively "Country Specific" and "Global"). Fontana and Scheiche (2010) identify the main determinants of the bond and CDS Spreads; they employ a lead-lag analysis for bonds and CDS to determine which market is more important in terms of price discovery. They also explore the evolution of the Basis between bonds and CDS, a variable which is also central in this work.

The second strand of literature is related to the link existing between sovereign CDS and banks CDS. On this topic the main contribution of this work is in expanding such link from a regional viewpoint (typically literature investigates the link between government CDS and its local banks) to a more aggregated monetary area perspective. In emphasizing such wider approach we refer to "Global Consolidation" as the consolidation of the entire banking sector: we strive to draw conclusions (via an econometric approach) on the entire banking sector rather than a regional subset. Acharya et al. (2011) provide a model for the interrelation of banks and government credit risk. Focusing on the current financial crisis, Demirguc and Huiziniga (2010) find that banks CDS level react to the deterioration of public finances conditions. High levels of public debt hamper the support to the financial sector and too big to fail banks may turn into too big to be saved. Ejsing and Lemke (2011) investigate the relationship between Sovereign and Banks CDS via a common risk factor, i.e. the Itraxx CDS Index of non-financial corporations (this work instead will analyze the evolution of the Itraxx CDS Index of financial corporations and will adopt the Non-Financial index as one of the regressors to explain the evolution of financial CDS). Alter and Schuler (2012) investigate the interdependence of the default risk of several

Eurozone countries and their domestic banks. Knaup and Wagner (2009) have found that correlation between banks stock returns and an index of corporate CDS spreads provides a good indication of bank asset risk exposure during the financial crisis.

Another field of literature considers liquidity as a feature to take into account as a deviation from a frictionless market. This leads theoretical works to redefine self-financing trading strategies with additional restrictions on hedging strategies (Cetin, Jarrow and Protter). Liquidity may also be considered when defining a Liquidity Stochastic Discount Factor (Chen, Cheng and Wu, 2005, and Buhler and Trapp, 2006 and 2008). Other more empirical approaches consider liquidity as one of the risky factors to include in the framework of CAPM to explain the return of a portfolio of CDS contracts.

This work emphasizes a different meaning of liquidity and it does not consider it as just one of the factors to explain the CDS levels for the portion that cannot be related to credit risk: liquidity during the financial crisis is an important variable in explaining the levels of the CDS whose reference entities are the most levered players in financial markets: Banks and, in general, financial institutions. This angle of liquidity is also analyzed by Vento and La Ganga (2009), who deal with Liquidity in a perspective of risk management addressing the Bank Liquidity Risk Management in light of the market turmoil experienced in recent years. Angelo Baglioni deals with liquidity crunch in the interbank market (2009): his model can explain the phenomenon of "flight to overnight" in traded volumes and produce outcomes of high spreads between interest rates at different maturities.

Introduction

This work is an attempt to address some topics of central importance during the financial crisis:

- Balance Sheet Deleverage
- Debt Markets not capable of addressing the refinancing needs of the banking sector
- Capital Structure
- Evolution of Sovereign CDS and Banks' CDS

- The role of monetary policy and its reliance on the banking system as a transmission mechanism

These topics will ultimately lead to addressing the main questions of this study: What is the role of liquidity in explaining the level of Banks' CDS? For the portion not attributable to Liquidity are we dealing with systemic risk or simply an entity specific risk?

Economic models typically describe equilibrium as a point of convergence of different agents acting within an economy: one interesting aspect is to consider the forces into play after a shock. What exactly connects variables and how do they interact until economy stabilizes after the shock? The financial crisis unfolded in 2008-2012 can be conceived as a long (and harsh) adjustment process, often with the bold intervention of Central Banks and governments.

Admittedly, analyzing a crisis from a financial viewpoint only is reductive since literature and intuition argues in favour of a crisis as a result of real and financial imbalances. Nevertheless, real variables take a long period to adjust and policy makers are left with the task of dealing with systemic risk and sustainability of the monetary areas: these issues sometimes need to be faced with a response far quicker than the structural adjustment of real variables.

The transmission mechanism is today the first concern when addressing survival of the system: the banking sector is indeed a transmission mechanism of both monetary inputs and deleverage policies.

Hence this study is composed by a simple theoretical framework where the key role is played by a liquidity constraint of the banking sector. We will impose a liabilities rolling constraint in the ordinary functioning of the banking sector. We will analyze the same liquidity constraint when the debt market does not clear. We will justify this event with a drop in profitability of the banking sector, such that the endogenous growth for equity is inferior to the endogenous growth of debt, thus forecasting an amount of equity far too low to protect bond holders from insolvency risk. Satisfying the liquidity constraint will be considered as the event of No Default: if the market for financial debt does not clear, the role of liabilities towards central bank will be crucial to avoid default. Such liabilities imply injection of liquidity, hence the liquidity may have an explanatory value on probabilities of default. We will show whether this intuition is confirmed by a linear regression model applied to a set of financial data.

How realistic is that Return on Equity for Banks may be lower than interest paid to roll liabilities? If this were the case, the capital structure would evolve endogenously towards a higher percentage of debt: this inevitably will be discounted by financial markets when pricing Debt and when subscribing new issuances. When Equity estimated by the market is too low compared to the stock of debt, the debt market no longer clears (this ultimately is the event of an excessive leverage).

The transmission mechanism proposed here is that a suboptimal capital structure causes a rise in the CDS of the bank, and a decrease in the speed of growth of equity (due to profitability reduction). A necessary condition for a bank capital structure to be stable (hence resilient to shocks) is that speed of growth of equity is equal or higher (within a certain timeframe) than the debt growth rate. If such necessary condition is not satisfied, the market prices a reduction of the equity percentage in the capital structure: financial debt is then forecast to bear equity risk. Market may then not clear, in the sense that no demand can absorb the supply of the financial debt which is meant to be rolled to finance imminent redemptions. In a framework where the level of CDS is assumed to be the credit spread for the new issuance (when the market for financial debt clears), financial CDS rise with a strong signalling power for central bank. Central bank then is called to assess how sound the transmission mechanism of monetary policy is. Intervention by the central bank is crucial in shaping the future capital structure of the bank, by controlling the refinancing rules. By setting a credit spread for refinancing below CDS, central bank addresses the problem by reducing the speed of growth of debt, thus not compressing the percentage of equity relative to debt.

By enlarging or reducing the set of constraints in defining the refinancing rules, the central bank influences the forward capital structure of a bank. The incentive for the central bank to intervene is mainly in preserving an orderly transmission mechanism of monetary inputs: a capital structure controllable in its evolution does not force management to a drastic deleverage (as a way to implement a debt reduction).

In this work we show that the liquidity availability for financial institutions is one of the explanatory variables for levels of CDS. The ability to satisfy liquidity constraints then influences the probability of default of the entire European banking sector, due to the strong interconnection of the liquidity conditions across banks. Hence the contribution of this study is in emphasizing that a probability of default can be explained via systemic variables not immediately attributable to the insolvency of one specific bank: one of these systemic variables is the liquidity available to the banking sector. If variations across time of CDS levels could be explained by systemic variables, then the approach to liquidity and solvency by addressing such themes to the specific financial institution is arguable. We will explore in depth this theme m in chapter 2 and 3.

Modeling Banks' Capital Structure

We represent the assets of a bank as a sequence $A(t)$. Every year there will be a decision made by management on the amounts of new loans and financial assets which we will denote by the sequence $A_n(t)$. Every year some of the assets will redeem in a certain percentage of the total Nominal Amount of the assets. Such percentage of the assets redeeming will be denoted by a(t) . Also, some assets will have to be impaired by a certain percentage $d(t)$, so that in a year the amounts of assets on balance sheet are

1

$$A(t) = A(t-1) + A_n(t) - d(t) * A(t-1) - a(t) * A(t-1).$$

Hence the evolution of the assets is described by (not including cash in the category "assets"[1])

$$\{A_n(s), a(s), d(s)\},$$

Such assets are financed with a mixture of liabilities, namely

$D(t)$: Deposits at time t

$B(t)$: Bond outstanding at time t

$CB(t)$: Liabilities against the central bank at time t

[1] Assets for the purpose of this chapter will be the items on balance sheet requiring financing.

$S(t)$: Capital at time t

As with assets, every year there will be an amount of issued bonds redeeming and new bonds issuance. For this reason the amount $B(t)$ can be re-written as the sum of all past issuance from time $t - y_b(t)$ until time t. We are implicitly assuming that the past $y_b(t)$ years contribute to the stock of issued bonds. Whereas all bonds issued more than $y_b(t)$ years ago redeemed, the stock of current liabilities, B(t) is described by the following

$$B(t) = \sum_{s=t-y_b(t)}^{t} B_n(s)$$

Similarly, assets are mainly legacy from past investment decisions: namely last $y_a(t)$ years contributed to the new composition of assets, so that the stock of assets is given by the sum of the investment decisions from time $t - y_a(t)$ until time t

$$A(t) = \sum_{s=t-y_a(t)}^{t} A_n(s)$$

The bank typically runs a transformation of maturities from liabilities to assets, in the sense that we should expect that the maturity of the assets be higher than the maturities of the liabilities. This maturity gap will prove of crucial importance when the banking system goes through a financial crisis: we will explore this aspect in a section below, when analyzing the liabilities rolling constraint.

A given set of liabilities as represented above will originate a certain profit for the year: we will assume that the bond issuance produces a cost of Euribor[2] + CDS, where CDS is the credit default swap of the issuer, at the time of issuance. Euribor may be defined as the rate of interest at which panel banks borrow funds from other panel banks, in marketable size, in the interbank market, for short term maturities. Hence CDS may be considered, for the purpose of this model, the additional cost for securing term liquidity.

---

[2] Euribor may be replaced by an analogous short term rate valid in monetary areas other than Euro. The rationale does not change: we are assuming that the cost of issuing debt is Short term rate + CDS, where CDS is the credit default swap level for the reference entity selling its own debt.

From the description of the liabilities above, then the actual cost paid by the bank for its bond issuance is given by a historical average of the CDS levels over the last $y_b(t)$ years. We will denote such average across past years as $CDS_H(t)$

The assets are a differentiated pool of credits towards various sectors of the economy, hence yielding a spread of $CDS_{all\,H}(t)$; $CDS_{all\,H}(t)$ is the level of the average CDS across all industrial and financial names (denoted as $CDS_{all}(t)$) over the past $y_a(t)$ years. Clearly the bank may include among its assets credits towards firms which may not be reference entities in the CDS market: we are implicitly assuming that the CDS market may provide a proxy for the yield of assets by observing the average level of all traded CDS (therefore obtaining a diversification that the assets of a bank may achieve while granting credit). Similarly, the cost for the liabilities is given by the sum of Euribor and $CDS_H(t)$; the latter is an average across the past $y_b(t)$ years of the level $CDS\ \ (t)$.

More formally, for all s between $t - y_b(t)$ and t

2

$$CDS_H(t) = \frac{1}{B(t)} \sum_{t-y_b(t)}^{t} B_n(s) * CDS(s)$$

And

3

$$CDS_{all\,H}(t) = \frac{1}{A(t)} \sum_{t-y_a(t)}^{t} A_n(s) * CDS_{all}(s)$$

Deposits and Central Bank Financing

For the sake of simplicity we will consider the cost for liabilities composed by Deposits equal to Eonia[3]. Eonia, for the purpose of this work, is to be defined as the weighted average of overnight Interbank Offer Rates for inter-bank loans. The liabilities against the central bank will instead produce a cost of v(t).

Central banks publish criteria to distinguish assets that may represent an admissible guarantee when the bank requires financing. Assets that comply with

[3] The notation so far introduced clearly shows that the author is primarily thinking of European variables: yet it is easy to generalize for every monetary area to find the equivalent rate with identical meaning.

such criteria are denominated "Elegible Assets": such criteria then lead to identifying a fraction of the assets, to be denoted[4] as ρ, which represents admissible collateral for repo transactions with the central bank. A higher number of eligibility criteria means a restrictive policy input. On the contrary, relaxation of parameters and longer tenor available for repo transactions represent an accommodative policy input. In this model such monetary input, in the form or number of eligibility criteria will be summarized by the variable ρ ($0 < \rho < 1$).

Deposits include liabilities versus the retail sector, redeemable with no notice. They also include unsecured lending in the interbank market and repo transactions with collateral where a repo market has developed[5].

The purpose of this study is to consider the banking system as an aggregate sector, hence the interbank deposit market will not be considered when evaluating the tools for liabilities management of the consolidated banking sector.

Deposits are by far the cheapest and the most stable[6] liability for the banking sector. This study will focus on the difficulties arising when debt issuance is no longer a tool for the purpose of liability management. Modeling a deposit run would be beyond the purpose of this work: a deposit run, if assumed against the entire banking sector would produce the collapse of the banking system and financial markets. We would thus enter the field of tail events, which calls for extreme measures of economic policies. Modeling such scenarios, dominated by frictions and panic is a pure theoretical exercise, which would be of no use in this framework.

We will then write the profit, as determined every year when publishing financials as

---

[4] Such percentage of assets is referred to the "counterbalance capacity" in the banks' portfolio.
[5]Typical repo markets where the banking system can enter repo contracts have as underlying assets government bonds; similar markets exist for quoted stocks when the stock lending activity has reached a certain relevance.
6 Maybe it would be more appropriate to write the least unstable, especially when compared with senior debt.

4

$$A(t) * [\text{Euribor} + CDS_{\text{all } H}(t)] - B(t) * [\text{Euribor} + CDS_H(t)] - D(t) * \text{eonia}(t) - \rho * A(t) * v(t) - A(t) * d(t) - C.$$

The reader may argue that the banking system may not use the full amounts of refinancing facilities offered by the central bank; hence the amount of assets refinanced may be lower than ρ. We would need then to introduce a different notation for the portion of assets actually refinanced with the central bank within this general framework. We avoid doing so since the model will soon focus on condition of distress of the financial markets, and the first reaction of the banking system is to use the central bank facilities at maximum potential as we will discuss below.

C is a generic cost that is not linked to the capital structure and to the investment decisions of the bank. Within this framework the potential profit for the banking system depends on the evolution of $CDS_{\text{all } H}(t)$ relative to $CDS_H(t)$. When such difference decreases, financial markets question the capability of the banking sector to produce profits in the foreseeable future. Reluctance to subscribe financial debt with long maturities follows, which leads to levels of $CDS_H(t)$ closer and closer to $CDS(t)$. Higher levels of Financial CDS typically are correlated with high levels of $d(t)$, a further reason for disputing the future profitability of the banking sector. This theme will be analyzed in more detail in the next paragraph.

No clearing Price for debt

We have analyzed how to decompose the profit for year t into revenues from the assets and costs on liabilities.

The market will cast a doubt on the sustainability of the capital structure when observing the yield of assets approaching the cost of liabilities. In this section we will ignore the operational/ administrative costs of a bank, a variable beyond the purpose of this study.

The market will then be reluctant to show a demand for financial debt when the difference between the credit spread on the assets and the credit spread on the issued debt (respectively $CDS_{\text{all } H}(t)$ and $CDS_H(t)$) is too small. A market confident reader would argue at this point that the market will adjust the price, i.e. the CDS level, to make sure that a certain supply for debt will find a price where to clear. Financial debt though is not like any other good, due to its systemic relevance and to the link implicitly existing with real economy. High yielding debt can be sustainable only via high yielding assets: this is at odds with low growth economies[7], typically made of firms with low ROE (on average), thus not capable to afford high interest rates on loans and credit granted by the banking sector.

When management cannot issue debt with an appropriate maturity the tenor of liabilities is shortened, in the attempt to reduce the cost for securing liquidity: this leads to increase the risk that even higher amount will have to be issued in the future, with a significant risk that supply in the future be not met by available demand.

In a more analytical framework the market evaluates the financial sustainability of assets and liabilities by comparing financial revenues and costs to be associated to the current stock of assets and capital structure. It is reluctant to subscribe financial debt if

$$\mathrm{A(t)} * [\mathrm{Euribor} + \mathrm{CDS}_{\mathrm{all\,H}}(\mathrm{t})] - \mathrm{B(t)} * [\mathrm{Euribor} + \mathrm{CDS}_{\mathrm{H}}(\mathrm{t})] - \mathrm{D(t)} * \mathrm{eonia(t)} - \rho * \mathrm{A(t)} * \mathrm{v(t)} - \mathrm{A(t)} * \mathrm{d(t)} < k * A(t)$$

Where k is to be interpreted as a minimum return on assets after costs. If we divide both sides by the amount of assets, then

5

$$\mathrm{Euribor} + \mathrm{CDS}_{\mathrm{all\,H}}(\mathrm{t}) - \mathrm{b(t)} * [\mathrm{Euribor} + \mathrm{CDS}_{\mathrm{H}}(\mathrm{t})] - \delta(\mathrm{t}) * \mathrm{eonia(t)} - \rho * \mathrm{v(t)} - \mathrm{d(t)} < k$$

Where $\mathrm{b(t)}$ is the percentage of assets financed by debt issuance, $\frac{\mathrm{B(t)}}{\mathrm{A(t)}}$, and $\delta(\mathrm{t})$ is the percentage of assets financed by a stock of deposits. The relevance of these ratios is not only emphasized here, but also common market reports consider the importance of "Loans to deposit ratios" when publishing relevant summary statistics. The condition above can be rewritten as

[7] The financial crisis experienced since 2007 is mainly located in highly developed countries, where it proves impossible to sustain a high cost of debt given the low growth of underlying economies. We do not consider here scenarios of high inflation.

6

$$\text{Euribor} + \text{CDS}_{\text{all H}}(\text{t}) - [1 - \delta(\text{t}) - \frac{1}{\lambda(\text{t})}] * [\text{Euribor} + \text{CDS}_{\text{H}}(\text{t})] - \delta(\text{t}) * \text{eonia}(\text{t}) - \rho * \text{v}(\text{t}) - \text{d}(\text{t}) < k$$

Where we have defined $\lambda(\text{t}) = \frac{\text{A}(\text{t})}{\text{S}(\text{t})}$, i.e. the leverage factor in the balance sheet.

Some important aspects to note at this stage are the following. The simple rule of a minimum profitability of the banking sector so that debt issuance may have a clearing price ultimately depends from a number of important variables. We will briefly comment on some of them

i. d(t) or the depreciation of assets is a random variable whose values are particularly high during economic crisis. Particularly high values could see the condition above satisfied.
ii. λ(t) is introduced in static terms as a ratio; in a previous work the author has explored its endogenous character and its dependency on the evolution of the credit market. During a financial crisis, leverage increases due to the drop in value of the assets[8].
iii. $\text{CDS}_{\text{all H}}(\text{t})$ and its evolution compared to $\text{CDS}_{\text{H}}(\text{t})$: Both these variables can be approximated, from an empirical point of view, as a moving average. The former is the moving average over the last $\text{y}_{\text{a}}(\text{t})$ years of a basket of the most liquid CDS traded, with no distinction for the industrial sector where the reference entities belong to. The latter is a moving average over the last $\text{y}_{\text{b}}(\text{t})$ years of all CDS whose reference entities are financial institutions. The reason why we look at a financial index rather than the CDS of one issuer only is because the financial crisis is affecting the entire banking sector and conclusions for a specific issuer could be biased by the specific situation and events proper of one financial institution only.

[8] This aspect is explored in length in "Optimal Capital structure of a bank: the role of asymmetry of information and Equityzation of debt"

Credit indices: Evolution and Impact on the Profitability of the Banking Sector

This brief section aims at describing the evolution of CDS in recent years, for the purpose of providing an intuition on the higher costs of the financial sector in managing their liabilities, compared to a small increase in the yield of the assets (for their portion redeeming, hence rolled with higher yields). It is evident that even if assets and liabilities were due and rolled in the same amount, then the increase of the Itraxx financial senior since 2008 means a drop in profitability of the banking sector (if the index can be considered as a proxy for the cost of liabilities and the yield of assets may be represented by the index Itraxx Europe Main[9]). This is witnessed by the substantial decrease in the net Interest Margin[10] of the banking sector, ultimately leading to a downgrade of profit forecast and to the unattractiveness of the financial sector for investors. We have assumed above that the actual profit for a bank depends on the evolution of a backward looking average of CDS. Also the cost of liabilities is backward looking, since liabilities still due at time t may have been issued various years ago. From an empirical point of view it is easier to observe the evolution of the CDS with no average over past years, in the understanding that the number of years to look back for liabilities is typically lower than the number of years required for the assets[11]. Hence we have that a higher cost of debt issuance, even if matched by an identical move on the yield of assets available in the market, affects negatively the Net Interest Margin of the bank and reduces profits. If instead the rise in financial CDS is higher than the movement in non financial CDS we can conclude a fortiori that such scenario is negative for the banking sector, even without considering that the effective cost of liabilities depends (likewise for the assets) on a backward looking average. The more such move (rise in the difference between financial and non financial CDS) takes place, the more likely it is that the market may move towards a state described as "no clearing price for debt".

[9] More detail on the composition and the rationale of construction of the indices is provided in the empirical section and the appendix of this work.
[10] Net interest margin (NIM) is a measure of the difference between the interest income generated by banks and the amount of interest paid out to their lenders, relative to the amount of their (interest-earning) assets. It is similar to the gross margin of non-financial companies.
[11] Due to the transformation of maturities proper of the banking balance sheet, we would expect that assets are financed with shorter dated maturities liabilities. Hence the Rolling speed of liabilities is typically higher on liabilities, if compared to the assets.

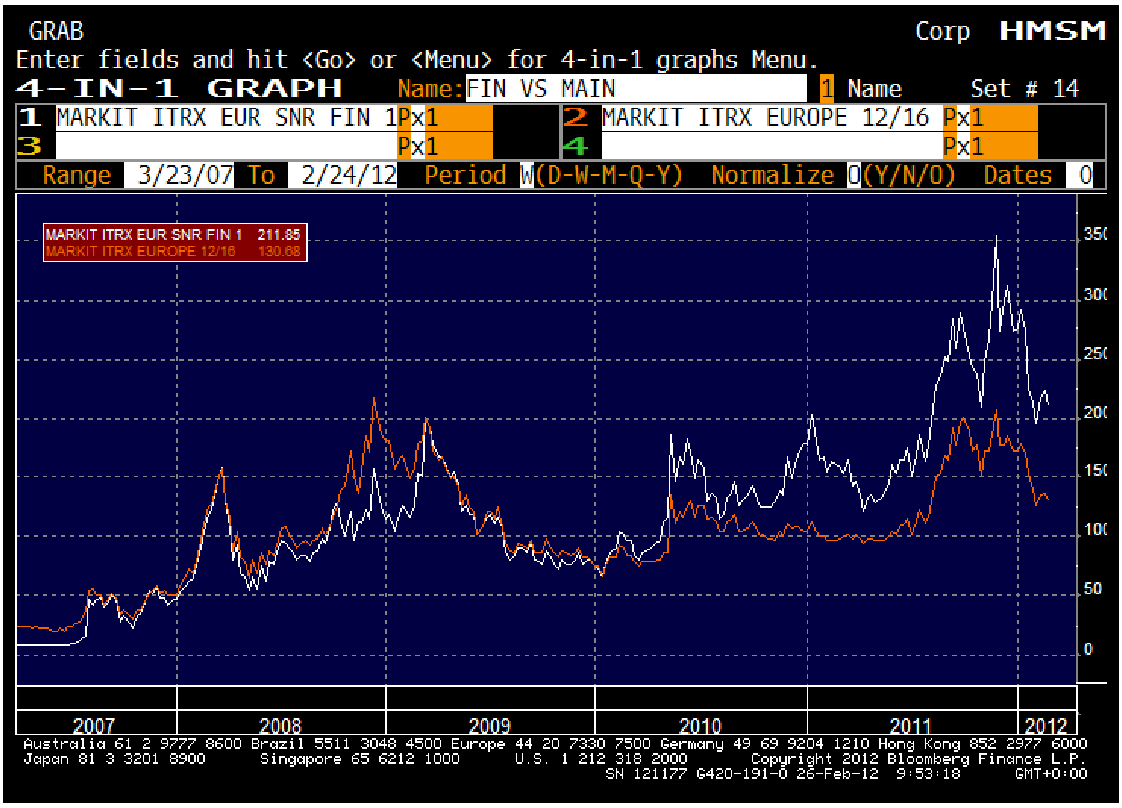


Figure 1:Financial senior index evolves to levels superior to Itraxx main, thus confirming that liabilities for the financial sectors are turning more expensive than the rise in yields of the assets.

The graph above (source: Bloomberg) shows indeed that the financial CDS (white line) has evolved, since 2010, drastically higher than the average of all Most liquid CDS. Figure 1 plots the evolution of the European (Euro denominated) indices in the family of Itraxx Indices. Itraxx financial senior (white line) and Itraxx Main Europe (red line) are here considered representative of, respectively, the average cost of the liabilities for the European banking sector (to be added to Euribor rates) and the average yield of the assets for a diversified pool (Itraxx Main is to be added to Euribor, too). Descriptions of such Indices are in the appendix.

Liabilities Rolling during a Financial Crisis

Every year some previously issued bonds are due for redemption. During ordinary times it would be realistic to assume that financial markets would determine a price for the new issuance so that demand is equal to supply.

We have determined that high debt interests may reduce the trust in the banking sector; hence management may be forced to plan the evolution of the capital structure with limited or no recourse to debt issuance.

The general constraint is

$$\Delta A(t) = \Delta D(t) + \Delta B(t) + \Delta CB(t) + \Delta S(t)$$

For the sake of simplicity we assume that deposit will not change from one year to another and that there will be no rights issuance[12]. Hence

$$\Delta A(t) = \Delta B(t) + \Delta CB(t)$$

$$\Delta A(t) = \Delta B(t) + \rho * \Delta A(t)$$

$$\Delta A(t) * (1 - \rho) = B_n(t) - b(t) * B(t-1)$$

Hence the minimum [13] amount to issue at time t, is equal to

7

$$B_n(t) = b(t) * B(t-1) + A_n(t) * (1 - \rho) - A(t-1) * (1 - \rho) * [a(t) + d(t)]$$

Such minimum amount to issue is immediate to interpret: further debt issuance is required for the debt due for redemption at time t; it is decreased by the assets redeeming their capital (in the amount which was not eligible for refinancing with central bank); new issuance is also required for the non eligible portion of new investments.

During last four years there were various periods when no issuer could approach the primary market[14], a fact described within this framework as "debt markets not clearing conditions". In light of these difficulties management may be forced to set $A_n(t)$ equal to zero or to start a deleverage program, which in most cases

---

[12] Even if we assumed that in a financial crisis Deposit reduced their amounts, then results would not change substantially. The reader could also argue that a variation in equity is produced by Profit/losses realized. To make the analysis consistent with a variation in equity due to losses or profit realized within the period, then we would not change the main conclusions of this work. In periods of financial crisis the profits are very low if not negative (losses): hence, if anything, the conclusions are even stronger when we derive the minimum amount of debt to issue compatible with the equilibrium in the evolution of the balance sheet.

[13] Management could issue more debt than such minimum, for various reasons: for prudential reasons or because it forecasts that soon too many redemptions will be due.

[14] As in all definitions of primary markets, here the primary market for financial debt is the market that changes the supply and introduces new debt freshly issued by the bank. The secondary market is where such debt, along with all existing (and older) issues trade at so called "secondary market price".

requires that the bank accept to sell assets at discounted value: indeed the market will determine the value of an asset also computing a liquidity premium, due to the structural search of liquidity and to the supply of illiquid credit from the banking sector.

Until this point we have analyzed all variables from a financial point of view, in a framework that makes an attempt to model evolution of assets and liabilities through time. From a broader perspective $A_n(t)$ equal to zero is ultimately a reaction of the banking industry which transmits a deleverage system to the real economy: a central bank is thus losing control of the transmission mechanism of monetary policy. A crunch in financial liabilities is generating a credit crunch immediately transmitted to the real economy.

Event of Default and Maturity Gap

A default is typically defined as the event that the value of the assets be lower than the value of liabilities. In a scenario characterized by non clearing market conditions, then the deleverage impulse is such that the condition of default, which relates to the value of assets, cannot even be assessed due to the illiquid prices of loans & receivables. When the debt market cannot achieve a clearing price for financial debt, then condition for default is that liabilities can no longer be rolled or just redeemed. Market players, in scenario of not clearing price for financial debt, scrutinizes the distribution of maturities for debt issued until that date.

We define

$$\beta(t, t+s) = \int_{x=0}^{s} b(t+x)\,dx$$

so that at time t the bank faces in the next s years an amount of debt to redeem equal to $\beta(t, t+s) * B(t)$

We define also

$$\alpha(t, t+s) = \int_{x=0}^{s} a(t+x)dx$$

so that at time t the bank faces a natural reduction in assets in the next s years (due to redemptions) equal to $\alpha(t, t+s) * A(t)$.

We also define a random variable $d(t, t+s)$ which represents the percentage of losses (due to impairment, defaults and deterioration of the loans and receivables portfolio) on the aggregate $A(t)$ occurring from time t until time t+s.

Then managing liabilities from time t until time t+s means imposing that the minimum issuance required from time t until time t+s, $B_n(t, t+s)$,

$$B_n(t, t+s) = \beta(t, t+s) * B(t) + A_n(t, t+s) * (1-\rho) - A(t) * (1-\rho) * [d(t, t+s) + \alpha(t, t+s)]$$

Default is the event

$$B_n(t, t+s) < \beta(t, t+s) * B(t) + A_n(t, t+s) * (1-\rho) - A(t) * (1-\rho) * [d(t, t+s) + \alpha(t, t+s)]$$

The maturity mismatch typical of the banking sector is such that liabilities have a shorter maturity than assets. In terms of the framework here adopted, this translates into

$$\beta(t, t+s) * B(t) > \alpha(t, t+s) * A(t)$$

Hence if financial markets were operating in the scenario of "no clearing conditions for financial debt", then $B_n(t, t+s) = 0$ and as a consequence management sets $A_n(t, t+s) = 0$; then the default condition would be

8

$$\beta(t, t+s) * B(t) > A(t) * (1-\rho) * [d(t, t+s) + \alpha(t, t+s)]$$

This condition of default emphasizes that the typical mismatch in maturities run by a bank between assets and liabilities implies that a default takes place in case of closure of the market for debt issuance. We will explore the central bank reaction below via a change in the parameter ρ.

The reader may argue that these strong conclusions find mitigation with the consideration that bonds are eventually subscribed by the banks customers, i.e. sold to retail. The industry indeed makes a strong differentiation between retail and wholesale issuance. For the purpose of this model, bonds issued to retail should represent a percentage of the aggregate here denoted as D(t). Retail customers accept a lower yield in view of their limited information and knowledge. Their wealth, be it under the technical form of Deposits or retail bonds, tends to be a stable liability of the bank which, for this reason, is categorized under the form of deposits in this simple framework of liabilities management.

Central Bank reaction

When the market moves towards no clearing conditions in the financial debt market, then the central bank is forced into action to avoid a major liquidity restriction (practitioners typically refer to "credit crunch") in the banking and real sector.

Central bank then evaluates the possibility of relaxing refinancing parameters to avoid a default.

We have already analyzed that when the market scrutinizes the capability of the banking sector to roll liabilities, then probability of default in the next s years may be written as[15]

9

$$P\{B_n(t,t+s) < \beta(t,t+s) * B(t) + A_n(t,t+s) * (1-\rho) - A(t) * (1-\rho) * [d(t,t+s) + \alpha(t,t+s)]\}$$

During a financial crisis risk aversion and the attempt by management to decrease the probability of default encourages to choose $A_n(t,t+s) = 0$, especially when experiencing severe stress due to the difficulty to issue and place new financial debt. On the other hand a period of distress requires that policy makers intervene with accommodative measures: monetary policies rely, for the transmission mechanism of accommodative inputs, on the banking system, which, instead, is transmitting a restrictive output[16].

The central bank then reacts to the estimated probability of default (in the formula above) by changing the parameter ρ to $\tilde{\rho}$.

On one side the central bank needs a functioning transmission mechanism, which requires a low probability of default; on the other lowering such

[15] Here P{.} denotes the probability of an event. We will not specify any probability distribution; adding formal introduction of such Probability function does not add strength to the conclusions of this study.
[16] $A_n(t,t+s) \leq 0$ is indeed the failure of transmission in monetary policy since an accommodative monetary input (central banks are intervening for the survival of the system) turns into a deleverage signal to the economy (A(t) decreases).

probability of default moves credit risk from the balance sheet of the bank to the central bank balance sheet[17].

If the primary market for financial debt is completely inactive (as per conditions of no clearing price for financial debt), then the expected value of $B_n(t, t+s)$ is zero and the central bank is called to set ρ as a tool of monetary policy. For $B_n(t, t+s) = 0$ and a change of monetary policy from ρ to $\tilde{\rho}$, then probability of default is

10

$$P\{\beta(t, t+s) * B(t) > A(t) * (1-\rho) * [d(t, t+s) + \alpha(t, t+s)] + A(t) * (\tilde{\rho} - \rho)\}$$

Such a definition of event of default shows the crucial role of liquidity: $\tilde{\rho} - \rho$ is the amount of liquidity injected in the system (as a percentage of assets) by monetary policy.

The last probability of default well summarizes the conclusion of this work (to be tested empirically in the econometric section below): probability of default decreases with high level of liquidity injection chosen by central bank (and viceversa).

Hence the author will move now to an empirical approach aimed at assessing such linkage between financial CDS levels and amount of liquidity existing in the system. If confirmed by data, such relationship will emphasize the transmission mechanism existing from monetary policy to CDS levels of financial institutions. Liquidity may also be seen then as a tool to avoid default, hence with an immediate consequence on financial CDS. In this light a high level of the CDS of financial institutions is to be interpreted also as an unhealthy transmission mechanism. A central bank may then intervene to make sure that the level of liquidity is such that failure to pay is not met on a daily level due to a liquidity shock.

Probability of default will approach zero for $\tilde{\rho}$ sufficiently high: a monetary policy made in terms of rules on eligible collateral rather than changes in interest rates

[17] The central bank, compelled to lower the probability of default of the banking system, will see the size of its balance sheet increase: sometimes central bank interventions are measured by the amount of the assets on central bank balance sheet (evaluated as a proportion to GDP)

does depict current years, where tenor of refinancing and enlargement of criteria to identify admissible collateral are key variables in monetary policies.

If a linear regression could explain the level of the index of financial CDS by means of variables explanatory of liquidity we could then exclude that financial CDS are pricing a default risk due only to idiosyncratic insolvency reasons. We could then conclude that financial CDS price the probability of default due also to a liquidity crunch, possibly arising from the effort to roll liabilities.

If such conclusions were deemed acceptable, a central bank should consider that only certain values of CDS are affordable by the banking sector. After a certain threshold, then the debt market can no longer clear and the central bank has to lower the value of CDS moving some leverage on its balance sheet, at least temporarily. It does so primarily by relaxing the refinancing parameters and by extending the maturity of such financing.

Meaning of Liquidity

Financial markets see the banking sector as one player across the wide range of institutional agents: the banking sector is active on bond issuance (supply) in various currencies; it is also buyer of various securities and participates to the repo markets with two main purposes: yield enhancement and liquidity management.

Liquidity is typically a concept relating to the efficiency of a particular market. In this work we mean instead the cash position of the banking sector, meant as sum of cash reserves and credit lines available to pay for any kind of obligation: be it a cash versus settlement obligation (upon purchase of a bond, for example), or to face payment of capital/interest on outstanding self issued bonds. As such, liquidity is not an observable variable. Recently it has become the centre of attention for regulators and for management: yet financial market players can only make an inference on its level by observing variables presumably highly correlated with the evolution of liquidity.

Such variables, which we will briefly comment on, are

i. Difference between Euribor and Eonia

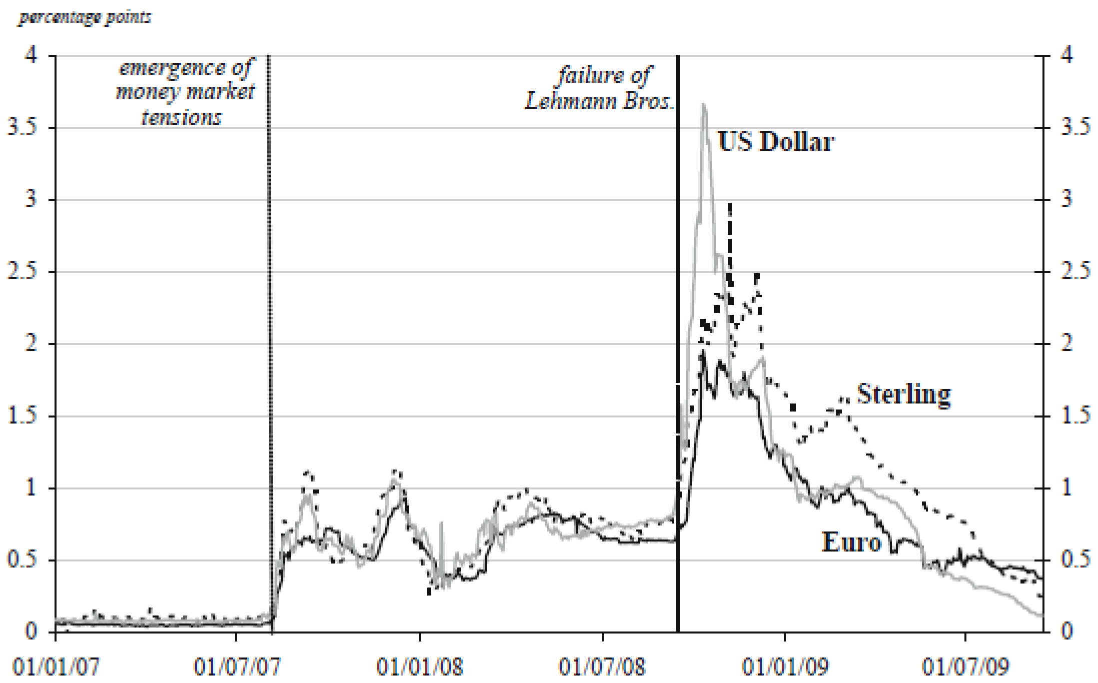
ii. Level of CDS of a sovereign issuer versus the actual yield of the bond issued by the same issuer.
iii. Levels of the cross currency swap EUR/ USD.
iv. The difference in yield between inflation linked and nominal bonds, issued by the same entity.

Inference on Liquidity by Few Financial Variables

In this paragraph we provide the rationale why the variables listed above are deemed relevant estimators for the purpose of investigating the liquidity aggregates available to the banking sector.

Euribor and Eonia are two indices that are considered respectively proxies for the interbank deposit rate for maturities respectively 3 months (e.g. 3-month EURIBOR) and 1 day, in case of Eonia. These parameters have daily fixings and a longer maturity is the reason for different rates especially in scenarios of high risk aversion. In a world where the health of the banking system is not questioned then we would expect that such difference be stable and not large. A negligible magnitude of such difference and a low volatility (of the latter) were features of the financial markets prior to 2007. The degree of financial distress is typically summarized in industry research and ECB papers[18] by means of graphs summarizing the evolution of such difference. The picture below is included in the work by Michele Lenza, Huw Pill and Lucrezia Reichlin published in the working paper series released by ECB.

[18] See for example "Monetary policy in exceptional times", October 2010, in working paper series no 1253.



Note: *The euro spread (labeled EUR) represents the difference between the 3-month EURIBOR fixing and the 3-month overnight interest swap (OIS) rate. For the US dollar (USD) and British pound (GBP), the interbank deposit rate used is the 3-month LIBOR fixing.*
Source: *ECB*

Figure 2: from "monetary policy in exceptional times", ECB working paper series no 1253

In this study we deem the difference between Euribor and Eonia as one of the variables to infer on the liquidity available in the system. We use, though a more forward looking measure of it, since we do not necessarily need to make inference on the liquidity available for one day only, but we investigate what the market estimates on the average evolution of liquidity for a horizon of 2 years. This approach reduces also the Fixing risk, i.e. the risk that the analysis may be misleading since some days may enter the sample with particularly high values due to a shock in liquidity which is 1 day only specific.

Financial markets quote the fixed rates financially equivalent to floating parameters for almost any tenor via swaps markets. These markets have proved reliable even during the core of the financial crisis. Hence rather than the difference on one day between Euribor and Eonia, we will analyze the difference between the swap rate equivalent to the parameter Euribor and the swap rate equivalent to the parameter Eonia. Both swap rates are considered for maturity 2 years and we thus obtain a measure forward looking at the evolution of liquidity for the next 2 years. The reason why we consider the tenor 2 years is simply because swaps with 2 years maturity are exchanged in very large Notional Amounts, therefore making available data very reliable.

The second variable we will analyze to make inference on the liquidity of the banking sector is the difference existing between CDS of a sovereign state and the yield of securities issued by the same sovereign state for a maturity similar to the tenor of the CDS.

Whereas CDS reflect the actual risk of default, the securities exchanged in the market have a demand which depends not only by the risk-return trade off, but also by the liquidity available in the system. Furthermore credit default swaps are unfunded transactions, i.e. no upfront payment is required at inception (which makes their values not dependent by liquidity constraints of market agents)[19]. Bonds purchases instead require the payment of the price. It is intuitive that for large amounts of liquidity there will be a higher amount of investments into securities as opposed to the synthetic purchase by selling protection on Sovereign CDS. More importantly it is a fact that the CDS market and the securities market are segmented, i.e., for various reasons, a market player participating in the cash market may not participate into the CDS Market. Hence whereas CDS do reflect mostly the risk of default, then the cash market, compared to the CDS, is also driven by the liquidity available in the system.

The difference between CDS and the yield of the bond with same tenor would not be very meaningful for sovereign states where the market does not generate a high number of transactions: for this reason (and the plethora of securities existing) we select an issuer whose debt is traded very actively. Among others we will consider the CDS whose reference entity is Republic of Italy and issued securities will be BTPS or "Buoni Poliennali del Tesoro". We will consider the most traded maturity for CDS, 5 years, and we will compose a basket of BTPS whose average maturity is 4.5 years[20]. We will be cautious in considering BTPs when monetary policy intervenes on the secondary market to stabilize prices: on

[19] As a result of the standardization of CDS contracts, the premium running may be different from the CDS levels. Such difference originates a difference of NPV which is settled upfront. Such amount is typically negligible if compared to the notional of the CDS and therefore the market activity on CDS cannot be considered affected on scarcity/ abundance of liquidity

20 The reason why we build a basket of 4.5 years and not 5 years (to match the maturity of CDS) is purely technical: the new issuance targets typically the benchmark 5 years(among others), hence on the day of issuance there would be a jump from the basket to the newly issued bond, which typically trades at premium to encourage investors to new subscriptions. This jump may bias the econometric analysis.

that particular period we would have prices affected by the central bank interventions. This explains why for the second part of the sample we present more than one regression, both adopting and discarding the Italy basis as a regressor: on one hand we wish to produce results comparable with the first part of the sample; on the other we fear that the central bank intervention may bias the meaningfulness of the regression. Once we drop the Italy Basis, we will consider instead the Germany basis, which instead cannot be considered in the beginning of the sample since CDS on Germany was traded very rarely before 2009.

The third variable we will use in the effort to make an inference on the liquidity available for the financial system is the level of cross currency swaps quoted in the market. A cross currency swap is a derivative instrument where 2 parties exchange a principal amount at inception and at maturity[21], denominated in 2 different currencies. The parties exchange interest payments on the two different currencies. If the 2 currencies were EUR and USD, then the counterparty paying USD principal at inception would receive libor and pay Euribor plus the so called "cross currency basis"[22] for the life of the swap. In practice the cross currency swaps are quoted in terms of spread over the benchmark rate for the leg other than USD. In simpler terms the market deviates from a theoretical value of zero and the party paying a benchmark rate plus a positive spread is receiving, on the initial exchange of notional, a currency with a structural higher demand than the one paid at inception of the swap. In intuitive terms, during periods of financial crisis foreign currency denominated liabilities may be even more problematic to manage (and roll) than domestic currency denominated ones. Hence some issuers sometimes address their demand for foreign currency by tapping into the cross currency market. This market allows them to exchange foreign currency with domestic currency. This is achieved by entering a swap where the bank receives foreign currency at inception versus paying domestic currency (initial exchange of notional). This initial transaction is reversed at maturity of the swap; during the life of the swap parties exchange interest on the notional borrowed.

[21] So called initial and final exchange of notional.
[22] Or "Cross Currency Level"

The last variable introduced for the purpose of inferring on the available liquidity in the market is a comparison between yields of instruments issued by the same entity and for similar maturities. In particular we will compare debt paying a real rate with debt paying a nominal rate. The government bonds market allows such a comparison: some bonds redeem simply at 100% of the notional amount (nominal bonds), whereas the so called inflation linked bonds redeem 100% of the notional amount, adjusted for the inflation between issuance and maturity of the latter. Clearly inflation linked bonds pay a lower coupon since the inflation balloon is due at maturity in addition to the notional (nominal) amount. This technical feature causes the inflation linked bonds to be traded at prices higher than a nominal bond, with identical or similar maturity.

The reason why we investigate on the difference of yields offered by these 2 instruments is due to the different conditions applied by the central bank and the repo market when the holder of these securities uses them as collateral for refinancing purposes. The ECB, for example, applies different haircut for nominal and inflation linked bonds, making the financing of the latter characterized by a higher haircut. For this reason, scarcity of liquidity will be inferred when the difference between the yield of these securities will increase, given that there is not enough liquidity to finance an inflation linked bond in spite of the extra yield offered with respect to the nominal bond of similar features (maturity and issuer).

For this reason we will consider the magnitude of the z-spread differential existing between inflation and nominal bonds. We will analyze such difference for two issuers: the Republic of Italy and the French Tresor.

More specifically we will term "Italian z-spread differential" the difference between the z-spread of the BTPS 2.1 15-Sep-2017 and the z spread of the BTPS 5.25 01-Aug-2017[23]. The z-spread is the number to add to 6m euribor such that the future flows of the bond, when summed and discounted at 6m euribor + z-spread are equivalent to the price of the bond.

[23] More detail on the z-spread and the bonds in the appendix

Similarly[24] we will define the “France z-spread differential” the difference between the z-spread of the bond FRTR 1 25-Jul-2017 and the bond FRTR 3.75 25-Apr-2017.

We will analyze if we can find a meaningful relationship between the Itraxx Index of financial CDS and the 4 variables just presented (as instruments to make inference on the liquidity of the banking sector).

Description of the Data

As anticipated, we will test some of the conclusions drawn in this study against daily data. We will describe the composition of the data and then mention the results. The appendix will provide further detail.

The data is composed by a database of daily observations, for the period elapsing from 30th of June 2008 until 28th of June 2013. We emphasize that this sample contains the entire data history representing the financial crisis, with inception before the Lehman collapse and the government financial crisis experienced more recently. Such database includes the event of the Private Sector Involvement (PSI)[25] in relation to the bonds issued by the Hellenic Republic and the bailout of the Spanish banking sector.

Such database includes

1. The levels of the index Itraxx Europe, with tenor 5y maturity: the index, also known simply as 'The Main', is composed of the most liquid 125 CDS referencing European investment grade credits, subject to certain sector rules as determined by the IIC and also as determined by the SEC. More specifically, The iTraxx® Europe index comprises 125 investment grade rated European entities selected from the Liquidity List[26]. All entities must

[24] We will provide more details about the specific bonds and the definition of the z-spread in the appendix. For the moment it may be considered the additional yield over 6 months Euribor that a bond offers

25 Friday, 24th of February 2012 (announcement date)

[26] The Liquidity List is broadly defined in terms of trading volumes. For the precise definition of the composition of the Liquidity List , the reader may refer to the Markit iTraxx Europe Index Rules, available on the web site http://www.markit.com/assets/en/docs/products/data/indices/credit-and-loan-indices/iTraxx/

satisfy the membership determination criteria[27]. Among such criteria it is disposed that the final index comprises 125 entities and is constructed by selecting the highest ranking entities in each sector on the Liquidity List, subject to the following sector restrictions:

a) 30 Autos & Industrials
b) 30 Consumers
c) 20 Energy
d) 20 TMT
e) 25 Financials

2. The levels of the index Financial Senior (more properly iTraxx Europe Senior Financials), with tenor 5y maturity, which intuitively includes all financial senior CDS of reference entities (and listed in the appendix, for a particular series of the Index). More specifically, this index is the weighted average of the 25 names belonging to the Financial sector and included in the index Itraxx Europe (as per description above, point e).

   Both Itraxx Main and Itraxx financial Senior will be considered within 2 subsamples: as time goes by the baskets of CDS shorten their maturity. In order to compare variables (bonds and CDS) with a similar maturity, the subsamples are built to make sure that the residual maturity of the indices does not fall below 3 years. Hence after 2 years from inception of the sample data, we will still consider the Itraxx indices, but we will replace the original basket (with 3 years maturity after 2 years), with a new one with 5 years maturity. Such new baskets with 5 years CDS will represent a new "Series" and this is the reason why the regressions will refer to Series 9 and Series 13, respectively basket of 5 years CDS in March 2008 and March 2010

3. The yield of a basket of securities with average maturity 4.5 years of BTPs (issued by the Tesoro Italiano), FRTR (issued by the France Tresor), DBR (issued by Republic of Germany). From such yield we obtain the Par Asset

[27] Membership determination criteria are listed on the documents available on the web site as per previous footnote: among others such criteria refer to the requirement of investment grade according to Fitch, Moody's or S&P. Entities with an Entity Rating of BBB-/Baa3/BBB- (Fitch/Moody's/S&P) with negative outlook or below are excluded.

swap level, via comparison with the swap rates with maturities similar to the securities.

4. The level of the 5 year maturity CDS contract with reference entity Republic of Italy, Republic of Germany, French Republic, all quoted on Dollar notional.

   It is important to notice that the CDS traded on Republic of Germany had negligible amounts traded prior to 2009, thus making this data not very meaningful prior to 2009. For this reason we will make use of this variable only for the sub-sample with dates after 2009.

5. The swap (fixed) rate with 2 years tenor quoted versus the floating rate eonia

6. The swap (fixed) rate with 2 years tenor quoted versus the floating rate euribor 6m

7. The cross currency spread for a tenor of 5 years, on EURO/USD, with initial and final exchange of notional

All CDS levels and Indices are sourced from a Markit Database, whereas all remaining variables are sourced via Bloomberg.

CDS: Liquidity Shortage or Structural Insolvency?

The ultimate purpose of the study is to explain the daily variations of the index iTraxx Europe Senior Financials in terms of liquidity-related regressors and one more variable representing the component of credit risk which cannot be related to liquidity only. At the beginning of this chapter a model was presented arguing that, when Debt market no longer clears, then liquidity plays a primary role in defining the event of default.

Under market not clearing conditions, probability of default for a bank can be represented as (equation 10 above)

$$P\{\beta(t,t+s)*B(t) > A(t)*(1-\rho)*[d(t,t+s)+\alpha(t,t+s)] + A(t)*(\tilde{\rho}-\rho)\}$$

From such probability we deduce that an empirical analysis should aim at measuring if the conditions of liquidity affect the level of CDS (hence the probability of default) of financial institutions. Indeed, for high degree of intervention via liquidity injections, probability of default decreases (high level of $\tilde{\rho}$ make the event less likely).

The contribution of this work is in not limiting itself to an analysis of the evolution of risk of default specific of one country only. The systemic risk extends cross borders and the econometric analysis presented below does not analyze a default risk which is idiosyncratic (specific of one or few institutions only). In this view we implement an econometric analysis that aims at explaining the default risk of an entire basket of financial issuers, where the latter are all investment grade. For all these reasons the linear regression we will analyze is

$$y_{fin}(t) = \propto + \beta x_{nonfin}(t) + \gamma x_{liquidity}(t) + \varepsilon$$

Where

i. $y_{fin}(t)$ is the level of the index Itraxx financial Senior at time t (we will consider daily differences)
ii. $x_{nonfin}(t)$ is a variable reflecting the level of credit for reference entities belonging to the non-financial sector (we will consider daily differences)
iii. $x_{liquidity}(t)$ is a vector of variables apt to infer on the liquidity level at time t (we will consider daily differences).

We move with a view that liquidity is a systemic variable: its shortage affects an entire economic area. Limited appetite of the market in subscribing senior and even secured issuance has been witnessed especially during the second half of 2011 for over one year: we will then expect that the role of liquidity in explaining the daily variation of CDS will be more relevant in the second part of the sample. We will comment below that not only the linear coefficients increase their magnitude in the second part of the sample, but also all regressors aiming at explaining the liquidity are estimated with better levels of significance and the adjusted R squared improves.

In detail we will estimate the linear regression above on 2 periods, selected so that the Itraxx Indices are not analyzed with a residual maturity less than 3 years: the data contemplates Series 9 from June 2008 to June 2010 and Series 13 from June 2010 until June 2012. For the sake of comparison we will keep the regressors identical across these 2 subsamples:

$$y_{fin}(t) = c + b_1x_1(t) + b_2x_2(t) + b_3x_3(t) + b_4x_4(t) + b_5x_5(t) + b_6x_6(t) + b_7x_7(t) + \varepsilon$$

Where

$y_{fin}(t)$ is the daily change of the Itraxx Financial Senior (9^{th} series in the sample from 30-Jun-2008 to 28-Jun-2010, for 464 days; 13^{th} series in the sample obtained 30-Jun-2010 to 28-Jun-2012, for 481 days)

$x_1(t)$ is the daily change of the Itraxx Non financial index (9^{th} series in the sample obtained from 30-Jun-2008 to 28-Jun-2010 , for 464 days; 13^{th} series in the sample obtained 30-Jun-2010 to 28-Jun-2012, for 481 days)

$x_2(t)$ is the daily change in the Italian Basis
$x_3(t)$ is the daily change in the French Basis
$x_4(t)$ is the daily change in the Italy z-spread differential
$x_5(t)$ is the daily change in the Euribor – Eonia basis.
$x_6(t)$ is the daily change in the level of the EUR/USD Cross currency (tenor 5y)
$x_7(t)$ is the daily change in the France z-spread differential.

The results of the regression confirm the main intuition that CDS levels for financial entities may be decomposed into a "principal" credit level summarized by the non financial world (Itraxx Non Financial), regressor with the highest explanatory power and an estimate with significance at 1%. This is confirmed by both regressions on the 2 subsamples. The relevant relationship existing by CDS of financial institutions and Non financial ones is also well documented in the empirical results of Ejsing and Lemke, as mentioned in related literature section and commented below.

The liquidity variables, when analyzed from the 30^{th} of June 2008 until the 28^{th} of June 2010 will have all significance of 5%, making an exception for the Italian basis (with a p-value of 8.8%), the Italian z-spread differential (with a p-value of 9.4%) and the France z-spread differential (with a p-value of 22.5%). The regression on this particular sample gives an R squared of 53%. More details and statistics are provided in the appendix.

One of the liquidity variables, the z-spread differentials (computed for France and Italy) analyzed from the 30th of June 2010 until the 28th of June 2012 will show a poor explanatory power. In particular their significance deteriorates across the 2 samples: the Italy z-spread differential moves its p-value from 9.4% to 36.9%; the France z-spread differential moves its p-value from 22.5% to 37.4%). In light of these results the z-spread differential variables seem to have a poor explanatory power across the years of the sample and therefore they add little value to the analysis. The remaining liquidity variables instead confirm their explanatory power across the two subsamples, all with a significance at 5%, with the exception for Euribor-Eonia basis, with a p-value of 5.7%. The regression achieves an R Squared of 60.6% (from 53%), thefore improving its explanatory power, as expected, in the second part of the sample.

What would happen if we extended this latest regression (from June 10 until June 12) for one more year, to June 13? We would be then considering (although for a minority of data points) that the Itraxx indices would have a residual maturity of less than 3 years. Such sample extension would also allow to assess if the variables, tested on the most turbulent times in recent financial history, would preserve their explanatory power also during the latest "normalization" period. If that were the case, then the intuition presented in this work would prove robust not only when tested across the different cycles of the crisis, but also to the evolution towards normalization experienced so far. When the sample is extended from 481 to 717 business days (30th of June 2010 to 28th of June 2013) the adjusted R Squared improves slightly, from 60.6% to 63.2%; all variables in the regression improve their significance and most of the explanatory power is still represented by the Itraxx Non Financial Index. We will provide more details in the appendix.

A comparison across the 2 samples (June 08-June 10 versus June 10-June 12) may shed further light on the two periods so far analyzed: we will analyze the change in the linear estimates for variables with significance at 5%. The estimate for the dependence to the Itraxx Non Financial Index shows that before 2010 one bp of movement of Itraxx Non-Fin was corresponding, according to the econometric results, to less than 1 bp movement for Itraxx Financials. In the second subset of the sample, the coefficient doubles (1 bp of movement for Itraxx Non Fin corresponds to 1.4 bps of movement for the Itraxx Financial Index).

The Italian basis increases its weight, although not significantly, while the French basis loses relevance: the latter reduces its estimate from 0.43 to 0.145: the absolute amount of the estimate is still higher than the one associated with the variable Italian basis, yet the evolution across subsamples would suggest that liquidity may have affected significantly more the Italian market of government bonds, when compared with the French one.

The coefficient estimated for the Euribor-Eonia basis evolves from 17.9 to 38.32 (both numbers are negative): this is consistent with the primary issuance market being inactive for lack of appetite to subscribe new issuance. This is the event described in the section above "No Clearing Price For Debt", which implies the urgency for all issuers to tap into alternative sources of liquidity to fill the funding need no longer manageable via senior debt issuance. This could explain why issuers have tapped into the interbank unsecured deposit market, accepting to pay a much higher premium (than historical ones) for longer tenor with respect to overnight maturities. Hence the higher sensitivity of the Itraxx Financial Senior to higher levels of the difference between Euribor and Eonia (such difference, again is read in terms of swap rates with tenor 2 years, in order to isolate the econometric analysis from daily fixings which could be one day only specific).

The event of no clearing conditions on the primary market for Debt issuance may be a valid reason why issuers may have tapped into the cross currency market when the scarcity of funds was particularly binding on a specific currency: the estimates in the linear regression (relating to the cross currency basis for EUR/USD) evolves from -0.15 to -1, which provides support to the conclusion that from 2010 European issuers (the ones included in the Itraxx Financial senior Index) may have accepted to tap into the cross currency market while experiencing higher CDS levels (hence presumably higher risk adversion from the market to underwrite senior debt risk and higher funding costs).

Various papers explore the relationship existing between financial sector and government CDS: this work has taken a different route, by explaining the evolution of Financial CDS via CDS of the non financial sector and some liquidity factors. Some of the liquidity factors include government CDS, but only as a measure of relative value with respect to nominal government bonds (in terms of basis towards the asset swap level of the bond matching the maturity the CDS). In this respect this work presents conceptual differences with respect to the results of Ejsing and Lemke who emphasize the explanatory power of the Itraxx Non-Financial Index in the linear regression where dependent variables are government CDS. Not only this empirical section was derived on daily data, but the aim of this work is providing a further variable apt to explain the evolution of Financial CDS, for the portion not explained by Non-Financial CDS.

In the appendix we will add further details on the statistics relating to the linear regressions commented so far. We will dedicate the remaining part of this section to some variations that may enhance the quality of the data in the second part of the sample. We have already provided the reason why the data adopts two series of the Itraxx indices and why this has caused the econometric analysis to be split into two subsamples. The second subsample also covers a period of central bank intervention on the market, aiming at providing some buying support against selling waves of government bonds. A reader could argue that the variables here adopted as regressors and determined in terms of BTP levels on the secondary market could be biased by central bank interventions. In order to address this concern we will consider, among the regressors, the German Basis in lieu of the Italian Basis.

We will preserve the logic behind this work and explain the evolution of CDS levels for financial issuers by adopting a different set of "liquidity variables" that were not affected by secondary market intervention. Also, we will reduce the number of regressors by discarding the z-spread differential, given the poor explanatory power achieved in the regressions so far presented.

More specifically we will consider the regression:

$$y_{fin}(t) = c + b_1 x_1(t) + b_2 x_2(t) + b_3 x_3(t) + b_4 x_4(t) + b_5 x_5(t) + \varepsilon$$

Where

$y_{fin}(t)$ is the daily change of the Itraxx Financial Senior (13th series)
$x_1(t)$ is the daily change of the Itraxx Non financial index (13th series)
$x_2(t)$ is the daily change in the French Basis
$x_3(t)$ is the daily change in the Euribor – Eonia basis.
$x_4(t)$ is the daily change in the level of the EUR/USD Cross currency (tenor 5y)
$x_5(t)$ is the daily change in the German Basis

By analogy with the terminology so far adopted, German Basis is the difference between the CDS on Germany (for a maturity of 5years) and the par asset swap of the securities (issued by the Republic of Germany) composing a basket whose average maturity is 4.5 years.

This linear regression contains less variables than the ones discussed so far (5 regressors versus 7). Yet it achieves a superior fitting of the data, both on the period 2010-2012 (484 observations) and the period 2010-2013 (730 days). We will comment upon such results and provide further detail in the appendix.

The regression on the period 30 June 2010 until 29 June 2012 provides an adjusted R squared of 63.8%, while the longer period 30 June 2010 until 29 June 2013 achieves an adjusted R squared of 64.6%. The improvement in the R squared in spite of a longer sample is a feature emphasized even in the linear regressions not adopting the German Basis as a regressor. The intuitive explanation may be that an average of CDS levels with shorter residual maturity is less volatile and therefore, in spite of the longer sample, a better fit is achieved.

The new regressor, the German Basis, is estimated in both linear regressions (2 years data and 3 years data) with a significance at 1%. Also, we notice that the logical approach dominating this empirical analysis, where we are testing for the explanatory power of liquidity variables on CDS referencing financial institutions, holds even when we change regressors. Indeed the linear estimate for Itraxx Non Financial Index is not only significant at 1%, but the magnitude of the estimate is similar in spite of adopting a different set of regressors. In the period 30 June 2010 until 29 June 2012 such estimate is 1.3 (5 regressors including German Basis) or 1.4 when adopting 7 regressor with the Italian Basis. In intuitive terms had we noticed very different estimates, then we would doubt the argument that a change in CDS level can be split into 2 separate components: a non financial world related change (Itraxx Non Financial Index) and a change in liquidity (remaining regressors). The fact that the role played by the Itraxx Non Financial Index is very similar across the 2 regressions (both on the sample 30 June 2010 until 29 June 2012) justifies the search for variables apt to infer on factors different than pure credit risk. This work argues that variables apt to infer on the liquidity in the system may provide explanatory value on the evolution of CDS levels for financial institutions. Two different regressions provide on the same time interval a similar conclusion on the liquidity variables: in spite of the different regressors the Itraxx Non Financial Index preserves a constant explanatory power across different linear regressions.

Can we state a similar conclusion when analyzing the sample 30 June 2010 until 28 June 2013? Even in this case the linear estimates are very similar (1.4 with 5 regressors including the German Basis and 1.5 with 7 regressors not including the German Basis). One more feature to emphasize in the regression adopting the variable German Basis is that out of five regressors, three are estimated at significance 1%, and 1 at significance 2% (respectively Itraxx Non financial Index, Eur/Usd cross currency level, German Basis and French basis). We therefore conclude that replacement of Italian basis (estimated at significance 2%) with German Basis (estimated at significance 1%) has not worsened the goodness of the fit and has confirmed the explanatory power of government bonds basis onto the CDS level for financial institutions. We also conclude that z-spread differentials between inflation linked bonds and nominal bonds with identical issuers do not prove relevant when explaining the evolution of CDS levels of financial institutions.

Conclusions

This chapter analyzes financial CDS behavior in their daily evolution during the most turbulent times after the Great Depression. It provides explanatory variables for financial CDS which ultimately map into the concept of liquidity available to financial institutions. Such liquidity is relevant to interpret the evolution of CDS, which suggests that the credit risk of financial institutions is also a macroeconomic variable rather than a microeconomic topic only. As such, the central bank may find it optimal to intervene with extraordinary measures of monetary policy to guarantee the survival of the system and to control the monetary transmission via the banking system.

APPENDIX

Details and results of the regressions

Regression

$$y_{fin}(t) = c + b_1x_1(t) + b_2x_2(t) + b_3x_3(t) + b_4x_4(t) + b_5x_5(t) + b_6x_6(t) + b_7x_7(t) + \varepsilon$$

For

i. Range: 01-Jul-08 until 28-Jun-10 (465 Days)

ii. Itraxx Indices as per series 9

Regressors:

$x_1(t)$ is the daily change of the Itraxx Non financial index

$x_2(t)$ is the daily change in the Italian Basis

$x_3(t)$ is the daily change in the French Basis

$x_4(t)$ is the daily change in the Italy z-spread differential

$x_5(t)$ is the daily change in the Euribor – Eonia basis.

$x_6(t)$ is the daily change in the level of the EUR/USD Cross currency (tenor 5y)

$x_7(t)$ is the daily change in the France z-spread differential.

Parameter	Regression Result	t-test	p-value
b_1	0.007	16.59	0
b_2	0.059	1.49	0.068
b_3	0.381	5.7	0
b_4	0.09	1.5	0.067
b_5	-15.559	-1.54	0.061
b_6	-0.109	-1.21	0.113
b_7	-0.074	-1.02	0.153
c	0.045	0.22	0.413

adj. R2	F-test	p-value	lookback
0.565	87.02	0	465

Series	ADF	ADF-crit	KPSS	KPSS-crit	DW
Residuals	-13.856	-2.871	0.124	0.463	1.704
y	-9.779	-2.871	0.103	0.463	1.7
x_1	-7	-2.871	0.138	0.463	1.807
x_2	-15.09	-2.871	0.072	0.463	1.936
x_3	-15.355	-2.871	0.147	0.463	1.922
x_4	-11.686	-2.871	0.32	0.463	1.658
x_5	-18.151	-2.871	0.095	0.463	2.329
x_6	-10.552	-2.871	0.085	0.463	1.717
x_7	-14.089	-2.871	0.448	0.463	1.704

Regression

$$y_{fin}(t) = c + b_1x_1(t) + b_2x_2(t) + b_3x_3(t) + b_4x_4(t) + b_5x_5(t) + b_6x_6(t) + b_7x_7(t) + \varepsilon$$

For

i. Range: 30-Jun-2010 until 28-Jun-2012 (Days: 481)

ii. Itraxx Indices as per series 13

Regressors:

$x_1(t)$ is the daily change of the Itraxx Non financial index

$x_2(t)$ is the daily change in the Italian Basis

$x_3(t)$ is the daily change in the French Basis

$x_4(t)$ is the daily change in the Italy z-spread differential

$x_5(t)$ is the daily change in the Euribor – Eonia basis.

$x_6(t)$ is the daily change in the level of the EUR/USD Cross currency (tenor 5y)

$x_7(t)$ is the daily change in the France z-spread differential.

Parameter	Regression Result	t-test	p-value
b_1	0.014	16.75	0
b_2	0.064	2.21	0.014
b_3	0.145	2.62	0.005
b_4	0.011	0.34	0.369
b_5	-38.327	-1.58	0.057
b_6	-1	-5.19	0
b_7	-0.023	-0.32	0.374
c	0.06	0.24	0.405

adj. R2	F-test	p-value	lookback
0.606	106.32	0	481

Series	ADF	ADF-crit	KPSS	KPSS-crit	DW
Residuals	-12.374	-2.871	0.064	0.463	1.739
y	-14.122	-2.871	0.077	0.463	1.821
x_1	-6.133	-2.871	0.191	0.463	1.9
x_2	-8.859	-2.871	0.044	0.463	1.711
x_3	-15.185	-2.871	0.062	0.463	1.911
x_4	-12.473	-2.871	0.051	0.463	1.811
x_5	-15.271	-2.871	0.171	0.463	1.721
x_6	-14.502	-2.871	0.123	0.463	1.679
x_7	-13.772	-2.871	0.046	0.463	1.739

Regression

$$y_{fin}(t) = c + b_1x_1(t) + b_2x_2(t) + b_3x_3(t) + b_4x_4(t) + b_5x_5(t) + b_6x_6(t) + b_7x_7(t) + \varepsilon$$

For

i. Range: 30-Jun-2010 until 28 28-Jun-2013 (Days: 717)
ii. Itraxx Indices as per series 13

Regressors:

$x_1(t)$ is the daily change of the Itraxx Non financial index
$x_2(t)$ is the daily change in the Italian Basis
$x_3(t)$ is the daily change in the French Basis
$x_4(t)$ is the daily change in the Italy z-spread differential
$x_5(t)$ is the daily change in the Euribor – Eonia basis.
$x_6(t)$ is the daily change in the level of the EUR/USD Cross currency (tenor 5y)
$x_7(t)$ is the daily change in the France z-spread differential.

Parameter	Regression Result	t-test	p-value
b_1	0.015	22.71	0
b_2	0.064	2.7	0.004
b_3	0.159	3.6	0
b_4	0.018	0.73	0.232
b_5	-30.614	-1.59	0.056
b_6	-0.911	-5.83	0
b_7	-0.031	-0.88	0.189
c	0.078	0.41	0.341

adj. R2	F-test	p-value	lookback
0.632	176.61	0	717

Series	ADF	ADF-crit	KPSS	KPSS-crit	DW
Residuals	-15.104	-2.871	0.04	0.463	2.331
y	-17.041	-2.871	0.073	0.463	1.863
x_1	-7.555	-2.871	0.092	0.463	1.916
x_2	-17.295	-2.871	0.061	0.463	1.759
x_3	-17.933	-2.871	0.14	0.463	1.908
x_4	-15.901	-2.871	0.056	0.463	1.933
x_5	-19.258	-2.871	0.151	0.463	1.759
x_6	-17.63	-2.871	0.081	0.463	1.696
x_7	-20.174	-2.871	0.041	0.463	2.331

Regression

$$y_{fin}(t) = c + b_1x_1(t) + b_2x_2(t) + b_3x_3(t) + b_4x_4(t) + b_5x_5(t) + \varepsilon$$

For

i. Range: 30-Jun-2010 until 29-Jun-2012 (Days: 484)

ii. Itraxx Indices as per series 13

Regressors:

y_fin (t) is the daily change of the Itraxx Financial Senior

x_1 (t) is the daily change of the Itraxx Non financial index

x_2 (t) is the daily change in the French Basis

x_3 (t) is the daily change in the Euribor – Eonia basis.

x_4 (t) is the daily change in the level of the EUR/USD Cross currency (tenor 5y)

x_5 (t) is the daily change in the German Basis

Parameter	Regression Result	t-test	p-value
b_1	0.013	15.02	0
b_2	0.104	2.12	0.017
b_3	-9.021	-0.38	0.353
b_4	-0.933	-4.99	0
b_5	0.408	5.69	0
c	0.002	0.01	0.496
adj. R^2	F-test	p-value	lookback
0.638	171.19	0	484

Series	ADF	ADF-crit	KPSS	KPSS-crit	DW
Residuals	-12.248	-2.871	0.088	0.463	1.962
y	-14.013	-2.871	0.061	0.463	1.809
x_1	-6.119	-2.871	0.167	0.463	1.873
x_2	-15.451	-2.871	0.061	0.463	2.075
x_3	-15.31	-2.871	0.182	0.463	1.711
x_4	-14.491	-2.871	0.106	0.463	1.677
x_5	-14.519	-2.871	0.105	0.463	1.962

Regression

$$y_{fin}(t) = c + b_1x_1(t) + b_2x_2(t) + b_3x_3(t) + b_4x_4(t) + b_5x_5(t) + \varepsilon$$

For

i. Range: 30-Jun-2010 until 28-Jun-2013 (Days: 730)

ii. Itraxx Indices as per series 13

Regressors:

y_fin (t) is the daily change of the Itraxx Financial Senior

x_1 (t) is the daily change of the Itraxx Non financial index

x_2 (t) is the daily change in the French Basis

x_3 (t) is the daily change in the Euribor – Eonia basis.

x_4 (t) is the daily change in the level of the EUR/USD Cross currency (tenor 5y)

x_5 (t) is the daily change in the German Basis

Parameter	Regression Result	t-test	p-value
b_1	0.014	20.76	0
b_2	0.108	2.67	0.004
b_3	-14.827	-0.78	0.217
b_4	-0.846	-5.54	0
b_5	0.329	5.74	0
c	0.079	0.43	0.333
adj. R^2	F-test	p-value	lookback
0.646	267.26	0	730

Series	ADF	ADF-crit	KPSS	KPSS-crit	DW
Residuals	-15.313	-2.871	0.042	0.463	2.038
y	-17.091	-2.871	0.074	0.463	1.864
x_1	-7.755	-2.871	0.092	0.463	1.9
x_2	-18.106	-2.871	0.146	0.463	2.057
x_3	-19.429	-2.871	0.149	0.463	1.746
x_4	-17.97	-2.871	0.08	0.463	1.696
x_5	-17.316	-2.871	0.201	0.463	2.038

Composition of the Itraxx Financial senior

As mentioned above the Itraxx Financial senior is a simple average across a number of CDS levels. Such average is determined with equal weights and the CDS names (reference entities) composing such average are:

	Issuer
1	Aegon N.V.
2	Allianz SE
3	ASSICURAZIONI GENERA
4	AVIVA PLC
5	AXA
6	BANCA MONTE DEI PASC
7	BANCO BILBAO VIZCAYA
8	BANCO POPOLARE
9	BANCO SANTANDER, S.A
10	BARCLAYS BANK PLC
11	BNP PARIBAS
12	COMMERZBANK
13	CREDIT AGRICOLE SA
14	Credit Suisse Group
15	DEUTSCHE BANK
16	Hannover Rueckversicherung AG
17	Intesa San Paolo
18	LLOYDS TSB BANK PLC
19	Muenchener Rueckversicherungs-Ges. AG
20	SOCIETE GENERALE
21	Swiss Reinsurance Company
22	The Royal Bank of Scotlan
23	UBS AG
24	UNICREDIT, SOCIETA P
25	Zurich Insurance Company

Composition of the Itraxx Main

As mentioned above the Itraxx Main Europe is a simple average across a number of CDS levels. Such average is determined with equal weights; the CDS names (reference entities) composing such average are (series 9):

1)	Accor SA	43)	Dixons Retail PLC	85)	Reed Elsevier PLC
2)	Aegon NV	44)	E.ON SE	86)	Renault SA
3)	Electrolux AB	45)	EDP - Energias de Portugal SA	87)	Rentokil Initial PLC
4)	Volvo AB	46)	Electricite de France SA	88)	Repsol SA
5)	Akzo Nobel NV	47)	EnBW Energie Baden-Wuerttemberg AG	89)	Thomson Reuters UK Ltd
6)	Allianz SE	48)	Endesa SA	90)	RWE AG
7)	ArcelorMittal Finance SCA	49)	Enel SpA	91)	Safeway Ltd
8)	Assicurazioni Generali SpA	50)	European Aeronautic Defence and Space Co NV	92)	Sanofi
9)	Aviva PLC	51)	Experian Finance PLC	93)	Siemens AG
10)	AXA SA	52)	Finmeccanica SpA	94)	Societe Generale SA
11)	Banca Monte dei Paschi di Siena SpA	53)	Fortum OYJ	95)	Sodexo
12)	Banco Bilbao Vizcaya Argentaria SA	54)	Orange SA	96)	STMicroelectronics NV
13)	Banco Espirito Santo SA	55)	Gas Natural SDG SA	97)	Suedzucker AG
14)	Banco Santander SA	56)	GDF Suez	98)	Svenska Cellulosa AB
15)	Bank of Scotland PLC	57)	GKN Holdings PLC	99)	Swiss Reinsurance Co Ltd
16)	Barclays Bank PLC	58)	Glencore International AG	100)	Tate & Lyle PLC
17)	BASF SE	59)	Groupe Auchan SA	101)	Telecom Italia SpA
18)	Bayer AG	60)	Danone SA	102)	Telefonica SA
19)	Bayerische Motoren Werke AG	61)	Hannover Rueck SE	103)	Telekom Austria AG
20)	Bertelsmann SE & Co KGaA	62)	Hellenic Telecommunications Organization SA	104)	Telenor ASA
21)	BNP Paribas SA	63)	Henkel AG & Co KGaA	105)	TeliaSonera AB
22)	British American Tobacco PLC	64)	Iberdrola SA	106)	Tesco PLC
23)	British Telecommunications PLC	65)	Intesa Sanpaolo SpA	107)	Royal Bank of Scotland PLC/The
24)	Cadbury Ltd	66)	J Sainsbury PLC	108)	ThyssenKrupp AG
25)	Carrefour SA	67)	JTI UK Finance PLC	109)	PostNL NV
26)	Casino Guichard Perrachon SA	68)	Kelda Group Ltd	110)	UBS AG
27)	Centrica PLC	69)	Koninklijke DSM NV	111)	UniCredit SpA
28)	Ciba Holding AG	70)	Koninklijke KPN NV	112)	Unilever NV
29)	Clariant AG	71)	Koninklijke Philips NV	113)	Union Fenosa SA
30)	Commerzbank AG	72)	Lafarge SA	114)	United Utilities PLC
31)	Cie de St-Gobain	73)	Linde AG	115)	Valeo SA
32)	Cie Financiere Michelin SCA	74)	LVMH Moet Hennessy Louis Vuitton SA	116)	Vattenfall AB
33)	Compass Group PLC	75)	Marks & Spencer PLC	117)	Veolia Environnement SA
34)	Continental AG	76)	Metro AG	118)	Vinci SA
35)	Credit Agricole SA	77)	Muenchener Rueckversicherungs AG	119)	Vivendi SA
36)	Credit Suisse Group AG	78)	National Grid PLC	120)	Vodafone Group PLC
37)	Daimler AG	79)	Nestle SA	121)	Volkswagen AG
38)	Deutsche Bank AG	80)	Next PLC	122)	Wolters Kluwer NV
39)	Deutsche Lufthansa AG	81)	Pearson PLC	123)	WPP 2005 Ltd
40)	Deutsche Post AG	82)	Peugeot SA	124)	Zurich Insurance Co Ltd
41)	Deutsche Telekom AG	83)	Portugal Telecom International Finance BV	125)	GDF Suez
42)	Diageo PLC	84)	Kering		

As mentioned above the Itraxx Main Europe is a simple average across a number of CDS levels. Such average is determined with equal weights; the CDS names (reference entities) composing such average are (series 13):

1)	Adecco SA	43)	Diageo PLC	85)	Publicis Groupe SA
2)	Aegon NV	44)	E.ON SE	86)	Reed Elsevier PLC
3)	Akzo Nobel NV	45)	Edison SpA	87)	Repsol SA
4)	Allianz SE	46)	EDP - Energias de Portugal SA	88)	Rolls-Royce PLC
5)	Alstom SA	47)	Electricite de France SA	89)	RWE AG
6)	Anglo American PLC	48)	EnBW Energie Baden-Wuerttemberg AG	90)	SABMiller PLC
7)	ArcelorMittal	49)	Enel SpA	91)	Safeway Ltd
8)	Assicurazioni Generali SpA	50)	European Aeronautic Defence and Space Co NV	92)	Sanofi
9)	Aviva PLC	51)	Experian Finance PLC	93)	Siemens AG
10)	AXA SA	52)	Finmeccanica SpA	94)	Societe Generale SA
11)	BAE Systems PLC	53)	Fortum OYJ	95)	Sodexo
12)	Banca Monte dei Paschi di Siena SpA	54)	Orange SA	96)	Solvay SA
13)	Banco Bilbao Vizcaya Argentaria SA	55)	Gas Natural SDG SA	97)	STMicroelectronics NV
14)	Banco Espirito Santo SA	56)	GDF Suez	98)	Suedzucker AG
15)	Banco Santander SA	57)	Glencore International AG	99)	Svenska Cellulosa AB
16)	Bank of Scotland PLC	58)	Groupe Auchan SA	100)	Swedish Match AB
17)	Barclays Bank PLC	59)	Hannover Rueck SE	101)	Swiss Reinsurance Co Ltd
18)	BASF SE	60)	Hellenic Telecommunications Organization SA	102)	Technip SA
19)	Bayer AG	61)	Henkel AG & Co KGaA	103)	Telecom Italia SpA
20)	Bayerische Motoren Werke AG	62)	Holcim Ltd	104)	Telefonica SA
21)	Bertelsmann SE & Co KGaA	63)	Iberdrola SA	105)	Telekom Austria AG
22)	BNP Paribas SA	64)	Imperial Tobacco Group PLC	106)	Telenor ASA
23)	Bouygues SA	65)	Intesa Sanpaolo SpA	107)	TeliaSonera AB
24)	BP PLC	66)	J Sainsbury PLC	108)	Tesco PLC
25)	British American Tobacco PLC	67)	JTI UK Finance PLC	109)	Royal Bank of Scotland PLC/The
26)	British Telecommunications PLC	68)	Koninklijke Ahold NV	110)	PostNL NV
27)	Cadbury Holdings Ltd	69)	Koninklijke DSM NV	111)	Total SA
28)	Carrefour SA	70)	Koninklijke KPN NV	112)	UBS AG
29)	Casino Guichard Perrachon SA	71)	Koninklijke Philips NV	113)	UniCredit SpA
30)	Centrica PLC	72)	Air Liquide SA	114)	Unilever NV
31)	Commerzbank AG	73)	LANXESS AG	115)	United Utilities PLC
32)	Cie de St-Gobain	74)	Linde AG	116)	Vattenfall AB
33)	Cie Financiere Michelin SCA	75)	LVMH Moet Hennessy Louis Vuitton SA	117)	Veolia Environnement SA
34)	Compass Group PLC	76)	Marks & Spencer PLC	118)	Vinci SA
35)	Credit Agricole SA	77)	Metro AG	119)	Vivendi SA
36)	Credit Suisse Group AG	78)	Muenchener Rueckversicherungs AG	120)	Vodafone Group PLC
37)	Daimler AG	79)	National Grid PLC	121)	Volkswagen AG
38)	Danone SA	80)	Nestle SA	122)	Wolters Kluwer NV
39)	Deutsche Bahn AG	81)	Next PLC	123)	WPP 2005 Ltd
40)	Deutsche Bank AG	82)	Pearson PLC	124)	Xstrata Ltd
41)	Deutsche Post AG	83)	Portugal Telecom International Finance BV	125)	Zurich Insurance Co Ltd
42)	Deutsche Telekom AG	84)	Kering		

A glance to the evolution of monetary aggregates

If this section we propose a reading of the implications of a transmission mechanism failing to transmit accommodative monetary inputs: in spite of a central bank injecting liquidity in the system, the banking system does not expand credit to the economy: as a result the correlation between growth of different monetary aggregates decreases during financially turbulent times. The picture below shows the evolution of the rate of growth of the aggregate M1(white line), M2 (red line), M3(yellow line) and inflation in Euro Area (green line)[28]. In this case we only have monthly data, hence we will not explore the time series of these aggregates in length. It is important to note that before the financial crisis, until 2006, the aggregates had a decent correlation, higher than 2008, when the European central bank intervenes with a growth of M1 rarely experienced before, yet not accompanied by a similar evolution of M2 or M3. Surprisingly the growth of M3 is below the rate of inflation (green line), which means that it is growing in nominal terms, but shrinking in real terms.

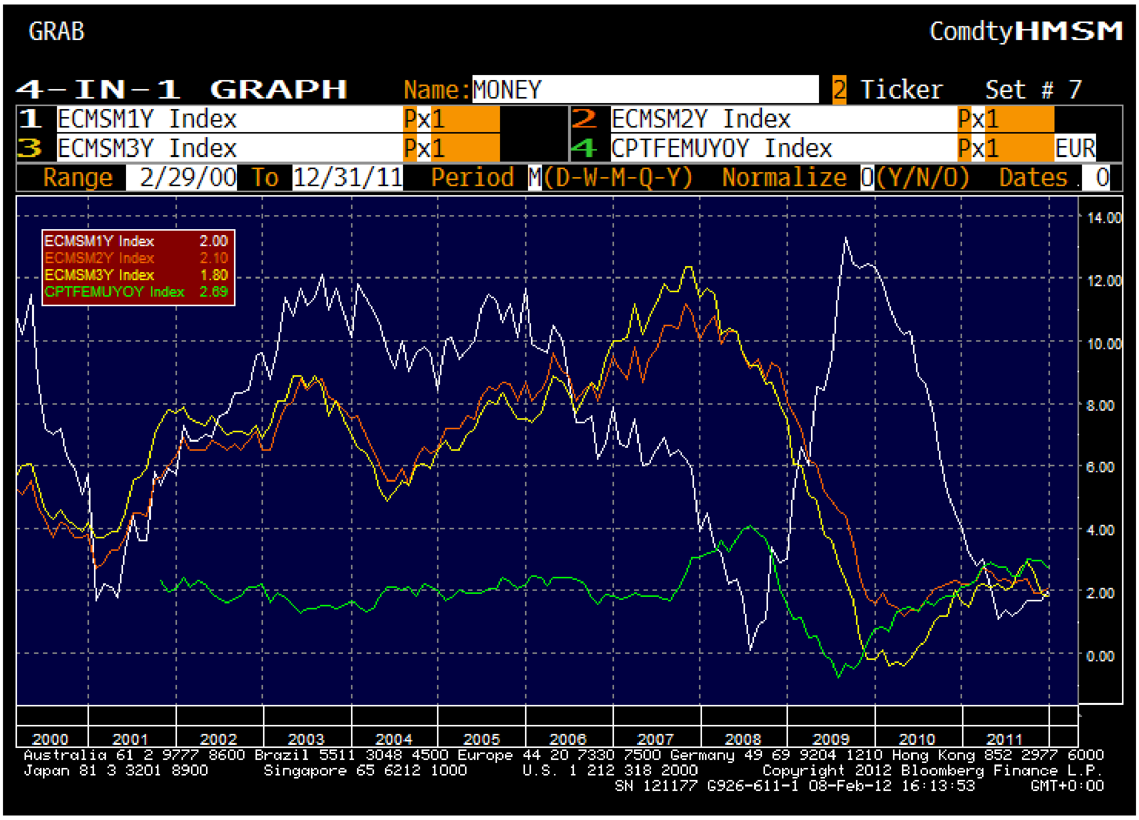


FIGURE 3: EVOLUTION OF MONETARY AGGREGATES THROUGH TIME.

[28] Source: Bloomberg

The effort to inject liquidity is not only represented by the effort of central banks considered individually in their monetary policy management: an example is the joint monetary policy intervention as described below by the press release available on the web site of all central banks on the 30th of November 2011 (below an extract of what published by the Board of Governors of the Federal reserve System[29]):

The Bank of Canada, the Bank of England, the Bank of Japan, the European Central Bank, the Federal Reserve, and the Swiss National Bank are today announcing coordinated actions to enhance their capacity to provide liquidity support to the global financial system. The purpose of these actions is to ease strains in financial markets and thereby mitigate the effects of such strains on the supply of credit to households and businesses and so help foster economic activity.

These central banks have agreed to lower the pricing on the existing temporary U.S. dollar liquidity swap arrangements by 50 basis points so that the new rate will be the U.S. dollar overnight index swap (OIS) rate plus 50 basis points. This pricing will be applied to all operations conducted from December 5, 2011. The authorization of these swap arrangements has been extended to February 1, 2013. In addition, the Bank of England, the Bank of Japan, the European Central Bank, and the Swiss National Bank will continue to offer three-month tenders until further notice.

As a contingency measure, these central banks have also agreed to establish temporary bilateral liquidity swap arrangements so that liquidity can be provided in each jurisdiction in any of their currencies should market conditions so warrant. At present, there is no need to offer liquidity in non-domestic currencies other than the U.S. dollar, but the central banks judge it prudent to make the necessary arrangements so that liquidity support operations could be put into place quickly should the need arise. These swap lines are authorized through February 1, 2013.

[29] Available in its entire content at http://www.federalreserve.gov/newsevents/press/monetary/20111130a.htm

References

1 ACharya, V., I.Drechsler and P. Schnabl, “A Pyrrhic Victory? - Bank Bailouts and Sovereign Credit Risk,” NBER Working Paper Series (2011).

2 Acharya V. - Gale D. - Yorulmazer T. (2009), Rollover risk and market freezes, FRB of New York, mimeo.

3 Bolton, Patrick and Olivier Jeanne, 2011, \Sovereign Default Risk and Bank Fragility in Financially Integrated Economies," NBER Working Paper 16899

4 Blanco R., S. Brennan and I.W. Marsh (2005) An empirical analysis of the dynamic relationship between investment-grade bonds and credit default swaps. Journal of Finance 60, 2255 - 2281.

5 Brunnermeier M. (2009), Deciphering the liquidity and credit crunch 2007-2008, Journal of Economic Perspectives, 23(1), 77-100.

6 Collin-Dufresne P., R. Goldstein and J. S. Martin (2001) The Determinants of Credit Spread Changes.

7 Demirguc-Kunt, Asli and Harry Huizinga, 2010, "Are Banks Too Big to Fail or Too Big to Save? International Evidence from Equity Prices and CDS Spreads", World Bank Policy Research Working Paper 5360.

8 Diamond, Douglas and Raghuram G. Rajan, 2005, "Liquidity Shortages and Banking Crises", Journal of Finance, 60(2), 615{647.

9 Dieckmann, Stephan and Thomas Plank, 2009, "Default Risk of Advanced Economies: An Empirical Analysis of Credit Default Swaps during the Financial Crisis", Working Paper, Wharton School of Business, University of Pennsylvania.

10 Drehmann M. - Nikolaou K. (2009), Funding liquidity risk. Definition and measurement, ECB Working Paper no.1024

11 ECB (2008), The Eurosystem’s open market operations during the recent period of financial market volatility, Monthly Bulletin, May.

12 "European Central Bank (2009b). The Impact of Government Support to the Banking Sector on Euro Area Public Finances. In ECB Monthly Bulletin July 2009 , pages 63–74. "

13 Ejsing, J. W. & Lemke, W. (2009). The janus–headed salvation. European Central Bank Working Paper Series.

14 Ericsson, J., K. Jacobs, and R. Oviedo, 2009, \The Determinants of Credit Default Swap Premia," Journal of Financial and Quantitative Analysis, 44, 109{132.

15 Fontana, A. and M.Scheiche, "An Analysis of Euro Area Sovereign CDS and Their Relation with Government Bond," ECB Working Paper (2010).

16 Lenza, Pill, Reichlin, "Monetary Policy In Exceptional Times" ECB Working Paper (2010).

CHAPTER 2:
RISK MANAGEMENT AND CAPITAL STRUCTURE TESTING WITH LIMITED INFORMATION

Introduction

The previous chapter presents a simple multi-period model representing the refinancing risk posed by the maturity gap existing between assets and liabilities. This is only one of the risks to be managed within the functioning of a bank. In this chapter we aim at extending the analysis to multiple risks, with no prior categorization, in a context of limited information.

Limited information derives from acknowledging that the assets are not observable in their evolution of value, not only due to non liquid market for each asset contained within the balance sheet, but also due to their representation via accounting rules, which may differ from a logic of "market price".

We will necessarily ignore a number of assets/ variables specific of one bank only and assume the existence on balance sheet of a number of liquid variables whose values can be monitored daily.

This approach entails a risk management ignoring idiosyncratic factors and we will further summarize the liquid variables via principal component analysis. Being these liquid variables exchanged in financial market, this work opens a methodological separation between market and idiosyncratic risk management. We will deal only with the first one.

The question stemming from this approach relates to how much relevant data is missed when a risk management skips the idiosyncratic information of a balance sheet: that depends on the period under observation, since within a certain timeframe market events may prevail on idiosyncratic variables; on some other occasions the main risk is represented by variables specific to each bank. In the former case, then, market variable represent the bulk of the risk, whereas in the latter case market variables may represent only a minor portion of the risk to manage.

For these reasons this approach to risk management may reveal powerful during periods of financial turbulence, strongly affecting the banking sector, like the financial crisis unfolding in the years 2008-2012.

In the awareness of the incomplete set of information adopted in the sample, next chapter will investigate how much explanatory power a risk management derived from market variables may have on the actual liabilities of the bank.

If market variables have a good explanatory value on the liabilities of a sample of banks, then we are effectively dealing with the concept of Systemic risk. If the banking sector is well represented by a selected sample of banks, then the possibility to explain the evolution of their liabilities via the same market variables suggests that such variables provide the starting point for defining a risk shared by all banks, hence systemic. Such analysis will be presented in next chapter which will also propose a transmission mechanism for systemic risk.

This chapter ultimately defines a risk management method and analyses how the risk of the assets is translated into volatility of the liabilities; therefore it must stand the test of the past literature which emphasized many flaws of risk management, especially in light of the current financial crisis. Therefore such new risk management has to prove robust to a number of questions, briefly mentioned below.

What is the role of accounting in banks' risk management? Could accounting distort management from choices which add economic value in favor of others that preserve accounting value as represented by Financials?

Are risk weights a satisfactory measure of risk on balance sheets? Is it methodologically valid to associate a risk weight to one asset, independently from the composition of the balance sheet?

These questions are at the heart of the topics under debate during current financial crisis. They also summarize most of the criticism towards risk management as implemented in current days. Hence in proposing a new method of risk managing the bank, the author cannot avoid acknowledging these questions: they represent a strong test to make sure that the foundations of this Risk management method does not fall back into the flaws that literature has already identified.

This work will be based on an empirical approach, with extensive use of the statistical tool of Principal Component Analysis.

Literature on the Topic

Literature on Risk Management may be divided into various strands, to be distinguished by content and chronologically.

Especially before the inception of the 2008 crisis, the most relevant contributions on the theme of risk management had its theoretical foundations commonly associated with the names of Markovitz, Sharpe, Fama, Samuelson. We deem redundant to describe the theories of Efficient Markets, CAPM and Portfolio Selection; they compose the "Modern Portfolio Theory".

Mainly after the inception of the latest financial crisis, a second strand of the related literature has analyzed what went wrong in risk management and in its theoretical foundations, both from a theoretical and regulatory point of view. The most recurrent theme is the difficulty of dealing with Tail events, or "Black swans", in the metaphor of Nassim Nicholas Taleb. He also mentions, among others, the usage of quantitative risk methods (Var) over heuristic methods; and the lack of accountability of the individuals involved in risk-bearing. A different approach in reviewing the flaws of risk management emphasizes the role of systemic risk; Lehar (June 2003) uses stock market information and estimates the joint dynamics of banks' asset portfolios for a sample of international banks: via a Monte Carlo simulations the author estimates the joint probability of default of banks within the sample. Acharya, Pedersen Philippon and Richardson (May 2010) present a model to quantify systemic risk where the contribution of a financial institution is measured via its Systemic Expected Shortfall, i.e. the event of being undercapitalized when the whole system is undercapitalized: the authors propose a taxation based on such measure so that such externality is internalized within the financial institution. Modelling systemic risk has proved a challenge for academia and practitioners: Bisas, Flood, Lo and Valavanis produce

"A Survey of Systemic Risk Analytics", thus providing an analysis of 31 quantitative measures of systemic risk in the economics and finance Literature. We will analyze this particular branch of the literature and its number of quantitative measures of systemic risk in next chapter, specifically dedicated to the philosophy, definition and state of the art relating to the fascinating topic of systemic risk. The author has opted for postponing the discussion on this literature since presenting first the risk management model will help in emphasizing the conceptual differences and novelties compared to the systemic risk analytics already established by the most relevant authors on the theme.

Risk management and Capital Management for banks are highly regulated fields: hence a third strand of literature analyzes the content of the regulatory innovations known as "Basel III". As a result, Risk Management and Capital Management have adopted rules of accounting and have implemented International Financial Reporting Standards as per regulator's requirements. Also, in the definition of capital and liquidity requirements the new Basel III regime is imposing criteria and addressing specific guidelines on composition of assets and liabilities. The result is that capital management becomes the tool to be compliant with the new regime, described in the document: "Basel III: A global regulatory framework for more resilient banks and banking systems". A field of research focuses on how Basel III plays a role in risk assessment, measurement and how it affects banks' and customers' portfolio selection and performance. Iannotta and Pennacchi investigate on the form of moral hazard where the current framework of Capital required for investments may lead banks to take excessive systematic risk. Some literature focuses on the flaws of such regulatory approach: Carmassi and Micossi (2012, CEPS) emphasize that Basel solvency ratios are not easy to read, fail to identify weak banks and fail to take account of systemic risk. This work contributes on this point by proposing a new definition of Risk weights, fully deduced by the introduction of a new concept of Risk Management. Within the new definition of regulatory capital the literature produces examples of alternative securities candidates for the purpose of being admissible in the "Additional Tier 1 Capital" as per Basel III approach: Pennacchi introduces, analyzes and values a new form of contingent convertible: COERC (Call Option Enhanced Reversed Convertible). This work contributes in this particular aspect by defining a new methodology to define capital shortage:

based on that next chapter will derive a proposal for subordinated debt. On the theme of Liquidity the publications range from regulators' opinions (Tarantola, 2008) to models of Liquidity Risk Management (Brunnermeier and Yogo, 2009) proposing a model of liquidity risk management in which a firm is subject to rollover risk.

A forth strand of literature elaborates on the principles to be respected for laying the foundations of a more mature Risk Management: Golub and Crum list and describe in detail eight lessons from the credit Crisis. Via a more quantitative approach Attilio Meucci (2011) presents the Prayer, a recipe of ten sequential steps for the risk management of portfolios with no restrictions in terms of asset classes allocation and investment horizons.

This and the following chapter are closely related, hence a list of references for the main contribution on the theme will be at the end of the two sections.

Market Variables and Idiosyncratic Variables

Different accounting rules applied to the various balance sheet items of a Bank make the estimate of the value of assets a challenging task. A sum over the balance sheet values of the assets would produce a biased estimate of the total assets with respect to the value estimated by financial markets: recent years have shown that only a small portion of the tangible book is reflected in the stock price of a bank.

Hence, we will introduce some assumptions on the assets of a bank. The focus of this work is not so much to estimate the absolute levels, but the variation in time: an effective risk management needs at its foundations a model that can well describe the evolution in time of the assets.

This work assumes that the assets of a bank may be split into 2 categories: market variables (*MV*) and idiosyncratic variables (*IV*). We will assume that the latter are independent from the former. The main difference between these 2 categories is that the latter are not observable with daily frequency and and in most cases are known only to the management of the bank. In light of the aim of this work, proposing a framework to risk manage (with limited information) the risk of the assets, we will focus on the Market variables (*MV*). In our assumptions, once we denote the assets by *A,*

11 $$A = MV + IV$$

The market variables assumed to be on balance sheet for a sample of European banks will be presented below; the author prefers to comment on each to share the rationale for their choice.

One of the most difficult items to estimate in a bank's balance sheet is the portfolio of credit granted by the bank: its illiquidity justifies the difficulty to evaluate such portfolio. The bank holds the credit until maturity and monitors the quality of the borrower with specific knowledge of the customer. If there are no arrear payments the bank will mark the credit at face value and, regardless of the evolution in credit market, its price will not change. Such balance sheet price may substantially differ from the purchasing price given by a third party, which instead will reflect, among other factors, the probability of insolvency and the general market appetite for credit portfolios. Granting credit to the economy is the core activity for a bank, hence we may expect that this illiquid portfolio represents the main portion of the banks' investments. We may consider 3 main categories when defining the portfolio of credit: residential mortgages, commercial credit (performing) and non performing credit.

Residential Mortgages and government risk: Although prices for mortgages portfolio are not liquid, prices for bond issued by banks and guaranteed by mortgage portfolios (covered bonds) are instead quoted by the market. Whereas a bond issued by any financial institution is priced according to the credit quality of the issuer and with respect to the secondary market price of an existing (and similar) bond previously issued, such reasoning does not apply to Covered Bonds. Covered Bonds[30] are indeed backed by (mainly) residential mortgages, which ultimately guarantee for interest payments and redemptions in case the bank is no longer solvent. Covered bonds are priced as a spread versus the most

[30] An exhaustive definition of covered bonds is beyond the scope of this work and we invite the reader to explore the number of publications on the topic. In essence Covered Bonds are bonds issued by the bank and guaranteed by a pool of segregated residential mortgages. Such guarantee is a credit quality enhancement: hence market prices covered bonds for similar maturities with a premium (positive or negative) to government securities (benchmark).

liquid benchmark for debt in their own jurisdiction: government bonds of similar maturity. The purchase of a covered bond exposes to the credit worthiness of the covered pool of residential mortgages, dynamically replenished when defaults and redemptions cause a value reduction. Indeed covered bond over-collateralize the nominal value (i.e the amount to redeem) by Prime residential mortgages: this is why pricing primarily reflects the risk of the covered pool of assets, more than the risk of the issuer. Covered Bonds trade at a variable spread with respect to government bonds; hence their variation in value can be decomposed into

a) Variation of the yield of the government bond for similar maturity
b) Variation of the credit spread of the covered bond with respect to the credit spread of the government bond adopted as "benchmark"

In light of this reasoning, yield of Residential mortgages will be approximated by the yield of government securities (for the same country where mortgages are granted). We will therefore, for simplicity reasons, neglect point (b) above. Although these assumptions may be disputable, the author considers them not misleading for the purpose of modelling daily variations of value. Hence we introduce the following assumption:

Government and residential mortgages risk will be represented by the yields of the main European sovereign issuers (European since the method here proposed will be applied to data for European banks in next chapter), for maturity of 4.5 years:

i. Yield of government bonds issued by Germany (Denoted as 4.5Y Smooth GER)
ii. Yield of government bonds issued by Italy (Denoted as 4.5Y Smooth ITL)
iii. Yield of government bonds issued by Spain (Denoted as 4.5Y Smooth ESP)

Once we have represented the portion of assets allocated into government risk and Mortgages, remaining assets may be represented as a diversified pool of credits. We will make use of very liquid indices belonging to the Itraxx family, in order to obtain proxies for a diversified portfolio of (performing) credit. We will also insert proxies for not performing credit, although the author acknowledges that the actual composition of the bank's credit portfolio may be more concentrated than these indices, depending upon the expertise and the knowhow of the bank in lending to particular sectors and regions of the economy.

Credit Risk: We will then represent the market variables component of the credit portfolio of a bank by adopting diversified indices of CDS, the Itraxx Main Europe and Itraxx Crossover. The reason for such choice of representation is that once we exclude mortgages, government bonds and Cash, the remaining portion of assets is allocated into a diversified portfolio of credit. The latter will be performing for its main portion and a subset will instead deteriorate in its credit quality. Hence the performing portion of credit will be approximated by Itraxx Main Europe, which by definition comprises 125 equally weighted credit default swaps on investment grade European corporate entities (the composition and description will be in the appendix). We approximate the non performing portfolio with the Markit iTraxx Europe Crossover index since it comprises 50 equally weighted credit default swaps on the most liquid sub-investment grade European corporate entities.

Exposure towards the banking sector: we will also represent the exposure a bank may have towards the banking sector via the liquid index Itraxx Financial Senior, which includes 25 liquid CDS levels with reference entities European financial institutions (more detail in the appendix). Similarly, we will select one more variable representing the exposure towards the subordinated financial debt: not only may some investments be allocated on subordinated debt, but a representation of the risks on the asset side should include at least two layers of the banking sector capital structure. The subordinated debt liquid variable will be represented by the Itraxx Financial Sub Index, which is composed by the same reference entities as the Itraxx Financial Senior; with the difference that the reference obligations are Subordinated bonds, rather than senior ones.

Interest Rate risk: We will also add to the variables swap rates (with 10 years tenor, having as underlying the floating parameter Euribor and Eonia) in order to introduce pure interest rate risk in the sample.

The table below summarizes the choice of market variables assumed to be on balance sheet (and the risk they represent); we will denote such liquid variables as v_i, for $i= 1,2,..,9.$

TABLE 2: LIQUID VARIABLES TO BE ANALYZED VIA PRINCIPAL COMPONENT ANALYSIS

Liquid Variable	Representing
Variable1: Swap EONIA 10Y (Yield in %)	Interest Rate Risk
Variable2: Swap EUR6M 10Y (Yield in %)	Interest Rate Risk
Variable3: 4.5Y Smooth GER (Yield in %)	Government risk and Mortgage risk
Variable4: 4.5Y Smooth ESP (Yield in %)	Government risk and Mortgage risk
Variable5: 4.5Y Smooth ITL (Yield in %)	Government risk and Mortgage risk
Variable6: iTraxx Euro S12-Financial Senior (5 Year CDS in %)	Senior Credits towards the Banking System
Variable7: iTraxx Euro S12-Financial Sub (5 Year CDS in %)	Subordinated exposure towards the Banking System
Variable8: iTraxx Euro S12 Main (5 Year CDS in %)	Performing Credit
Variable9: iTraxx Euro S12 Crossover (5 Year CDS in %)	Not performing Credit

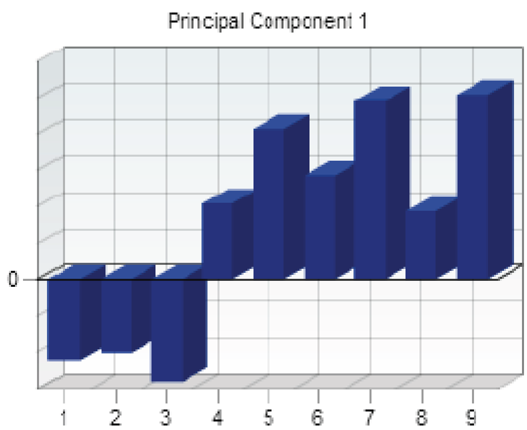
PCA Risk Management Applied to Market Variables

We will analyze this set of variables to investigate, under a principal component analysis, the definition of risk. In other words, when dealing with so many variables the bank would run risk suboptimally if it ignored the correlation across such portfolio and if it contemplated managing risks one by one. Principal component analysis defines, from historical data, the principal factors of risks explaining most of the variance of the assets. We will denote such Principal Components of Risk as PCR.

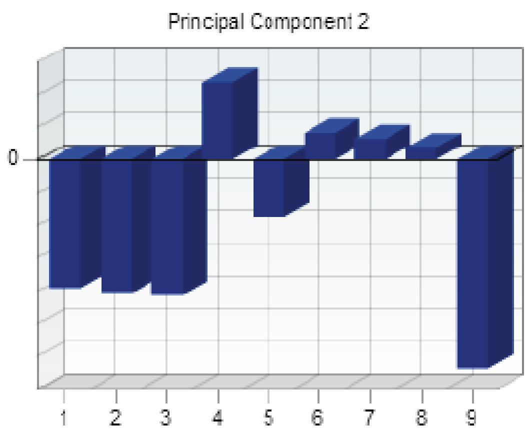
The principal component analysis run on 2 years of data[31] shows that the variables may be summarized in only 3 principal components, for the representation of a significant part of the sample variation. In particular, we report below the composition of the first 2 principal components and the percentage of the sample variance associated to each principal component.

PCA run on a 2y window
Range: 25-Oct-2010--19-Oct-2012 (Days:492)
Analysis Date: 19-Oct-2012
Explained Variance
Factor1: 66 %
Factor2: 20.6 %
Factor3: 9.65 %

[31] The source of this data is Bloomberg for the first 5 variables and the Markit database.



Loadings:								
-0.223	-0.204	-0.28	0.208	0.414	0.285	0.492	0.186	0.508



Loadings:								
-0.391	-0.408	-0.416	0.237	-0.177	0.083	0.064	0.036	-0.639

FIGURE 4: LOADINGS OF THE FIRST 2 PRINCIPAL COMPONENTS FOR A PCA RUN ON 492 DAYS

From the results of the principal component analysis we then define the principal components of risk (PCR):

12

$$PCR_1 = \sum_{i=1}^{9} \alpha_1 (i) v_i$$

$$PCR_2 = \sum_{i=1}^{9} \alpha_2 (i) v_i$$

$$PCR_3 = \sum_{i=1}^{9} \alpha_3\,(i) v_i$$

We will report a more detailed analysis in the appendix; α(i) represents the loading of each variable v(i) in the definition of PCR. The loadings are summarized in the picture above and in the table below:

TABLE 3: WEIGHTS DEFINING THE PRINCIPAL COMPONENTS OF RIKS (OCT 2010-2012)

Explained Variance	PCR 1: 66 %	PCR 2: 20.6 %
Variable1: Swap EONIA 10Y (Yield in %)	-0.223	-0.391
Variable2: Swap EUR6M 10Y (Yield in %)	-0.204	-0.408
Variable3: 4.5Y Smooth GER (Yield in %)	-0.28	-0.416
Variable4: 4.5Y Smooth ESP (Yield in %)	0.208	0.237
Variable5: 4.5Y Smooth ITL (Yield in %)	0.414	-0.177
Variable6: iTraxx Euro S12-Financial Senior (5 Year CDS in %)	0.285	0.083
Variable7: iTraxx Euro S12-Financial Sub (5 Year CDS in %)	0.492	0.064
Variable8: iTraxx Euro S12 Main (5 Year CDS in %)	0.186	0.036
Variable9: iTraxx Euro S12 Crossover (5 Year CDS in %)	0.508	-0.639

Interpreting PCR and Implications for Risk Management

PCR stands for principal component of risk; the results above suggest that 86% of the movements realized over 2 years may be summarized by a risk manager only by 2 principal components (linear combination of the variables listed above). From the sign of the weights we may understand from a risk decomposition perspective which variables move together; the absolute magnitude of the loading factor signals the importance of the variable for the purpose of the definition of the Principal Component of Risk. Principal component 1 emphasizes that the world sees a strong correlation across the world of credit and government yields other than German government risk. The first principal component (PCR1) may be summarized as a "Credit versus the joint movement of Rates and German yields", since rates and German government bonds move in the opposite directions if compared to all other variables. In a second scenario, recurring less frequently (principal component 2) and independently (statistically, from PCR1) the index Crossover behaves differently from what described in the first PCR: its level may decrease while the yield of Spain may increase.

The risk manager can then reduce the number of variables to manage from 9 to 3: this reduction in the number of variables leads to a negligible loss of sample variance. Principal Components are independent, which allows the risk manager to address them separately.

Next question relates to capital structure: who bears all the variance produced by the portfolio of assets? How is it distributed across equity and debt? Can volatility of the assets explain the volatility of equity? We will explore the theme of capital structure below, when running specific econometric assessments on PCR based on a sample of European banks.

Every bank may consider adding to this framework all the relevant (idiosyncratic) information that would make the analysis more specific when approximating the market value of the assets of the specific bank.

It is immediate to identify the bold differences between a regulatory and a PCA Approach: the first defines the risk factors and their relevance by the adoption of Risk Weights. Principal Component Analysis analyzes the behavior of assets and provides fewer risk factors: it then restricts the attention from a plethora of variables to very few.

Leverage or deleverage policies can then be implemented by looking at risk factors primarily. Deleverage is ultimately a reduction on Balance Sheet Variance: being the latter explained in terms of PCR, deleverage ultimately can be rephrased as the reduction of exposure to PCR. Thus deleverage can also be achieved if financial markets quote derivatives on (some of) the principal factors identified by PCA. We will introduce in next chapter a specific example on how to originate a new set of liabilities with the purpose to reduce balance sheet variance.

The rationale leading this work is quite simple: we introduce assumptions on some assets on a bank's balance sheet. We then run a Principal component analysis and derive that the extraordinary volatility experienced in recent years can be decomposed into few principal factors; we will also derive that such factors also have a strong explanatory power on CDS[32] and equity levels.

We will then derive that an observable variable, CDS of financial issuers, is much more than a mere derivative contract quoted by the market: its variance may be linked to the volatility of assets, even for the portion not disclosed by published financials.

CDS and balance sheet variance[33] will prove central in the definition of risk management of the bank; standard balance sheet representation of the bank avails itself of a realized set of costs and revenues. We are then facing two opposite approaches: accounting well reflects the status quo, or, better, the past status, i.e. what occurred; financial markets instead require an assessment on balance sheet soundness for the future and in relation to the turbulent times we have experienced in the years 2009-2012. The appendix also contains the results of the PCA when a shorter sample is considered and an economic intuition of such results; furthermore the appendix analyzes if a change in the sample produces major changes in the definition of Principal Components of Risk.

Capital Management (Regulatory Approach) and Implications for Risk Management

Management faces then a decision: a volatile world requires active balance sheet management especially in the format of Variance management: the number of stress tests taking place during the financial crisis is the demonstration that the market needs reassurance on the balance sheet strength of the banking sector. If it is immediate to agree upon the need of managing risk, it is not so trivial to choose a model of risk management.

In particular, when financial markets question balance sheet strength, the reply is often addressed in regulatory terms showing what would happen to Core Tier 1 Ratio under certain assumptions of stress test. Addressing balance sheet

[32] When referring to CDS and equity level, we will consider the CDS and the stock price of the bank running risk management. When instead we refer to CDS of other reference entities we will be explicit or refer to indices.
[33] We will denote balance sheet variance as BSV below.

strength in terms of regulatory measures, like Tier 1 ratio, is equivalent to the adoption of a regulatory model for the assessment of the balance sheet soundness and for the purpose of running risk management[34]. In essence such model is based on a notion of equity, or core capital, equal to the raised capital and the sum of past profits[35]: the limitation is that past profits are a pure accounting measure. More simply, if a loss is not realized, it does not participate to the computation of the yearly profit: hence it does not affect the computation of Core Capital. This is relevant, for example, for the book of Loans and Receivables[36], which contains most of the credit originated and represents for the majority of banks the most relevant book (by dimension) within the assets. In the regulatory framework such a notion of capital, which allows for latent losses, is the buffer for risk. Risk instead is defined as a fraction of the assets. Such fraction is named “Risk weight”. Risk weighted assets are the sum of all assets, multiplied by their respective risk weight. If we try to read the rationale behind it, a risk weight may be interpreted as the loss (in percentage points) that could be realized on such asset: such loss would imply a deduction from capital[37]. Once we consider the ratio between the Core Capital as previously defined (denoted as CT1) and the Risk weighted assets (denoted as RWA) then we obtain the leading indicator (in a regulatory world) of balance sheet strength.

$$\mathrm{ct1} = \frac{\mathrm{CT1}}{\mathrm{RWA}}$$

Given that the numerator is an accounting measure of capital, it may substantially differ from a credible capital measure from the viewpoint of financial markets: in other words market capitalization of a bank may be a percentage, sometimes even well below 100%, of the book value; and it may even be below the Core Tier 1 Capital of the bank. Such a difference clearly has many reasons to exist: one of them is that the market believes too many assets are marked on balance sheet above their market value, hence the value of the

[34] Here the terms of Risk Management also includes the notional of Capital Management given that risk ultimately affects, with gains and losses, the consistency of capital.
[35] We are exposing a reductive rationale behind the construction of Core tier1 ratio, sometimes with an oversimplification meant to address more effectively the questions of this work.
[36] The accounting treatment of the assets in the category “Loan and Receivables” is compliant with the rule of amortized cost, hence only an impairment would decrease the value during the life of the assets.
[37] This rationale holds well for the majority of assets, whose risk weight is below 100%

bank quoted in terms of market capitalization, is much lower to the "Tangible Value" deduced from the balance sheet.

The importance of the risk weights is then crucial given that the numerator is purely an accounting measure: from a methodological point of view an asset whose losses may not be deducted from capital unless realized should not receive a zero risk weight unless there is absolute certainty, especially at a regulatory level, that any future decline in value of the asset will be only temporary and led by demand supply dynamics rather than fundamental reasons of deterioration.

From a capital management point of view an asset whose fall in value would never contribute to a decrease of the numerator and never increase the denominator is an asset with infinite return on (regulatory) capital: if its cost of financing is lower than the yield of the assets, then management has an incentive in choosing such investments in large notional (maybe ignoring the actual volatility of the asset), especially when operating in a context of high scrutiny of regulatory ratios and poor profitability. Indeed such asset is simply disregarded until default (or impairment) from capital considerations.

The author believes that Capital Management from a regulatory point of view should not be confused with a Capital Management oriented to the creation of value for shareholders. As mentioned before, at least two variables will be crucial when proposing a framework to run a modern risk management: the set of PCR and BSV (Balance Sheet Variance). Next chapter contains a proposal for a new definition of risk weights, consistent with the role of PCR in describing risk.

Assumptions on the Value of Debt

If management considers the maximization of return for shareholders a priority then CDS and BSV play a relevant role. Given the leveraged nature of the banks, costs for interests on debt is a central variable in determining profit for current and future years. The author models the cost of debt as determined by[38] Euribor

[38] Although Euribor is a parameter commonly used for Euro denominated issuance, Euribor in this work should be considered as the interbank offer rate for funds over a certain short horizon (for

+ CDS. CDS is the credit default swap quoted by the market whose reference entity is the bank itself; admittedly, the actual levels where the bank may issue its debt may be different from Euribor + CDS: the primary market will determine a premium to the current outstanding bonds' yields for subscribing the new issuance. This is not necessarily linked to CDS levels; yet, when we analyze the aggregate bond issuance and the variations in cost for servicing the debt, the CDS is a good and readily available proxy. The reader may argue that most of the bond issuance is subscribed by retail; therefore analyzing CDS may be misleading. Yet, even in this case, the analysis should be based on the opportunity cost of debt and not on the actual cost. Modeling debt as paying Euribor + CDS makes the evolution of debt observable with daily frequency.

Exploring the Capital Structure via PCA Risk Management

It is evident to the reader that the term risk management is adopted with a wide meaning by also including Capital Management: in the author's opinion only a unified frame may bring together 2 sides of the same coin: risk ultimately has to do with capital, since a high balance sheet variance will eventually require capital to absorb potential negative realizations.

The rationale of this work until now can be summarized as follows: banks operate on balance sheets whose volatility of assets may be significantly underestimated by Financials. Accounting may not prove a good model to estimate the risk represented by assets, primarily because it was not conceived for managing risk. The author proposes an approach merging the intuition of the critical market variables to manage (management is supposed to have a view and a deeper knowledge of the balance sheet assets) with a statistical approach (principal component analysis) in order to identify the main factors of risk (from the former variables).

Clearly running a PCA on the assets of a bank requires a strong modeling effort; therefore we introduce a number of assumptions and decide to disregard the idiosyncratic component of the assets. In this framework, where market variables can be scrutinized in their evolution in value, Risk management should

---

example 3 months), across a panel of financial institutions of primary standing, with no restriction on the currency of funds.

derive the main risk factors and focus on the management of very few variables: the few that have the highest explanatory power on the variance of assets, or, as per previous notation, PCR.

PCR(s) may be considered the main building block of risk in terms of liquid variables traded in the market. Risk management may consider such variables when hedging risks, aiming at choosing hedging policies which reduce the variance of the assets.

This framework may find its limit in the error of approximating the behavior of assets by means of market variables. This is the reason why, once obtained the PCRs from liquid (and approximating) variables, they must be validated in their explanatory power.

We denote by D the stock of debt of the bank (market value) and by E its value of equity.

13

$$\Delta \text{Assets} = \Delta \text{Liabilities}$$

$$\Delta \text{MV} + \Delta \text{IV} = \Delta \text{D} + \Delta \text{E}$$

It is intuitive at this stage that, if PCR have explanatory power on the liabilities of a bank, then the model may be considered reliable for the purpose of managing market variables. More importantly, if PCA risk management proves reliable, then it also allows insights on the evolution and soundness of the capital structure. This and next chapter will investigate on the economic and statistical significance of the explanatory power of the PCRs onto the evolution of debt and equity.

This work has introduced some assumptions on the assets since their market values are not disclosed within financials. On the liability side, instead, we may derive from the CDS level the representative market value of all senior debt, in terms of its daily variations; the market capitalization of the bank is obtained by the stock value quoted on the stock exchange[39]. Deposits are typically guaranteed and subject to first call reimbursement, hence for the purpose of this work their variance (of their value) will be deemed equal to zero. Before the

[39] We may also introduce the CDS for subordinated debt as representative of the stock of subordinated debt: this will not change significantly the conclusions of this work.

PCR's are tested in their explanatory power, we will model the evolution of capital structure via a state variable ($E_t^{\sim}$), representing the intrinsic value of equity, i.e the mere difference between Assets and liabilities. In case of adverse evolution of the assets (dropping in value), then such state variable may reach negative levels. Should that be the case, the value of equity is still nonnegative, given that its value equals the value of a call option with underlying the value of the assets (and strike the nominal value of liabilities). The state variable turning negative is equivalent to the event of the bank running on negative capital, hence strongly undercapitalized.

14

$$E_t^{\sim} = E_{t-1}^{\sim} + \Delta A_t$$

The value of $E_0^{\sim}$ is imposed identical to E_0, i.e. the raised capital when the bank was founded. This modeling of the state variable, of Debt and Equity (and corresponding assumptions) is conceived only for analysis of daily variations: therefore ΔA_t is the variation of assets which is not attributable to an increase of leverage obtained, for example, by debt issuance with proceeds meant to increase the amount of assets.

The introduction of such State Variable also allows modeling the value of debt, which is identical[40] across periods if the state variable is positive. In case the evolution of the intrinsic value of equity turns negative, then such negative value will be deducted from the value of debt. Indeed, in case of immediate liquidation when $E_T^{\sim} < 0$, then the value of equity would be zero and the value of debt would be recovered with loss equal to the amount of the state variable.

15

$$D_t = D_{t-1} + \Delta A_t * I_{\{E_t^{\sim} < 0\}}$$

The equation above suggests that if the daily variation of assets had a satisfactory explanatory power on Debt, then that might be considered evidence that the bank may be undercapitalized.

PCA risk management offers a tool to model the evolution of assets due to market variables only. We will use that model to derive a test for the soundness

[40] We are considering the variations in value of debt not attributable to a change in interest rates and/or redemptions.

of the capital structure of a bank: a very simple methodology can be based on a test of hypothesis. This represents a departure from the regulatory model, based mainly on the computation of the Tier1 Ratio and deeming equity adequate if such ratio is higher than certain thresholds.

From Equation (3) we can impose that, for β=1,

$$E_t = E_{t-1} + \Delta A_t - \beta * \Delta D_t$$

We can further decompose the variation of assets as the variation of the values of the principal components of risk plus an independent (by construction) variable from PCRs. The full variation of assets within a certain period is given below, once we denote by L the variable summarizing the sample variance disregarded as a result of representing the market variables only via principal components.

16

$$\Delta A_t = \Delta PCR_t + \Delta L_t + \Delta IV_t$$

IV is independent (by assumption) from MV=L+PCR and L is independent from PCR (by construction of principal components). We will rewrite (3) above as

17

$$E_t = E_{t-1} + \Delta PCR_t + \Delta L_t + \Delta IV_t - \beta * \Delta D_t$$

Where β = 0 in case of a well capitalized banks, thus meaning that all variations of assets are reflected into equity. This is true for a bank whose value of assets is by far higher than the amount of liabilities. If that is the case the equity is a very in the money call (when viewed as an option with strike price the value of liabilities) and therefore its value is almost linear in the underlying (assets).

PCR Capital Adequacy Test: We will consider the regression

18

$$\Delta E_t = \lambda * \Delta PCR_t - \beta * \Delta D_t + \varepsilon_t$$

Let H_0 be the event that the bank is well capitalized (β=0), then H_1 is the event of the bank being undercapitalized, $\beta \neq 0$. This is ultimately a significance test and the rejection of the null hypothesis takes place for absolute numbers of the t-statistic higher than the values corresponding to a selected probability of type I error.

Next chapter will apply this methodology to a sample of European banks. The variation in the value of assets will be modeled by considering the daily variations of the Principal Component of Risks as introduced in this chapter. Therefore the capital adequacy test will effectively be run against market risk, skipping the idiosyncratic risk of the bank. Conclusions therefore that a bank may be seen as solid for the behavior of its equity has to be mitigated by the consideration that this work analyzes only a subset of the balance sheet risk handled by a bank.

Economic importance versus statistical significance: in essence the capital adequacy test via PCA simply assesses the role of debt in the joint evolution of assets and liabilities. If debt (whose variations are measured via daily changes of the CDS levels) is significant in the regression (8), then the bank under scrutiny may be deemed weak in its amount of equity. Yet statistical significance does not imply necessarily economic importance: if, for example the amount of the linear estimate β were very low, although significant with a very low probability of type 1 Error, then the conclusion of the bank being undercapitalized should be mitigated.

For this reason, when performing the capital adequacy test, we will also assess the explanatory power of PCRs onto the 2 components of the liabilities: equity and debt. The results will produce a number of qualitative and quantitative assessments on the capital structure of the banks in the sample. We will provide the rationale below; data and regression results will be presented in next chapter.

Debt Regression and Equity Regression: Assessment on Capital Structure without Test of Hypothesis

By Debt regression we mean the linear regression as per equation below:

19

$$y = c + b_1 * \Delta PCR(1) + b_2 * \Delta PCR(2) + b_3 * \Delta PCR(3) + \varepsilon$$

where, after running a PCA on the Market Variables, we gauge the explanatory power of PCR (daily variations) on the daily variations of the CDS (y) of the Bank. By Equity regression we adopt the same linear model (9) where y represents the daily variation of the stock value of the bank. We emphasize the economic meaning of these regressions: whereas above we presented a test for capital adequacy, therefore controlling for the type I error, here we are instead assuming that the bank is well capitalized when regressing equity onto PCRs. We are also assuming that it is not well capitalized when regressing Debt onto PCRs. Evaluating the fit of these regressions suggests a further approach to evaluate which assumption on the capital structure may be deemed more likely. If from a statistical viewpoint a formal test (as outlined above) is to be preferred, from an economic standpoint such capital adequacy test may be coupled with the results of these regressions, which can produce various outcomes: the most relevant for the purpose of this work are:

a) PCR have explanatory power on neither equity nor debt: hence the approximation of risk via PCR does not properly address the volatility of assets and therefore PCR cannot explain the volatility of liabilities. The assumption of the assets as composed by Market Variables and Idiosyncratic Variables is disputable and PCA risk management may prove inadequate in managing risk.
b) PCR have a satisfactory explanatory power on equity, but not satisfactory on debt: this is a signal of a healthy capital structure, since the equity is more reactive than debt and most of the volatility of assets is absorbed by equity. Therefore such scenario provides poor evidence that the amount of equity is not adequate. Also PCR obtained via liquid market variables may be considered of good explanatory power for the evolution of assets and adequate for the purpose of running risk management.
c) PCR have a satisfactory explanatory power on debt, but not so satisfactory on equity. If this is the case, then debt is absorbing most of the volatility of the assets and therefore this hints to a bank operating under an inadequate capital structure since the role of equity is being played by debt.

We might consider meaningful to analyze the magnitude of the positive difference between Debt regression R Squared and Equity regression R Squared.

Point (a) above means that PCA Risk Management did not guess the right Principal components of risk, which were derived from the most liquid variables representing Rates risk, Government risk, and Credit Risk. The scenario under (a) is a simple assessment that such a guess may be misleading, since PCR have nothing to explain on balance sheet variance. If instead we are under the scenarios described according to point (b) and/or (c), then PCA risk management has an adequate descriptive power on the risk handled by the bank. In this sense PCA driven risk management may be considered a new tool of risk management since it decomposes risk into independent factors, which can be handled separately.

If PCR provide a satisfactory explanatory power on debt (and/or equity) management cannot ignore if the capital structure is best described under point (b) or (c). A comparison across R Squared (Debt versus equity) is the judgment of Markets on the soundness of capital of the bank, in spite of any regulatory opinion or assessment.

PCA Risk management allows the computation of R Squared coefficients which may lead to further conclusion on the current status and evolution of capital structure. Provided at least one of them is large enough, then we find useful to analyze their joint evolution through time. We may thus analyze an evolution in continuous time of balance sheet ratios versus a regulatory world where ratios are released only on a discrete time schedule and they are dependent on accounting rules/choices. Given the relevance of the R squared coefficients in this work we will refer to

- Adjusted R squared obtained by regressing the daily differences of the CDS onto the daily differences of PCR: such coefficient will be denoted as $R_{pca}(d)$
- Adjusted R squared obtained by regressing the daily differences of the stock value of the bank onto the daily differences of PCR: such coefficient will be denoted as $R_{pca}(e)$

We will define "Inverted Capital Structure" the event

$$R_{pca}(e) < R_{pca}(d)$$

Regardless from the regulatory compliance of solvency ratios, Inversion of capital structure has a warning power for management: debt is better explained than equity by market variables. This may signal that Equity may no longer be capable to absorb the (market variables) risk handled by the bank. $R_{pca}(e)$ and $R_{pca}(d)$ represent the PCA Risk Management statistics for capital structure ("PCR Statistics" in the remainder of this work).

We will compute the PCR Statistics for the banks contained in the 12th series of the Itraxx Index "Financial Senior" in next chapter.

Limits of the PCR Capital Adequacy Test and Importance of the PCR Statistics

PCR Capital Adequacy Test presented above aims at exploring the role of debt, as one of the regressors, in explaining the evolution of Equity. In this section we emphasize the main limit of such test. A judgment on the capital structure of a bank is a complex task: it is also currently debated via a hectic evolution of regulatory guidelines on capital requirements and Stress tests. As such no simple econometric test may have the power to assess the right amount of capital for a bank. The market metric proposed in the second part of this thesis certainly skips a number of relevant variables, but provides some measures on the status of the capital structure as perceived by the market, away from a regulatory filter. The PCR Capital Adequacy Test is based on such market metric, yet may prove inadequate in the event of a strongly undercapitalized bank.

In particular, a bank heavily undercapitalized can be represented via an equity behavior comparable to a very out of the money call option: the value of assets is so lower than the value of liabilities that any variation (in the value) of assets translates into a variation of (the value of) debt. In a state of a significant undercapitalization, the value of equity is a close to zero delta call on the value of assets: therefore it no longer reacts in response to an evolution of the assets. If this is the scenario, then we should expect that the PCR Capital Adequacy Test cannot detect the role of debt in the evolution of capital structure: indeed, recalling the regression (8), debt simply would have no explanatory power on equity. This would result into a low beta and possibly a poor significance of the variation of debt. In this case the conclusion that the bank is not undercapitalized, at least with respect to a market risk metric, would be inaccurate

$$\Delta E_t = \lambda * \Delta PCR_t - \beta * \Delta D_t + \varepsilon_t$$

Hence when the quality of the regression (8) is poor, then the analysis of the PCR statistics should prevail on the PCR Capital Adequacy test, as a tool to judge the capital structure of the bank under scrutiny. There is no simple formula that maps an undercapitalized bank to certain values of the PCR statistics; the latter provide, especially if analyzed through time, a hint on the evolution of the capital structure and give an intuition on the sensitivity of debt to the risk represented by market variables.

Why a Market Metric for Capital Structure?

The reader may argue that assessment of capital structure should not be confused with Market perception of capital structure, the latter assessed by the joint evolution of debt and equity, as quoted by financial markets. If the market is wrong in quoting debt and equity, then the assessment on capital structure will be misleading. While agreeing in principle with this objection, the self-fulfilling aspect of the market perception is quite a binding constraint for the banking sector. If, for the sake of example, the market expresses a market value of debt and equity lower than the fundamental one, the bank may have no other route for rolling its debt and capital issuance than the market itself. Hence, while rolling debt at market levels, far from fundamentals, market evaluation prevails and is imposed on the bank with no other refinancing tools other than the financial market. Similar reasoning holds for a capital increase: if a bank is forced to recapitalize due to the compulsory requirement to be compliant with regulatory guidelines, then the market valuation will prevail, thus imposing a significant discount on tangible equity. 2008-2012 have been years where the banking sector had to tap the refinancing facilities offered by central banks in order to escape the punitive yields required by the financial market to roll debt. Such intervention of central banks has been at the center of many debates questioning the role of the central banks and ultimately resulting into a significant increase of the assets held by central banks. We regard the bold intervention of central banks as an exogenous variable when conceiving risk management for a bank: the latter should be centered on the actual cost for debt and equity. This is the reason why the analysis on capital structure and the tests proposed have been derived from market variables.

APPENDIX

Practical implications: when regulatory framework diverges from PCA Risk Management

PCA risk management may lead to conclusions quite divergent from the regulatory/accounting model of risk management. Yet the latter is imposed by regulators, hence it is widely used in the banking sector, at least at the stage of computing capital and solvency requirements to be published within Financials.

The financial crisis has made evident that the accounting definition of capital may diverge from economic capital. Similarly risk, from a regulatory viewpoint, may turn out to be a substantially different from what perceived by the market: PCA risk management is one of the many attempts to build a frame to address a notion of "economic" risk, to be read as an alternative viewpoint from "regulatory risk"

In this section we will make one example, relating to interest rates risk. Interest rates risk is the risk that a change in interest rates may cause a change in the value of an asset (or a liability). Interest rates risk is quite closely monitored by regulators who impose, among various requirements, that a change[41] in interest rates of 2% should not erode more than 20% of the regulatory capital.

Interest rates risk was so central until few years ago that Banks ALM department were considering it as one of the main variables to jointly manage assets and liabilities. The argument is that interest rates risk management would decrease the potential change in the value of assets and liabilities. Hence, ultimately, reducing this risk would mean a smaller variability on the capital of the bank.

Balance sheet items typically hedged against interest rates movements are mainly loans where the borrower pays fixed rate or debt where the bank pays fixed rate. The overall idea is to hedge the net exposure (after a "natural hedge" effect between assets and liabilities) to interest rates. This reasoning was leading ALM departments to identify a net interest rates exposure by maturity

[41] Meant as absolute variation.

(sometimes called "buckets"). Such interest rates exposure is most of the times hedged via an accounting scheme[42] called "Fair Value Hedge Accounting".

Fair Value Hedge accounting is a hedging technique whereby an asset (Hedged Item) is hedged against, for example, a rise in interest rates (Designated Risk), by a derivative contract (Hedging Instrument)[43]. Hence, if, for example, we consider a fixed rate Government Bond in the scenario of an interest rates rise, the Bond will lose value and such value loss will be associated in accounting terms to a derivative contract gaining value in the same scenario. This is the logic behind Fair Value Hedge accounting; a similar reasoning (although on the liability side) may be made in terms of ordinary bond paying fixed rate coupon.

The key question is: will assets and liabilities paying fixed rate be actually worth more due to a drop in interest rates?

Adopting Fair Value Hedge Accounting (below FVHA) means an affirmative reply to last question. We may ask the same question to PCA and then deduce if, in the metric of PCA risk management, FVHA is an efficient tool in preserving the value of assets and liabilities. More generally, we may ask the question by analyzing the same portfolio of 9 variables presented at the beginning of this work: we will then determine if, in the context of an entire portfolio, hedging the interest rate component adds stability to the portfolio or produces an increase in variance.

More specifically, we will determine if an increase in interest rates does actually primarily imply a reduction of value in Government bonds.

We have emphasized above that interest rates loading factor in the definition of the first principal component of risk (PCR) is negligible with respect to the loading factor of the government bonds. We deduce that the variance of the assets is not explained by interest rates if not by a small percentage; when narrowing the attention to government bonds, their role in defining the first PCR (measured by the magnitude of the loading factor) is so much more relevant than the interest rates risk that hedging the interest rate component of bonds

[42] This section does not mean to list all accounting schemes implemented to manage risk. It simply provides examples of the drastic change in approach PCA risk management may mean.
[43] The author acknowledges that such a definition is reductive, yet it suffices for the purpose of this work.

cannot be expected to reduce significantly the overall variance of the portfolio. However the conclusion may significantly change if we consider German government bonds rather than Italian/ Spanish government bonds. The conclusion also depends on the length of the sample we are considering. In the table below we only analyze one subset of the PCA results, relating to the weights of only 5 variables (weights for the definition of the first PCR). We are thus narrowing the focus on the interest rates risk and government risk. Fair Value Hedge Accounting would argue that such weights should have the same sign and a similar magnitude (so that a rise in interest rates would imply a gain on the derivative contract and a similar loss for having purchased a bond at lower level of yields). If the signs were not the same, then we would be at odds with the implicit assumption of fair value hedge accounting. If, in the assumption of dealing with the same sign, the magnitude of the weights were materially different, than we would not face a symmetry between gain and loss, which is the requirement of any efficient hedging technique.

TABLE 4: EVOLUTION OF INTEREST RATE RISK AND GOVERNMENT RISK IN DEFINING PCR(1): COMPARISON ACROSS SAMPLES

Range	25-Oct-2011--19-Oct-2012 (Days:247)	26-Apr-2011--19-Oct-2012 (Days:372)	25-Oct-2010--19-Oct-2012 (Days:492)	26-Apr-2010--19-Oct-2012 (Days:619)
Security1: Swap EONIA 10Y (Yield in %)	-0.05	-0.105	-0.223	-0.186
Security2: Swap EUR6M 10Y (Yield in %)	-0.075	-0.081	-0.204	-0.171
Security3: 4.5Y Smooth GER (Yield in %)	-0.039	-0.148	-0.28	-0.233
Security4: 4.5Y Smooth ESP (Yield in %)	-0.27	0.156	0.208	0.331
Security5: 4.5Y Smooth ITL (Yield in %)	-0.563	0.435	0.414	0.497

Numbers across different samples show the same sign of German government bonds and the magnitude is quite similar too (comparison between Security 1 and Security 3). That would entail then that FVHA is an accounting treatment of a hedging technique which proves consistent with the conclusion of PCA risk management. Such a conclusion instead changes when we apply the same hedging technique to Spanish and/or Italian government bonds. Not only most of the samples show different signs, but even in the only sample when the sign is the same, the weight of the Italian/Spanish government yields is by far higher. PCA risk management would encourage not to apply Fair Value Hedge Accounting to government bonds unless issued by Germany.

PCA risk management would even imply the opposite: not only a loss of value on the government bonds due to a rise in yields cannot be compensated by a derivative contract gaining when interest rates increase; but hedging the value of a government bonds portfolio would imply to enter positions gaining when interest rates drop (rather than rise). This would prove variance reductive in all samples other than the shortest one, of 247 data points).

Risk management and regulatory framework were originally conceived during periods that had not confronted the current level of turbulence. More importantly, they never confronted a systemic fragility. They were built in times when risk could be decomposed into simple variables and the latter managed individually. Differentiation theories were sound since correlation across different asset classes was stable enough. Such stability in correlation was even exploited by financial markets in the wake of structured products: CDO (collateralized debt obligations) were products offering leveraged exposure to defaults of multiple entities and priced with reliance on stable correlation (implied by the correlation market and by the actual stability of realized correlation).

In its own way the bank deals with a leverage exposure to plenty of variables too: a risk management cannot ignore the correlation across all of them. The bank also needs a focus on fewer variables to understand where the core risk is and how it affects the perception of the riskiness of the bank on the market (i.e. the CDS level).

Some readers may object to the mentioned divergence between PCA approach and Fair Value Hedge accounting, by emphasizing that the reason why a drop in interest rates is simultaneous with a drop in the value of some government bonds is due to the credit deterioration priced by the market against sovereign risk. Hence the interest rate risk is properly addressed by the risk manager applying FVHA; Credit risk is not addressed since the purpose of the investment is to monetize the credit risk priced by the market for government bonds. This kind of objection finds its rationale in the logic division between credit risk and interest rates risk. Principal component analysis hints that a risk management does not have to take as given the number of risks to analyze. PCA driven risk management asks history what relevant variables of risk are to be considered. Credit and rates move together, hence addressing them separately may lead to amplifying risks rather than managing the balance sheet variance.

Furthermore risk is not necessarily to be avoided, otherwise we could not expect profitability either. Uncorrelated (or poorly correlated) risk contributing only marginally to the balance sheet variance may provide, ceteris paribus, a high return on economic capital (even if such conclusion may not apply in regulatory terms).

Increasing interest rates have the property to be negatively correlated with credit deterioration during the financial crisis: a reduction on interest rates was simultaneous with an increase in yields of many securities. Hence to hedge the interest rate risk component of such securities may have reduced the volatility (ex ante) in terms of regulatory capital, but it did not have the same result in terms of Balance sheet variance (hence volatility of economic Capital).

Results of the PCA - Sensitivity of PCA Risk management to sample history

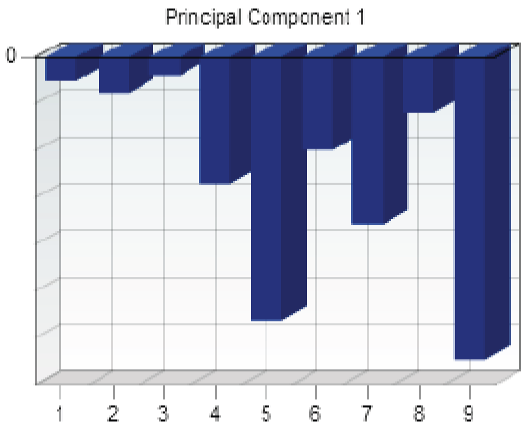
We run a PCA on the 9 liquid variables (representative of liquid market risk) presented in the work for 1 year of sample history, and obtain the following decomposition of variance across 3 principal components, or PCR:

PCA run on a 1y window
Range: 25-Oct-2011--19-Oct-2012 (Days:247)
Analysis Date: 19-Oct-2012
Explained Variance
Factor1: 72 %
Factor2: 23 %
Factor3: 2.83 %

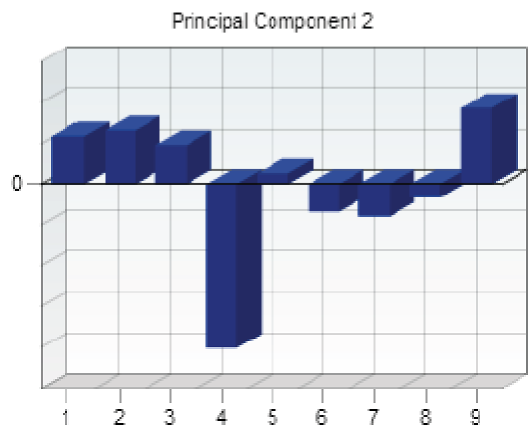
TABLE 5: WEIGHTS FOR EACH VARIABLE WHEN DEFINING PCR(1) AND PCR(2)

Explained Variance	PCR 1: 72 %	PCR 2: 23 %
Variable1: Swap EONIA 10Y (Yield in %)	-0.05	-0.391
Variable2: Swap EUR6M 10Y (Yield in %)	-0.075	-0.408
Variable3: 4.5Y Smooth GER (Yield in %)	-0.039	-0.416
Variable4: 4.5Y Smooth ESP (Yield in %)	-0.27	0.237
Variable5: 4.5Y Smooth ITL (Yield in %)	-0.563	-0.177
Variable6: iTraxx Euro S12-Financial Senior (5 Year CDS in %)	-0.199	0.083
Variable7: iTraxx Euro S12-Financial Sub (5 Year CDS in %)	-0.357	0.064
Variable8: iTraxx Euro S12 Main (5 Year CDS in %)	-0.119	0.036
Variable9: iTraxx Euro S12 Crossover (5 Year CDS in %)	-0.647	-0.639

Following in a histogram format are the loadings of each variable in defining PCR(1) and PCR(2).



Loadings:	-0.05	-0.075	-0.039	-0.27	-0.563	-0.199	-0.357	-0.119	-0.647



Loadings:								
0.235	0.265	0.194	-0.805	0.051	-0.136	-0.16	-0.066	0.372

Figure 5: Loadings of the first 2 principal components obtained via a PCA run on 247 days

If the representation of the asset, for the purpose of analyzing risk, could be deemed correct (this issue will be addressed in the remainder of this work), then PCA Risk management would allow the following considerations:

The improvement of the credit conditions of government bonds (lower yields) is simultaneous with the improvement in quality of subinvestment grade entities. The first Principal component of risk (representing over 70% of the variation of the portfolio) also signals that the main variables in the sample are the index Crossover, the yield of Italian Government bonds and the Index Financial Sub.

A remaining 23% of the variance is explained by Spanish government bonds moving in the opposite direction with respect to Crossover. This latest analysis emphasizes the importance of government bonds as a variable: not only they are relevant when analyzing the first PCR (typically the first PCR represents the bulk of systemic risk in the economy), but a further 23% of the variance is mainly driven by their movements.

Government bonds and Crossover have the highest absolute loading factor in defining PCR1 (the one summarizing most of the sample variance); interest rates have the lowest absolute weights.

Also, hedging does not have to observe rigidly the definition of the Principal components of risk: it is evident for example that if the risk manager buys protection on the index Crossover, he will have a benefit also in the scenario of a deterioration of a government position (in 63% of the cases). Also, interest rates movements do not seem to have a particular role in explaining risk during the analyzed year.

How would the analysis change if, rather than 1 year the risk manager chose 2 years of history? We will define PCA Risk Management as "Adaptive" since it captures correlations as they realize within the data sample; clearly with a different time series the definition of risk factors may be different. Hence, as time evolves, PCA ran to the latest window of data will adapt to new correlations shown by the market.

This question is addressed by investigating on the change in the PCR definition upon different choices of sample history. We will therefore consider a sample with (a) 247 days, (b) 492 days and (c) 619 days. We would find it desirable if PCA risk management could exhibit a robustness property: hence we determine the variability of ranking of the absolute value of the weights when defining the Principal Components of Risk. The first 2 principal components of risk summarize more than 85% of the sample variance, hence we will not analyze the ranking variability on the third principal component of risk.

Table 6: Ranking score for each variable in defining PCR(1). 1 is associated to the variable with highest loading; 9 is associated to the variable with lowest loading.

Sample History	25-Oct-2011--19-Oct-2012 (Days:247)	25-Oct-2010--19-Oct-2012 (Days:492)	26-Apr-2010--19-Oct-2012 (Days:619)
Explained Variance	PCR 1: 72 %	PCR 1: 66 %	PCR 1: 64.5 %
Variable1: Swap EONIA 10Y (Yield in %)	8	6	7
Variable2: Swap EUR6M 10Y (Yield in %)	7	8	9
Variable3: 4.5Y Smooth GER (Yield in %)	9	5	6
Variable4: 4.5Y Smooth ESP (Yield in %)	4	7	4
Variable5: 4.5Y Smooth ITL (Yield in %)	2	3	2
Variable6: iTraxx Euro S12-Financial Senior (5 Year CDS in %)	5	4	5
Variable7: iTraxx Euro S12-Financial Sub (5 Year CDS in %)	3	2	1
Variable8: iTraxx Euro S12 Main (5 Year CDS in %)	6	9	8
Variable9: iTraxx Euro S12 Crossover (5 Year CDS in %)	1	1	3

TABLE 7: WEIGHT OF EACH VARIABLE WHEN DEFINING PCR(1)

Dates	25-Oct-2011--19-Oct-2012 (Days:247)	25-Oct-2010--19-Oct-2012 (Days:492)	26-Apr-2010--19-Oct-2012 (Days:619)
Explained Variance	PCR 1: 72 %	PCR 1: 66 %	PCR 1: 64.5 %
Variable1: Swap EONIA 10Y (Yield in %)	-0.05	-0.223	-0.186
Variable2: Swap EUR6M 10Y (Yield in %)	-0.075	-0.204	-0.171
Variable3: 4.5Y Smooth GER (Yield in %)	-0.039	-0.28	-0.233
Variable4: 4.5Y Smooth ESP (Yield in %)	-0.27	0.208	0.331
Variable5: 4.5Y Smooth ITL (Yield in %)	-0.563	0.414	0.497
Variable6: iTraxx Euro S12-Financial Senior (5 Year CDS in %)	-0.199	0.285	0.298
Variable7: iTraxx Euro S12-Financial Sub (5 Year CDS in %)	-0.357	0.492	0.538
Variable8: iTraxx Euro S12 Main (5 Year CDS in %)	-0.119	0.186	0.177
Variable9: iTraxx Euro S12 Crossover (5 Year CDS in %)	-0.647	0.508	0.341

Absolute lack of variability in ranking represents the maximum degree of robustness: this is equivalent to the statement that the relative importance of the variables in defining the PCRs does not change when we select a different sample history. Such a level of robustness would be too high, since risk management would not have a tool capable to learn new correlations and new relevance of the variables upon analysis of a different sample length.

On the other hand, too much variability would imply that risk management is too sample dependent, hence risk management would be redefining PCRs too often with the consequent need to readjust hedging strategies.

Also ranking variance is to be analyzed with particular attention for the variables with the highest loading, since a substantial change in the weight of such variables would imply a substantial change of the PCR. A low ranking variable with high ranking volatility would not imply a major change for risk management.

The most ranking-volatile variable (across different samples) is the yield of the German bonds which, from lowest ranking (9th) on a 247 days sample, gains more importance when the sample length is extended to 492 and 619 days (scoring respectively 5th and 6th). Apart from German yields, the ranking variance is contained for the most relevant variables (the ones with highest ranking).

We also analyze, with respect to ranking volatility, the second component of risk PCR(2), in the appendix.

The second aspect to analyze across various samples is the sign of the loadings of the variables (relative to each other): if two variables have the same sign, then PCA risk management is noticing that they increase or decrease together. Hence when analyzing the sign of the variables, relative to each other, we refer to the sign of the variable with highest absolute weight and compare it with the sign of all the variables ranking immediately after (in terms of weight magnitude). In analogy with what stated in terms of ranking variance, a different sample may show changing correlations: PCR may see some variables change sign with respect to the one ranking first (i.e. in one sample one variable may have the same sign as the one with the highest absolute weight and in a different sample they instead may have weights with opposite sign).

Given the importance of correlation when dealing with risk management, it is relevant that at least the highest ranking variables may have the same sign across samples (relative to each other). If that were not the case then correlation caught by PCA Risk management would be too unstable and suggest a decomposition of risk into PCR(s) which would prove too data dependent.

In order to evaluate this point on the available samples we rank the variables according to their weight's absolute magnitude: we notice that the highest 4 ranking variables preserve their (relative) sign. The same analysis across samples also holds for the second component of risk: the first 5 highest ranking variables preserve their sign across samples (relative to each other). More analysis will be presented in the appendix.

In this work we are applying a very basic implementation of PCA: a field of literature explores how to make PCA and Functional PCA more robust to data and time variation. Ideally PCR should be temporally and market consistent to produce a consistent risk management. While the purpose of this work is to propose a new idea of risk management, the author acknowledges that the statistical tools here adopted are by choice the simplest: further literature develops the theme of how PCA can be best adapted to the features of financial time series. Ramsay & Silverman and Hamilton are excellent for an introduction to Functional PCA. Also, Jaimungal & Eddie K.H.Ng (2007) propose to remove the temporal structure embedded in the time series so that the principal components can be extracted in a self consistent manner. Among the practical implications, the authors show that a sample perturbation produces a higher difference on the standard principal components as opposed to the principal components obtained via the method they propose.

TABLE 8: DEFINITION OF THE FIRST PRICINIPAL COMPONENT OF RISK (WEIGHTS ASSIGNED BY PCA TO EACH VARIABLE)

Dates	25-Oct-2011--19-Oct-2012 (Days:247)	25-Oct-2010--19-Oct-2012 (Days:492)	26-Apr-2010--19-Oct-2012 (Days:619)
Explained Variance	PCR 1: 72 %	PCR 1: 66 %	PCR 1: 64.5 %
Variable1: Swap EONIA 10Y (Yield in %)	-0.05	-0.223	-0.186
Variable2: Swap EUR6M 10Y (Yield in %)	-0.075	-0.204	-0.171
Variable3: 4.5Y Smooth GER (Yield in %)	-0.039	-0.28	-0.233
Variable4: 4.5Y Smooth ESP (Yield in %)	-0.27	0.208	0.331
Variable5: 4.5Y Smooth ITL (Yield in %)	-0.563	0.414	0.497
Variable6: iTraxx Euro S12-Financial Senior (5 Year CDS in %)	-0.199	0.285	0.298
Variable7: iTraxx Euro S12-Financial Sub (5 Year CDS in %)	-0.357	0.492	0.538
Variable8: iTraxx Euro S12 Main (5 Year CDS in %)	-0.119	0.186	0.177
Variable9: iTraxx Euro S12 Crossover (5 Year CDS in %)	-0.647	0.508	0.341

TABLE 9: DEFINITION OF THE SECOND PRICINIPAL COMPONENT OF RISK (WEIGHTS ASSIGNED BY PCA TO EACH VARIABLE)

Dates	25-Oct-2011--19-Oct-2012 (Days:247)	25-Oct-2010--19-Oct-2012 (Days:492)	26-Apr-2010--19-Oct-2012 (Days:619)
Explained Variance	PCR 2: 23 %	PCR 2: 20.6 %	PCR 2: 18.5 %
Variable1: Swap EONIA 10Y (Yield in %)	0.235	-0.391	0.147
Variable2: Swap EUR6M 10Y (Yield in %)	0.265	-0.408	0.172
Variable3: 4.5Y Smooth GER (Yield in %)	0.194	-0.416	0.122
Variable4: 4.5Y Smooth ESP (Yield in %)	-0.805	0.237	-0.441
Variable5: 4.5Y Smooth ITL (Yield in %)	0.051	-0.177	-0.055
Variable6: iTraxx Euro S12-Financial Senior (5 Year CDS in %)	-0.136	0.083	-0.035
Variable7: iTraxx Euro S12-Financial Sub (5 Year CDS in %)	-0.16	0.064	-0.05
Variable8: iTraxx Euro S12 Main (5 Year CDS in %)	-0.066	0.036	0.023
Variable9: iTraxx Euro S12 Crossover (5 Year CDS in %)	0.372	-0.639	0.856

TABLE 10: RANKING OF THE VARIABLES IN DEFINING PCR(1), BY ABSOLUTE MAGNITUDE OF THE WEIGHT ASSIGNED BY PCA

Sample History	25-Oct-2011--19-Oct-2012 (Days:247)	25-Oct-2010--19-Oct-2012 (Days:492)	26-Apr-2010--19-Oct-2012 (Days:619)
Explained Variance	PCR 1: 72 %	PCR 1: 66 %	PCR 1: 64.5 %
Variable1: Swap EONIA 10Y (Yield in %)	8	6	7
Variable2: Swap EUR6M 10Y (Yield in %)	7	8	9
Variable3: 4.5Y Smooth GER (Yield in %)	9	5	6
Variable4: 4.5Y Smooth ESP (Yield in %)	4	7	4
Variable5: 4.5Y Smooth ITL (Yield in %)	2	3	2
Variable6: iTraxx Euro S12-Financial Senior (5 Year CDS in %)	5	4	5
Variable7: iTraxx Euro S12-Financial Sub (5 Year CDS in %)	3	2	1
Variable8: iTraxx Euro S12 Main (5 Year CDS in %)	6	9	8
Variable9: iTraxx Euro S12 Crossover (5 Year CDS in %)	1	1	3

TABLE 11: RANKING OF THE VARIABLES IN DEFINING PCR(2), BY ABSOLUTE MAGNITUDE OF THE WEIGHT ASSIGNED BY PCA

Sample History	25-Oct-2011--19-Oct-2012 (Days:247)	25-Oct-2010--19-Oct-2012 (Days:492)	26-Apr-2010--19-Oct-2012 (Days:619)
Explained Variance	PCR 2: 23 %	PCR 2: 20.6 %	PCR 2: 18.5 %
Variable1: Swap EONIA 10Y (Yield in %)	4	4	4
Variable2: Swap EUR6M 10Y (Yield in %)	3	3	3
Variable3: 4.5Y Smooth GER (Yield in %)	5	2	5
Variable4: 4.5Y Smooth ESP (Yield in %)	1	5	2
Variable5: 4.5Y Smooth ITL (Yield in %)	9	6	6
Variable6: iTraxx Euro S12-Financial Senior (5 Year CDS in %)	7	7	8
Variable7: iTraxx Euro S12-Financial Sub (5 Year CDS in %)	6	8	7
Variable8: iTraxx Euro S12 Main (5 Year CDS in %)	8	9	9
Variable9: iTraxx Euro S12 Crossover (5 Year CDS in %)	2	1	1

Composition of Itraxx indices (series 12): index Itraxx Europe and Financial Senior

The index Itraxx Europe, also known simply as 'The Main', is composed of the most liquid 125 CDS referencing European investment grade credits, subject to certain sector rules as determined by the IIC and also as determined by the SEC. More specifically, the iTraxx® Europe index comprises 125 investment grade rated European entities selected from the Liquidity List. All entities must satisfy the membership determination criteria. Among such criteria it is disposed that the final index comprises 125 entities and is constructed by selecting the highest ranking entities in each sector on the Liquidity List, subject to the following sector restrictions:

a. 30 Autos & Industrials

b. 30 Consumers

c. 20 Energy

d. 20 TMT

e. 25 Financials (separate Senior & Subordinated indices)

The levels of the index Financial Senior (more properly iTraxx Europe Senior Financials), with tenor 5y maturity, intuitively includes all financial senior CDS of financial reference entities. More specifically, this index is the weighted average of the 25 names belonging to the financial sector and included in the index Itraxx Europe (as per description above, point e).

TABLE 12: COMPOSITION OF THE ITRAXX FINANCIAL SENIOR INDEX (SERIES 12). THE GREY FIELD EMPHASIZES THE NAMES ANALYZED IN THE ECONOMETRIC SECTION IN THIS WORK

Itraxx Financial Senior Index (Series 12)			
Company Name	Weight	Reference Obligation	Corp Tkr
Aegon NV	4	XS0207157743	AEGON
Allianz SE	4	XS0158792381	ALVGR
Assicurazioni Generali SpA	4	XS0218469962	ASSGEN
Aviva PLC	4	XS0066877258	AVLN
AXA SA	4	XS0130738213	AXASA
Banca Monte dei Paschi di Siena SpA	4	XS0173287516	MONTE
Banco Bilbao Vizcaya Argentaria SA	4	XS0250172003	BBVASM
Banco Espirito Santo SA	4	XS0210031315	BESPL
Banco Santander SA	4	XS0262892549	SANTAN
Bank of Scotland PLC	4	XS0218984572	LLOYDS
Barclays Bank PLC	4	XS0232785880	BACR
BNP Paribas SA	4	XS0405664813	BNP
Commerzbank AG	4	XS0100221349	CMZB
Credit Agricole SA	4	XS0315528850	ACAFP
Credit Suisse Group AG	4	XS0099472994	CS
Deutsche Bank AG	4	DE000DB5S6U6	DB
Hannover Rueckversicherung AG	4		HANRUE
Intesa Sanpaolo SpA	4	XS0304508921	ISPIM
Muenchener Rueckversicherungs AG	4		MUNRE
Societe Generale SA	4	XS0354843533	SOCGEN
Swiss Reinsurance Co Ltd	4	CH0012491335	SRENVX
Royal Bank of Scotland PLC/The	4	XS0235714804	RBS
UBS AG	4	XS0359388690	UBS
UniCredit SpA	4	XS0185030698	UCGIM
Zurich Insurance Co Ltd	4	XS0201168894	ZURNVX

TABLE 13: COMPOSITION OF THE INDEX ITRAXX MAIN (SERIES 12).

Accor SA	Deutsche Telekom AG	Publicis Groupe SA
Adecco SA	Diageo PLC	Reed Elsevier PLC
Aegon NV	E.ON AG	Repsol SA
Volvo AB	Edison SpA	Rolls-Royce PLC
Akzo Nobel NV	EDP - Energias de Portugal SA	RWE AG
Allianz SE	Electricite de France SA	SABMiller PLC
Alstom SA	EnBW Energie Baden-Wuerttemberg AG	Safeway Ltd
Anglo American PLC	Enel SpA	Sanofi
ArcelorMittal	European Aeronautic Defence and Space Co NV	Siemens AG
Assicurazioni Generali SpA	Experian Finance PLC	Societe Generale SA
Aviva PLC	Finmeccanica SpA	Sodexo
AXA SA	Fortum OYJ	Solvay SA
BAE Systems PLC	France Telecom SA	STMicroelectronics NV
Banca Monte dei Paschi di Siena SpA	Gas Natural SDG SA	Suedzucker AG
Banco Bilbao Vizcaya Argentaria SA	GDF Suez	Svenska Cellulosa AB
Banco Espirito Santo SA	Glencore International PLC	Swedish Match AB
Banco Santander SA	Groupe Auchan SA	Swiss Reinsurance Co Ltd
Bank of Scotland PLC	Hannover Rueckversicherung AG	Technip SA
Barclays Bank PLC	Hellenic Telecommunications Organization SA	Telecom Italia SpA
BASF SE	Henkel AG & Co KGaA	Telefonica SA
Bayer AG	Holcim Ltd	Telekom Austria AG
Bayerische Motoren Werke AG	Iberdrola SA	Telenor ASA
Bertelsmann SE & Co KGaA	Intesa Sanpaolo SpA	TeliaSonera AB
BNP Paribas SA	J Sainsbury PLC	Tesco PLC
Bouygues SA	JTI UK Finance PLC	Royal Bank of Scotland PLC/The
BP PLC	Koninklijke Ahold NV	PostNL NV
British American Tobacco PLC	Koninklijke DSM NV	Total SA
British Telecommunications PLC	Koninklijke KPN NV	UBS AG
Cadbury Holdings Ltd	Koninklijke Philips Electronics NV	UniCredit SpA
Carrefour SA	Air Liquide SA	Unilever NV
Casino Guichard Perrachon SA	Lanxess AG	United Utilities PLC
Centrica PLC	Linde AG	Vattenfall AB
Commerzbank AG	LVMH Moet Hennessy Louis Vuitton SA	Veolia Environnement SA
Cie de St-Gobain	Marks & Spencer PLC	Vinci SA
Compass Group PLC	Metro AG	Vivendi SA
Credit Agricole SA	Muenchener Rueckversicherungs AG	Vodafone Group PLC
Credit Suisse Group AG	National Grid PLC	Volkswagen AG
Daimler AG	Nestle SA	Wolters Kluwer NV
Danone SA	Next PLC	WPP 2005 Ltd
Deutsche Bahn AG	Pearson PLC	Xstrata PLC
Deutsche Bank AG	Portugal Telecom International Finance BV	Zurich Insurance Co Ltd
Deutsche Post AG	PPR	

CHAPTER 3: PCR STATISTICS AND CAPITAL ADEQUACY TEST: A NEW METRIC FOR SYSTEMIC RISK?

Systemic Risk: Introduction and Motivation

Systemic risk is a key concept to interpret current financial and economic crisis, yet there is no consensus on its definition and measurement. It is associated with lack of confidence on the self adjustment of the financial markets without a disruptive outcome.

Ultimately systemic risk is questioning that the system may not survive: when facing the possibility that the system may collapse the reactions of economic agents are unpredictable and so is the transmission mechanism of economic policy. This unpredictability of transmission effects has made the expression "Unchartered territories" quite adopted even by policy makers.

These intuitions do not lead to a definition of systemic risk but provide an explanation on why systemic risk is mainly a macro-economic concept: the novelty of this chapter is in providing a micro approach to systemic risk.

Insolvency of the financial system and extraordinary variance of financial variables are, in light of the intuitions above, the very first factors to monitor in the aim of proposing a measure of systemic risk. For this reason we are decomposing the variability of the main financial liquid variables into principal components, in order to dispose of orthogonal factors of risk, to be addressed independently. We can read the variability of the assets of a bank as a sum of idiosyncratic risk and market risk. PCR will propose a summary of the variance deriving from market risk if PCR are derived as a PCA on market variables. How do we move from this definition of risk to the concept of systemic risk?

The author believes that systemic risk requires a transmission mechanism that makes such risk shared by the entire system. The contributions of many authors on the theme focus on the idea that systemic risk is the propensity of a financial institution to be undercapitalized when the financial system as a whole is undercapitalized: this reading of the systemic risk has generated a plethora of successful estimators of systemic risk but does not help in addressing the propagation of systemic risk. Risk managers and regulators need to address systemic risk before facing the consequences of a firm being undercapitalized when the entire system is undercapitalized. More importantly, if a bank is strongly exposed to a certain risk, for the sake of examples, a rise in interest rates, is that risk systemic?

The Propagation of Systemic Risk

The framework presented in the previous chapter proposes a reading of risk obtained via liquid variables, via decomposition of market risk of a bank into PCRs: is such risk compatible with the size of equity? If the size of the available capital is too small, then the variation of the assets cannot be fully absorbed by the variations in value of equity. Therefore other layers of the capital structure must adapt in value due to the scarcity of capital. Hence, the intuition that inspires the next econometric section and this entire work is that once equity is insufficient, then debt has to adapt to the variations of the value of assets. Financial debt is a typology of instrument that not only serves the purpose of securing term liquidity for the issuing bank, but also contributes to the growth (or stability) of the leverage in the economy where banks operate. This statement is justified by acknowledging that financial senior debt is commonly accepted as eligible collateral, among the many facilities, for refinancing with the central bank (provided that the rating of the issuing bank is investment grade).

As a result, when debt adapts its value to the variations of the assets of a bank then it becomes a transmission tool of the variance that can no longer be absorbed by the equity.

This introduction justifies why the author proposes a reading that a market risk (represented via PCR) is systemic (in a certain percentage) in the extent that Equity is no longer capable to provide a buffer against it. We would be facing then the event that Debt is explanatory of a high percentage of the variability of the Market risk, which triggers a questioning of solvency, since debt is affected by the strong fluctuations of the assets value.

This introduction serves the purpose of presenting PCR Statistics as a measure of adequacy of capital structure to the risk as perceived by markets (away from a regulatory meter). When solvency is questioned (Equity may prove inadequate as a buffer for the variance experienced by assets) and PCR have a strong explanatory power towards debt, then we deem that the risk experienced by the single financial institution is potentially highly systemic and that debt is acting as a transmission mechanism of the systemic risk. The risk represented by a Principal Component of risk is systemic if a large number of the financial institutions share the same dependence. This reading would also provide an explanation why one of the distinguishing feature of the current financial crisis is the amount of liabilities guaranteed by a sovereign state: this work would encourage seeing such guarantees as an attempt to break the transmission mechanism of the systemic risk. This reading also emphasizes the separation between market variables and intrinsic variables: by definition, systemic risk can be explained by the variables shared by the banking sector and not by the ones specific (intrinsic) to a single financial institution. Principal components of risk, in their role of summarizing market variables only, not only represent the starting point in investigating systemic risk, but also propose the building blocks (independent from each other, in statistical terms) to manage in case the risk represented by market is to be controlled.

We will then define the systemic risk, for the single financial institution, as the explanatory power that PCR have on Debt. In this work we avail ourselves of a simple statistical tool of linear regression and therefore the explanatory power of PCR on debt can be summarized via (adjusted) R squared. Future research may explore the link between market risk in the assets of a bank and its debt via more refined tools and therefore propose different measures. Yet this work emphasizes the role of debt as transmission mechanism of market risk, due to a size of available equity not adequate for the realized volatility of assets. The intuition behind the choice of debt as transmission mechanism is that a volatile debt makes the refinancing transactions in the economy as volatile, being debt the most accepted collateral for refinancing operations via the repo market and central banks. In light of this intuition, the actual transmission of systemic risk takes place via debt admitted as elegible collateral by central banks and by the netting mechanisms existing in financial markets. Hence the choice, in the econometric section of this work of Itraxx Financial Senior as the index representing the exposure towards financial debt held by a bank: such index is composed by the CDS of issuers whose rating is in the investment grade category; therefore their debt is widely accepted as collateral.

Such an analysis of capital structure leads then to the search of new capital structure instruments that may decrease the sensitivity of Senior debt to market risk: that would prove the primary tool for reduction of systemic risk.

From a macroeconomic viewpoint, if debt is a transmission mechanism for systemic risk we should expect that the adjusted R squared for the Debt regression is high for a sample of banks simultaneously. This intuition derives from the definition of "systemic risk", i.e. affecting a system and not limited to few institutions only. We will assess this statement from an econometric viewpoint in the section below.

We acknowledge that such definition of Systemic risk, centered on the idea of debt as transmission mechanism is dissimilar from a measure aimed at capturing the degree of undercapitalization of a financial institution when the entire system is undercapitalized. Whereas the latter is the idea emphasized by many authors, including Engle, Jondeau and Rockinger (2012), this work instead is investigating the event that equity is inadequate for the purpose of absorbing the fluctuations of the assets. This is investigated independently from the behavior of the entire financial system and we derive a measure of undercapitalization when fluctuations in equity are no longer explained by the fluctuations of assets.

This reading of the event of undercapitalization is also dissimilar from the "regulatory event" that the tier 1 ratio falls below a certain ratio. In the frame proposed in this work an undercapitalization is signaled by a low R squared in the Equity regression (or, more generally, by a weak link between risk of the assets and equity of the same institution). This work relies on a reading of the risk via Principal components of Risk, and adopts the simplest econometric model to explore the relationship between assets and liabilities. Future research may explore how to best summarize the behavior of assets and therefore derive a different notion of risk management. Exploring the link between assets fluctuations and equity will then have different regressors, yet the measure of undercapitalization will ultimately be translated as a poor explanatory power of the regressors onto the fluctuations of equity.

Such a frame also allows investigating the event of undercapitalization via a market metric rather than a regulatory metric. Such event of undercapitalization may or may not be experienced in an undercapitalized financial system. Yet identifying a transmission mechanism via debt addresses how to reduce systemic risk via tools other than capital increases.

The author believes in a role of the subordinated debt (as presented at the end of this work) as a valid remedy especially when a capital issuance is too detrimental for current shareholders (or unfeasible). Risk management via Principal component of risks and subordinated debt represent a cheaper and less drastic way to reduce balance sheet volatility.

Debt as transmission mechanism for systemic risk also proves a valid intuition to explain the so called "Endogenous Risk", i.e. the amplification of market volatility due to the reaction of the system to an exogenous shock. Danielsson, Shin and Zigrand produce a powerful analogy to recall the meaning of Endogenous Risk: "*a small gust of wind produce a small sway in the Millennium bridge. Pedestrians crossing the bridge would then adjust their stance slightly as a response, pushing the bridge further in the same direction. Provided sufficiently many pedestrians found themselves in the same situation, they will find themselves coordinating spontaneously and unwittingly to move in lockstep, thereby reinforcing the swaying into a something much more violent. Even if the initial gust of wind is long gone, the bridge continues to wobble. Similarly, financial crises appear to gather more energy as they develop. And even if the initial shock is gone, volatility stays high".*

Similarly, when financial senior debt and/or government debt loses value, then it is immediate to identify a number of transactions requesting further margin calls and, more generally, the entire refinancing system in the economy disposing of less collateral. It goes beyond the scope of this paper to analyze in detail such transmission mechanism, yet this introduction to systemic risk provides a hint to why volatility of debt is so relevant. Debt[44] is financed via repo markets or via refinancing facilities made available by Central Banks: hence a volatile debt implies volatile refinancing conditions.

This measure of systemic risk provides a change in perspective from the systemic risk analytics derived so far in the literature, which we will very briefly recall below.

Literature on Systemic Risk

Bisias, Flood, Lo and Valavanis offer an excellent survey of systemic risk analytics: in this paragraph we will recall what they categorize the "Forward-Looking Risk Measurement" and the "Cross Sectional measures". Recalling the principal aspects of these measures will help in emphasizing both the limits and the novelties presented in this work.

Gray and Jobst apply Merton's model where equity is analyzed as a call option on the assets of the firm. The comparison across equity prices and CDS levels is the base to derive the proportion of the expected loss born by the private sector as a systemic impact. Such approach relies on an assumption of distribution of the assets and does not hint to the intervention in the micromanagement of the firm in order to deal with systemic risk.

Segoviano and Goodhart model systemic risk via a banking system multivariate distribution function: they employ a maximum entropy estimation, to be consistent with observed probabilities of distress, derived via a variety of approaches, including equity options and CDS levels. This approach allows the authors to obtain a banking stability index, reflecting the number of banks becoming distressed given that at least one bank has become distressed. This measure of systemic risk has the advantage of not introducing a large number of assumptions on the assets of a bank. As a result the systemic risk measure obtained may be of particular use to a regulator to monitor the evolution of the financial system; It would not add powerful insights on the transmission mechanism of the systemic risk, nor its management at a micro level.

[44] Purchased by a third party

Principal Component Analysis is at the heart of the definition of the Absorption Ratio, in Kritzman, Li, Page and Rigobon. Their measure of systemic risk aims at capturing the extent to which markets are unified or tightly coupled. The crucial difference with respect to this work is that they apply PCA to the daily returns for the 51 industries of the MSCI US Index.

In the field of Cross sectional measures we will instead mention some of the measures developed by the literature aiming at examining the co-dependence of institutions on each other's health. Before we list some of the major contributions in literature on this particular theme, how does PCR Risk Management provide such cross sectional reading of the health of the financial system? The answer, once more is in the reading of the PCR Statistics. Do the financial institutions in the sample share all the same dependence (in terms of sign and magnitude), towards PCRs? Is that true for equity and debt?

More will be discussed in the econometric section below: in the scenario of Equityzation of Debt, should different banks have a high linear coefficient (with same sign) towards the first principal component of risk, then that PCR would represent the composition of Systemic Risk and the co-dependence across financial institutions is quite high due to the significant and simultaneous sensitivity of debt to the same PCR.

Adrian and Brunnermeier (2010) develop the CoVAR measure which, in its simplest format, investigates the VAR of one institution for a specific probability, conditional on the Var of another institution being at its VAR threshold for the same quantile. CoVAR adopts quantile regression to capture the empirical relationship between VaRs in the tails of the joint distribution. In order to capture time variation in the joint distribution between two firms (or between one financial institution and the entire system), the authors introduce an assumption on the evolution of the value of assets, by selecting as input the equity market capitalization of financial institutions and assuming a constant leverage across dates of publication of financials. Also the authors capture time variation in the joint distribution between a singular financial institution and the system by introducing a conditional distribution estimated as a function of state variables.

Co-Risk measure of International Monetary Fund shares a similar structure with CoVar, with the exception that CDS levels are analyzed, conditional on the 95th percentile of the other firm's CDS level (in terms of empirical distribution). In particular, the level of one firm is regressed onto the cds level of another and a vector of risk factors. Also in this model a quantile regression plays a crucial role. The approach relies on no assumptions relating to the assets of the firm and defines the CoRisk as the ratio between the quantile regression- estimated CDS level (of a certain firm) and its actual percentile CDS level from the empirical distribution.

PCR Statistics represent a very different approach from CoVar and CoRISK: PCR statistics consider jointly both CDS and Equity levels and investigate the adequacy of capital structure to systemic risk for each institution. PCR Statistics rely on a smaller set of assumptions; yet they do not propose how to meausure the simultaneity of the distress across two institutions. The main difference is in the philosophy and the questions at the heart of the PCR Statistics as opposed to any Cross Sectional measure of systemic risk, including CoVAR and CoRisk. Cross sectional measures aim at measuring a distress occurring in few datapoints of the sample (by construction the co-movement in rare scenarios over the 95th quantile). PCR statistics are conceived in a framework where the author is dubious about predicting the behavior of the system when the latter is affected by extreme realizations of systemic risk. Hence PCR Statistics provide an idea of the sensitivity of the capital structure to systemic risk, be it when it is still benign and also when degenerating to its disastrous realizations. The main logic is that, if few Principal Components of Risk have a good descriptive power on all capital structures of all banks in the sample, then such principal components are a common explanation for risk and the system no longer relies on a principle of diversification. Robert Engle defines systemic risk the propensity of a financial institution to be undercapitalized when the financial system as a whole is undercapitalized; this work defines systemic risk as the propensity that a financial institution's risk be explained by few liquid variables when the same variables are also explanatory of the risk of the entire system. The difference in approach is quite dissimilar, since the question is very different at the very beginning: this work does not aim at providing a measure of systemic risk at a cross sectional level; it aims towards an effort of risk management ready to take into account that a significant portion of risk may be systemic. Therefore managing risk requires acknowledgement of its systemic character along with the implications on capital structure and (potential) losses for the entire system. Cross sectional measures of systemic risk like CoVAR and CoRISK do not mean to explore the capital structure of single financial institutions.

Acharya, Pedersen, Philippon and Richardson (2010) also rely on a measure of undercapitalization of one firm when the system as a whole is undercapitalized: such measure is the systemic expected shortfall and they propose three proxies (stress test based, equity based and CDS based). Systemic expected shortfall is regressed on the MES (Marginal expected Shortfall) and leverage. Both variables are also given a microeconomic theoretica foundation with SES. The marginal expected shortfall of a financial institution is the average return of the latter during the 5% worst days for the overall market return. Compared to the framework proposed in this work, one of the differences is in the input data, which also relies on balance sheet data, as the very first input to determine the standard approximation of leverage; also the model does not consider equity levels and CDS levels jointly. Each firm is measured for the predictable component of its systemic risk, as determined by SES; yet no capital structure related conclusion can be drawn.

The last measure of systemic risk to be mentioned in this brief summary is the "Distressed Insurance Premium" (Huang, Zhou, and Zhu, 2009b) which is an estimate of the total losses that exceed a given threshold, for example 15% of total banks' liabilities. This model requires a number of assumptions on asset correlation, which is proxied by equity correlation. An assumption of constant leverage is adopted and an estimation procedure for future correlation is based on a predictive regression where average correlations and a set of financial variables represent the regressors. Probabilities of default are inferred from CDS levels and the price for insurance against losses in the banking sector over next quarter can be calculated. Distress, in this case, stands for default of a certain percentage of the liabilities in the banking sector. Such a measure of systemic risk relies on introducing, for the N banks' asset values, common and idiosyncratic components as in the ASRF (Vasicek, 1991) model of portfolio credit risk. Distressed insurance premium model offers a monetary measure of distress and it differs from the approach in this work for the number of assumptions and for being based on a Montecarlo approach, in 2 important phases: computation of probabilities of joint defaults and distribution of LGD.

Data and Computation of PCR Statistics

The data is the set of daily levels for all liquid variables, already commented at the beginning of the second chapter introducing the principles of PCA risk management. Principal Components Analysis provides principal components of risk, or PCR. We then regress the daily differences of CDS onto the daily differences of PCR(s) and we interpret the R squared as the degree of the reactiveness of Debt to the variation in the value of assets.

We then run a similar regression where we regress the daily variations of the stock's price onto the daily differences of PCR(s) and we interpret the R squared as the degree of the reactiveness of Equity to the change in the value of assets.

The sample period is the set of daily observations from 25th of October 2010 until 19th of October 2012 (492 observations[45]). The banks whose CDS and equity Prices[46] are explained in terms of PCR are[47]

1. Banca Monte dei Paschi di Siena SpA (Monte)
2. Credit Agricole SA (Calyon)
3. Intesa Sanpaolo SpA (Intesa)
4. BNP Paribas SA (BNP)
5. Societe Generale SA (SocGen)
6. Deutsche Bank AG (DB)
7. Commerzbank AG (CMZB)
8. Banco Santander SA (Santander)
9. Credit Suisse Group AG (CS)
10. Ubs AG (UBS)
11. Banco Bilbao Vizcaya Argentaria SA (BBVA)

[45] The period and the number of observations have to be consistent with the database where PCA risk management is applied and the PCRs derived. Hence we focus on a length of 2 years since we have already presented the results of PCA risk management on the same sample.
[46] Source for Equity prices is Bloomberg. Source for CDS level is Markit database.
[47] We discard the UK banks since we would need to consider liquid variables for the UK economy and determine UK specific PCR(s). All remaining banks compose the index Itraxx Financial Senior (series 12).

The liquid variables are[48]

- Variable1: Swap EONIA 10Y (Yield in %)
- Variable2: Swap EUR6M 10Y (Yield in %)
- Variable3: 4.5Y Smooth GER (Yield in %)
- Variable4: 4.5Y Smooth ESP (Yield in %)
- Variable5: 4.5Y Smooth ITL (Yield in %)
- Variable6: iTraxx Euro S12-Financial Senior (5 Year CDS in %)
- Variable7: iTraxx Euro S12-Financial Sub (5 Year CDS in %)
- Variable8: iTraxx Euro S12 Main (5 Year CDS in %)
- Variable9: iTraxx Euro S12 Crossover (5 Year CDS in %)

Hence first we will run a PCA on the latter variables and then regress the daily differences of CDS (and equity values) of each of the 11 banks listed above on the 3 PCR obtained.

We will then obtain specific regression estimates for the CDS and the equity of each bank in the sample. Ceteris paribus, we would then expect higher coefficients for banks operating with lower capital and/or higher leverage. In the appendix we list the estimates of the regression. In this section we wish to explore the conclusions on the theme of capital structure, basing our considerations on the values of PCR Statistics[49].

[48] Source for the first five variables is Bloomberg; Markit database is the source for the remaining four variables.
[49] When we refer to R squared, we always refer to Adjusted R Squared.

TABLE 14: PCR STATISTICS COMPUTED FOR A SAMPLE OF EUROPEAN BANKS (SAMPLE FROM 25 OCT 2010 TO 19 OCT 2012)

Banks	R2(Equity)	R2(Debt)	DW (Equity)	DW (Debt)
Intesa	0.45	0.672	1.941	1.76
Monte	0.195	0.609	1.835	1.705
Calyon	0.424	0.707	1.84	1.753
BNP	0.574	0.724	1.809	1.79
SocGen	0.491	0.668	1.749	1.748
DB	0.573	0.384	1.841	2.007
CMZB	0.262	0.418	1.794	1.897
Santander	0.441	0.624	1.754	1.844
BBVA	0.47	0.638	1.745	1.858
CS	0.446	0.631	1.684	1.922
UBS	0.411	0.597	1.876	1.897

PCR statistics, especially $R_{pca}(d)$ and the estimates in the linear regression will allow to compare capital structures; they will also provide a base to the analysis of debt via decomposition into more liquid variables (PCR). This is relevant not only from a risk management perspective, but also from an investor point of view.

The results summarized in the table above provide a picture where PCA risk management may be considered a good tool to explain risk and to explain the movements of both equity and debt. The role of debt in absorbing the volatility of assets is quite relevant, with $R_{pca}(d)$ reaching levels[50] even higher than 70%, for BNP Paribas.

The inversion of capital structure, as defined in this work, is particularly evident for Banca Monte dei Paschi di Siena and Credit Agricole. Although the explanatory power of PCR on Debt is quite high in these 2 cases, there is a substantial difference: Equity is also well explained by PCR in the case of Credit Agricole, with an adjusted R squared of 42.4%. Hence equity is still capable to absorb the risk as summarized by PCR; yet the debt of the same bank is explained with an R squared of over 70%, thus making systemic risk an important component of the risk to be managed by this financial institution. The

[50] The heading of the column refers to R2(Debt) for $R_{pca}(d)$ (and to R2(Equity) for $R_{pca}(e)$).

same conclusion cannot be made for Banca Monte dei Paschi, where an adjusted R squared of 19.5% signals a poor explanatory power of PCR on the daily variations of the stock price. These results will be commented in depth in the section dedicated to PCR Capital Adequacy Test.

Far from making statements from a regulatory point of view, the analysis of the PCR statistics for these 2 banks would argue that their equity is too weak to absorb the risk as measured via Principal components of risk.

The lowest explanatory power of PCR onto Equity is reached by 2 banks: Banca Monte dei Paschi , as explaned above; and Commerzbank. It is relevant that in both cases the daily variations of CDS can still be explained in terms of PCR, whereas the same PCR have very poor descriptive power on equity. In both cases we are facing 2 banks where the sovereign state has intervened on different layers of the capital structure with aid packages during the most turbulent periods of the financial crisis. Hence one might interpret results of PCA risk management as reflecting that equity is no longer reactive to risk, leaving most of the adjustment to Debt. The sovereign aid may be interpreted as the need to reinforce a capital structure no longer capable to absorb the volatility of assets experienced during the financial crisis.

The role of PCRs and CDS is quite powerful for management in its investment decisions. The most suitable investments are the ones which, ceteris paribus, exhibit a poor (or even negative) correlation with PCR. Risk weight factors (as they are defined today) may be misleading since they may provide incentives to invest into assets which require no or little regulatory capital, yet they may prove correlated with PCR. In case of inversion of capital structure, assets may exhibit a strong correlation with CDS. We will explore this theme in depth below.

PCA Risk Management Metric for Systemic Risk

We will make use of the econometric analysis above and analyze the estimates of the coefficients in the linear regression. Provided that $\mathrm{R}_{\mathrm{pca}}(\mathrm{d})$ is high enough, then banks may be compared by investigating on the systemic risk handled by each one; this is equivalent to analyzing the magnitude of the linear coefficient estimated for PCR(1). We have two estimates: the coefficient obtained by regression of Equity on PCR(s) and the analogous one derived by linear regression of CDS on PCR(s). We will consider only the latter. The reason for this choice lays in the definition of systemic risk provided in this work: we have associated it with a direct linkage that assets may have on the debt of the bank. This work has explored such linkage via the adoption of a linear regression model and therefore the measure of the explanatory value of the assets on Debt is investigated via the Adjusted R squared obtained regressing daily variation of CDS onto daily variations of the Principal Components of Risk.

TABLE 15: EXPRESSING THE SYSTEMIC RISK VIA ESTIMATES OF REGRESSION OF CDS ON THE FIRST PRINCIPAL COMPONENT OF RISK.

Banks	R2(Debt)	PCR 1 Coeff (Debt)	Significance
Intesa	*0.672*	*2.301*	*1%*
Monte	*0.609*	*2.951*	*1%*
Calyon	*0.707*	*1.205*	*1%*
BNP	*0.724*	*0.854*	*1%*
SocGen	*0.668*	*0.972*	*1%*
DB	*0.384*	*1.17*	*1%*
CMZB	*0.418*	*1.3*	*1%*
Santander	*0.624*	*2.113*	*1%*
BBVA	*0.638*	*2.338*	*1%*
CS	*0.631*	*0.461*	*1%*
UBS	*0.597*	*0.361*	*1%*

PCA risk management also allows a different perspective on the theme of leverage, which is very heavily scrutinized by regulators. The most popular measure of leverage is an accounting measure, the ratio between Total Assets and Equity. PCA risk management would argue instead that such a ratio may point towards a different direction from a risk analysis consistent with this work. Even when the leverage ratio is very high, there could be a poor correlation of the assets with PCR. Hence size should not matter if it is not converted into an adequate measure of risk. This is one more point where accounting and risk management may lead to different conclusions.

If the adjusted R squared of the regression is high enough to justify the explanatory power of PCR, then a measure of leverage provided by the metric of

PCA risk management is given by the linear regression estimate listed in the table above. Such table lists the estimates, bank by bank, of the linear coefficient of the first PCR to explain the movement of CDS. With the exception of Deutsche Bank, the adjusted R squared[51] are all higher than 40%, with an average of 60.65%. We then deduce that while Italian and Spanish banks exhibit the highest estimates of leverage (Risk corrected for PCR exposure), Swiss banks have the lowest leverage (according to a PCA risk management reading of risk). This is also easy to interpret in light of the safe heaven role played by Switzerland during the financial crisis.

This approach to leverage and Systemic risk exposure could also produce incentives for management to reduce exposure not necessarily selling assets, in order to decrease the number of assets: Management could choose to reduce the exposure to PCR[52], thus expecting that the magnitude of the linear coefficient of CDS onto PCR may decrease.

Given the relevance in this work of the PCR statistics and the coefficients of PCR, we have conducted a series of tests to deal with the issue of unit root presence in the time series. Both the KPSS and the augmented Dickey–Fuller test point towards the conclusion that all principal components of risk and regressand variables are stationary. More detail is provided in the appendix.

PCR Capital Adequacy Test and PCR Statistics: Inference on a Bank's Capital Structure

This chapter has presented a wealth of results relating to econometric regressions of Debt onto PCRs and Equity onto PCRs. The purpose of such regressions is to provide a viewpoint from an economic angle on the role of debt in explaining the evolution of capital structure when we restrict the analysis of risk to market variables only. We have therefore derived a measure of systemic risk, by analyzing the levels of adjusted R squares and the amount of the linear coefficient for the first Principal Component of risk.

---

[51] $R_{pca}(d)$, or R2(Debt)

[52] The variables composing PCR are traded, hence reduction of the exposure entails trading the liquid variables according to the weights α introduced in chapter 2 when defining PCR.

This section will instead assess the statistical significance of debt in the evolution of the capital structure, with respect to the variation of assets as described by PCRs. This test, introduced in the previous chapter, was named PCR Capital Adequacy Test and consists in testing

H_0: β=0 versus H_1: $\beta \neq 0$ in the regression below:

$$\Delta E_t = \lambda * \Delta PCR_t - \beta * \Delta D_t + \varepsilon_t$$

Accepting the alternative hypothesis requires values of the t-statistics sufficiently high (absolute number). In essence the Capital Adequacy test imposes the analysis of a regression similar to the one run for the purpose of computing one of the PCR Statistic, $R_{pca}(e)$: the difference in the two regressions is in the introduction of one more regressor, the variation of CDS. Indeed $R_{pca}(e)$ is the adjusted R squared obtained from the regression

$$\Delta E_t = \lambda * \Delta PCR_t + \varepsilon_t$$

We will present the results of the PCR Capital Adequacy test for all the banks within the sample introduced above and determine the result of the test on the same dates adopted for the computation of the PCR Statistics.

In the table below we will therefore summarize the evolution of R squared with and without the adoption of the daily variations of CDS as further regressor when explaining daily variations of Equity via daily variations of PCRs (in the table respectively *R2(Equity)PCRCA* and *R2(Equity)*).

The screening of the PCR statistics has already provided a qualitative understanding of the capital structure of the 11 banks analyzed above: does PCR Capital Adequacy test provide a similar assessment on their capital soundness?

We will also list below the Estimate of β, and the lowest significance level at which the null hypothesis can be rejected (the P-value).

As mentioned in the previous chapter, rejecting the significance of the debt in the regression when the fit of the data is poor (Adjusted R squared below a certain percentage) may simply imply that debt does not add much explanatory power to the evolution of equity when the latter is not well explained by PCRs either: hence the significance of CDS will be deemed poor. In such context to accept the null hypothesis is not economically equivalent to the conclusion that the capital structure of the bank does not rely on debt for absorbing the volatility of assets. Therefore it may be inappropriate to conclude that the bank is well capitalized (in first place a poor R squared signals that Equity cannot be explained by the variation of assets, if the reader believes in the decomposition of market variables proposed by PCR).

Hence methodologically the writer proposes to select a significance threshold and analyze which banks see the alternative hypothesis accepted. Formally the alternative hypothesis is a value of beta different from zero. By analyzing the regression, beta, if significantly different from zero, is expected to have a negative value, since a drop in the value of equity should manifest itself with higher risk of the debt, hence higher level of CDS. Hence, although we report P values for the alternative assumptions of a value of beta different from zero, economic intuition should lead to reject the relevance of debt for positive values of the t-statistic. This is the case for UBS and Intesa. In both cases the value of the t-statistic is positive and the R squared is very similar; the P-values would then encourage the conclusion that the alternative assumptions of Beta different from zero can be rejected in both cases, especially for Intesa (greater P-Value): hence the capital buffer of these 2 banks would seem appropriate according to this test. Would we derive a similar conclusion from the Debt Regression introduced in the previous chapter?

TABLE 16: RESULTS OF THE EQUITY REGRESSION AND THE PCR CAPITAL ADEQUACY TEST

Banks	R2(Equity)	R2(Equity) PCRCA	Beta Significant (P-Value)	T-test	Beta Estimate
Intesa	0.45	0.45	27.9%	0.59	0.0000
Monte	0.195	0.225	24.4%	-0.69	0.0000
Calyon	0.424	0.431	0.7%	-2.49	-0.0030
BNP	0.574	0.576	3.0%	-1.88	-0.0110
SocGen	0.491	0.503	<1%	-3.61	-0.0140
DB	0.573	0.576	1.3%	-0.41	-0.0080
CMZB	0.262	0.263	9.0%	-2.76	-0.0010
Santander	0.441	0.45	1.0%	-3.17	-0.0020
BBVA	0.47	0.477	0.2%	-2.98	-0.0020
CS	0.446	0.446	42.6%	-0.19	-0.0010
UBS	0.411	0.411	13.2%	1.12	0.0020

Economic intuition suggests that if Debt does not play a role in the evolution of the capital structure, then the variation of the assets will not have a good explanatory power on the variations of CDS. If instead we found a contradictory result, then the conclusion that the bank is well capitalized requires further scrutiny. The analysis of the Debt regression indeed brings a wealth of considerations that helps in understanding the different nature of these 2 banks, yet so similar at a very first stance derived from the PCR Capital Test. Not only the PCR statistic for debt is much higher for Intesa, but also the analysis of the coefficients shows that all coefficients for the 3 PCRs shows a significance lower than 1%. Hence we do not conclude that in the observed years Intesa has a sufficient buffer of equity such as to exclude the role of debt in explaining the variation of the assets. The actual sensitivity of debt, in terms of dependence from PCR(1) is over 6 times the one determined for UBS. We are keener instead in concluding that UBS is a well capitalized bank, due to its low coefficients for PCR(s) estimated in the Debt Regression and for the positive value of the t-statistic while performing the PCR Capital Adequacy Test.

TABLE 17: PCR CAPITAL ADEQUACY TEST AND PCR STATISTICS (INTESA AND UBS)

Analysis of capital Structure	Intesa	UBS
R2(Equity)	0.45	0.411
R2(Equity) PCRCA	0.45	0.411
Beta Significant (P-Value)	0.279	0.132
T-test	0.59	1.12
Beta Estimate	0	0.002
R2(Debt)	0.672	0.597
PCR 1 Coeff (Debt)	2.301	0.361
P Value PCR 1	<1%	<1%
P Value PCR 2	<1%	37.50%
P Value PCR 3	<1%	35.80%

We will now explore the banks whose Capital Adequacy Test leads to accept the alternative hypothesis with a significance at 1%. Calyon , Societe' Generale, Santander and BBVA represent the bank where the null hypothesis is rejected, due to a value of Beta strictly negative.

TABLE 18: BANKS WHOSE CAPITAL ADEQUACY TEST REJECTS THE NULL HYPOTHESIS (WITH 99% CONFIDENCE)

Analysis of capital Structure	Calyon	SocGen	Santander	BBVA
R2(Equity)	0.424	0.491	0.441	0.47
R2(Equity) PCRCA	0.431	0.503	0.45	0.477
Beta Significant (P-Value)	0.007	<1%	0.01	0.002
T-test	-2.49	-3.61	-3.17	-2.98
Beta Estimate	-0.003	-0.014	-0.002	-0.002
R2(Debt)	0.707	0.668	0.624	0.638
PCR 1 Coeff (Debt)	1.205	1.17	2.113	2.338
P Value PCR 1	<0.01%	<0.01%	<0.01%	<0.01%
P Value PCR 2	4.90%	45.80%	<0.01%	<0.01%
P Value PCR 3	0.80%	22.80%	<0.01%	<0.01%

The joint analysis of PCR Capital Adequacy test and the of the results of the Debt regression on the Spanish banks (in the sample) will lead to the conclusion on the relevance of debt in the evolution of the capital structure (for a sample from 25 Oct 2010 to 19 Oct 2012). Not only the PCR Capital Adequacy test rejects the null hypothesis of a null value for beta, but the Debt regression estimates the 3 coefficients for the Principal components of risk at a significance of 1%. Credit Agricole's capital structure also relies on debt in aborbing the risk of the assets. The coefficients of the Principal Components of Risks (for BBVA, Santander and Calyon) are estimated at a significance of 5%. Hence in this case PCR capital adequacy test and Debt regression, respectively with type I error probability of 1% and 5% lead to the same conclusion of the relevance of the debt in explaining the variations of assets. A similar conclusion cannot be reached with the same low probability of type I error for Societe' Generale. Indeed the second and the third component of risk may be irrelevant for the purpose of explaining the variations of debt (given the high P-value).

We will now comment upon the banks where the null hypothesis was not rejected, which could hint that these banks do not rely on the role of debt for absorbing the variations of the assets. In order to gather a further insight on the results of the PCR Capital Adequacy Test we will avail ourselves of the Debt regression results and the Equity regression results.

Credit Suisse and BNP not only pass the PCR Capital Adequacy Test, but the the second and the third principal component of risks may have no explanatory value on the variations of debt with probability higher than 5%. This is not the result of a poor fit of the data, given the high adjusted R Squared of the debt regression of respectively 63.1% and 72.4%. Interpreting the results for Deutsche Bank is not so immediate. The linear coefficients for the 3 principal components of risk are estimated different from zero with a significance level lower than 1%. Yet it is important to notice that the the Debt Regression exhibits a poor fit of the data, with an adjusted R Squared of 38.4%, i.e. the lowest across the whole sample of banks investigated in this thesis. On the other hand economic intuition would suggest that the equity component is well explained, in its daily variations, by the PCR, with an adjusted R squared of 57.3%, significantly higher than the adjusted R squared obtained in the Debt regression. We therefore conclude that PCR Capital Test and the Equity regression make the writer inclined to believe that the equity buffer for DB shows a magnitude such as to be deemed sufficient to absorb the daily variation of assets.

TABLE 19: BANKS WHOSE CAPITAL ADEQUACY TESTACCEPTS THE NULL HYPOTHESIS

Analysis of capital Structure	CS	DB	CMZB	BNP
R2(Equity)	0.446	0.573	0.262	0.574
R2(Equity) PCRCA	0.446	0.576	0.263	0.576
Beta Significant (P-Value)	0.426	0.013	0.09	0.03
T-test	-0.19	-0.41	-2.76	-1.88
Beta Estimate	-0.001	-0.008	-0.001	-0.011
R2(Debt)	0.631	0.384	0.418	0.724
PCR 1 Coeff (Debt)	0.461	1.17	1.3	0.854
P Value PCR 1	<0.01%	<0.01%	<0.01%	<0.01%
P Value PCR 2	9.70%	<0.01%	3.20%	29.90%
P Value PCR 3	7.80%	<0.01%	0.60%	12.20%

Banca Monte Dei Paschi di Siena is one of the banks where PCR Capital Adequacy test and the Debt regression suggest two different judgements of the capital structure. Yet the PCR Capital Adequacy Test relies on a fit of data so much poorer than the Debt Regression (respectively adjusted R Squared of 22.5% and 60.9%) that we deem valuable the analysis of the linear coefficient of the principal components of risk (in light of their significance). Not only they are different from zero with a significance level lower than 1%, but the magnitude of the coefficients is the highest across the entire sample.

Data also shows that the Equity Regression provides a poor adjusted R squared (19.5%) due to increase slightly once we add CDS variations as one more regressor (for the purpose of running the PCR Capital Adequacy Test). Such increase in the adjusted R Squared (from 19.5% to 22.5%) still signals a poor fit and therefore a statistical acceptance of the null hypothesis is of little added value, if compared to the quality of fit of the Debt Regression (60.9%). Hence the author is inclined to conclude that Debt plays a relevant role in adapting to the market variables variations for Banca Monte dei Paschi di Siena.

TABLE 20: RESULTS FOR BANCA MONTE DEI PASCHI DI SIENA

Analysis of capital Structure	Monte
R2(Equity)	0.195
R2(Equity) PCRCA	0.225
Beta Significant (P-Value)	0.244
T-test	-0.69
Beta Estimate	0
R2(Debt)	0.609
PCR 1 Coeff (Debt)	2.951
P Value PCR 1	<0.01%
P Value PCR 2	<0.01%
P Value PCR 3	<0.01%

Merging PCA Risk Management with a Regulatory Framework

We have emphasized the limits and the rationale of the regulatory framework when it defines capital and risk weight factors. On one hand we acknowledge the need to build a framework not too market oriented. A limit of the PCA approach is that it derives from a market evaluation of risk. Hence such a risk management could overreact in case the market is stressing some market variables as a result of panic behavior or lack of liquidity[53]. On the other hand ignoring the market pricing may lead to divergences where Management addresses and discloses a measure of risk quite dissimilar from the ones perceived by the market.

Hence this section is dedicated to the proposal of a new solvency ratio which, on one hand considers the accounting input and, on the other, embeds the most relevant conclusions here drawn in terms of risk management and Principal components of risk.

[53] The author also believes that PCRs derived from a history of data of 2 years or more do not expose to the danger of running a risk management based on variables biased by panic or overreactions, under the belief that panic cannot last for such a long amount of time.

Changes in regulatory frameworks, mostly acknowledged at the time of writing as CRD IV have introduced a number of requirements on capital, some of which will be explored in the appendix. In terms of solvency ratio, as explained earlier in this work, such new definition of capital has affected primarily the numerator of the ratio (*CT1/RWA*). Risk management deals with risk on balance sheet as opposed to risk asset specific (not seen in the context of a balance sheet/ portfolio where it is hosted): hence this work should provide suggestions on the methodology to assign a weight converting an asset into a risk weighted asset (RWA), in light of the specific characteristics of the balance sheet and taking in consideration the behavior of the asset itself.

The weight of the asset should ideally be higher for assets that represent a significant risk for the bank: if the reader believes that a reading of risk can be simplified via PCR(s), then the asset is risky if the correlation with PCR is high.

On the other hand we can rely on PCR(s) for the purpose of summarizing balance sheet risk only if they have explanatory power on debt and/or equity of the bank.

Furthermore, we would expect that a measure of soundness would suggest the strength of the balance sheet to tolerate an adverse shock: not a simple analysis of scenario, but an abrupt change in correlation that would deprive the bank from the diversification it was relying when composing the portfolio. If we revisit the evolution of the crisis, many assets behaved similarly during their fall in value. These vague principles will be clearer at the end of this paragraph when introducing a formula with all the inputs that we deem relevant to define the weight of one asset.

For all these reasons the proposal of a Solvency Ratio relies on a numerator derived from an accounting measure of profits: it is very similar to the one considered in the Core Tier 1 Ratio. The implicit assumption that we are making is that the numerator, as a measure of available capital, has to reflect a long term measure which accounting models can provide. Ultimately if management has decided that some assets are not impaired in spite of their loss in value, they deem that they will recover the losses and therefore the accounting measure will prevail in the long term as a capital measure. On the other hand, to make the measure of Tier1 Capital credible, the latter cannot be composed of latent losses for a percentage higher than k%, which is the reason why we introduce point (B) below.

On the denominator we will give a different rule of construction, derived from the main concepts exposed in this work.

The denominator will be a sum of the assets multiplied by a risk weight factor, similarly to the approach of risk weights as currently adopted. The only difference derives from the definition of risk weights which will depend, among others, upon the correlation between the yield of the assets and the PCR of the bank. Such a definition of solvency ratio would produce incentives to build a composition of assets aligned with a correct computation of risk reward in the metric of the balance sheet volatility. In this light a low yielding asset, yet poorly (or negatively) correlated with the evolution of the principal component of risk may be selected as a good investment by management.

In line with the reasoning so far exposed, the definition of risk weights will be dependent on asset specific factors and bank specific factors. The considerations to be blended (numerically) for the purpose of enhancing the significance of capital ratios are:

A. The explanatory power of the PCR on the stock of the bank and its debt (or CDS). If a bank is characterized by very contained Balance sheet variance (relative to its capital structure), then the incentive in adding among its assets a PCR correlated security should be treated differently from the same choice of another bank with high level of PCR Statistics. This point is very financial institution subjective and forces management to keep under control the balance sheet from cumulating too much systemic risk. This point is asset non specific, since it does not depend so much on the single asset but mainly on the capital structure of the bank determining the risk weights. For this reason the risk weight will be dependent on the value of the PCR statistics, i.e. the sum $\mathrm{R_{pca}(e)} + \mathrm{R_{pca}(d)}$. On the other hand, a low value of the PCR statistics warns that the reading given via PCR(s) has a weak explanatory power on the capital structure of the bank and therefore Risk weighted assets derived via a PCR Risk Management should be very small because such risk management did not “guess” the principal component of risks apt to describe the evolution of the bank’s capital structure.

B. The potential (accounting wise) that a large not realized loss is not deducted from Tier 1 Capital. In order to address such issue the bank should not exceed a certain percentage of Tier 1 Capital in terms of latent losses (hence not deducted from Tier 1 Capital). In simpler terms: unrealized losses not deducted from Tier 1 Capital cannot represent more than k% of the tier 1 capital. If they turn to be higher then the amount in excess has to be deducted from the numerator of the Tier 1 Ratio. This requirement allows market players to believe in the intrinsic amount of published capital by suggesting that a haircut (to the amount of Tier 1 Capital and to the published ratios) higher than k% is too conservative. It also makes different banks comparable since two banks with and without latent losses over k% should reflect such difference. This requirement is also not asset specific. k should be a variable chosen by regulators.

C. Estimate of the linear regression of the asset yield on the level of the first principal component of Risk: this factor is asset specific and encourages management in selecting investments efficient in terms of return versus systemic risk, rather than return versus generic risk. It is important to notice that a negatively correlated asset may generate therefore a negative risk weight, since the correlation would be negative. This would be an important incentive in not looking at the yield only of the asset but to apply a portfolio approach achieving the minimum balance sheet variance. We will denote by $\rho(y_i, PCR(1))$ the correlation between the (variation of the) asset yield y_i and the (variation of the) first principal component of risk; we will denote by $\beta(y_i, PCR(1))$ the estimate in the linear regression

$$\Delta y_i = a + \beta * \Delta PCR(1) + \varepsilon$$

D. Historical average[54] in the last 2 years of the implied probability of default derived from the CDS market. When a CDS market does not exist for the specific issuer, then a similar average should be computed in terms of the

[54] Such historical average may be computed over a number of years equivalent to the residual maturity of the assets. For a matter of homogenous treatment of data the author prefers an average over the same history of data used to compute PCRs.

closest comparable by rating and sector. Such average allows smoothing out periods of panic in the market. Such implied average probability should be multiplied by (1-r), where r is the recovery value used as input to obtain the implied probability of default from the historical levels of CDS. We will denote the probability thus derived as p(r), which may be interpreted as a probability of default of the asset whose risk weight is to be determined[55].

Hence the risk weight for a specific asset i whose yield is y_i would be, according to the criteria listed above:

$$[R_{pca}(e) + R_{pca}(d)] * \rho(y_i, PCR(1))|\beta(y_i, PCR(1))| * p(r) * (1 - r)$$

Accounting and Risk Management: Time to Use a Unique Language?

Even if the reader agreed with most of the proposals and conclusions contained in this work, the implementation would face a technical difficulty: if management found a hedging technique which could reduce the balance sheet volatility, then what accounting format should be used? Any practitioner is aware that the adoption of derivatives as a hedging instrument is contemplated by IAS within a set of rules defining Hedge Accounting. Hedge Accounting has the ultimate rationale to preserve the value of the Hedged Item against a designated risk. Even without an in depth analysis a simple introduction to Hedge Accounting is enough to clarify that the notion of risk management introduced in this work is very different from the one known to accountants when applying Hedge Accounting: Risk management as per IAS approach deals with single assets and/or liabilities. This work instead proposes a frame to deal with balance sheet variance. Chances to ultimately address balance sheet variance via addressing the value of single assets are, in the writer's opinion, very low.

From a pure methodological approach a risk manager should identify principal risk factors, hedging policies and suggestions for management aiming at being

[55] We acknowledge that the probability thus determined is not a "true" probability since it embeds a market price for the risk which, especially during turbulent times, may overestimate the "actual" probability of default. Yet this work is keener to incorporate within risk weights the actual price for risk, rather than a theoretical probability: management ultimately means implementing hedging policies at market prices rather than simply representing a distribution of risk with the doubt that it may prove wrong.

countercyclical with respect to the PCR. In a more pragmatic approach, especially when dealing with inverted capital structures, then a risk manager may find immediate to evaluate counter-cyclicality against CDS and not against PCR. Especially if debt is not liquid on the secondary market, then the author believes it may be efficiently approximated by the level of CDS (if quoted).

Ultimately supporters of the notion of risk management discussed in this work will face a dilemma. Most of the risk summarized by the principal components of risk derives from assets under an accounting treatment which requires no change of value (accounting wise) unless a specific impairment is made. This is the most relevant contradiction: accounting shows no volatility whereas PCA driven Risk management emphasizes exactly the opposite. If a hedging policy were designed and proved efficient to implement according to PCA Risk management, then such policy would simply add noise to Financials, since it would hedge the value of assets whose accounting representation will instead show no variation.

One of the reasons for the skepticism towards the soundness of the banking sector is due to a communication to the market of a value distorted from its economic perception: positive profits and drop in market capitalization are the sides of a coin where the market assessment of value is at odds with the accounting conclusions of management. Believing to the accounting measurement of value has proved very costly, since it caused, among other effects, that the banking sector was the slowest player in the market either in adjusting its risk, or in deciding not to adjust it at all, in the belief that ultimately capital is to be read through financials and not through market values.

A proposal on how to fill the gap between these 2 measures of value is well beyond the purpose of this work and is left as a topic for future research.

Subordinated debt: Can it Help in Reducing Balance Sheet Variance?

In this section we provide the terms of a subordinated debt which may achieve the goal of reducing the balance sheet variance. We emphasize that such idea was never shared with a regulator: therefore some readers may find the terminology “subordinated” misleading, since capital management typically associates a regulatory benefit in issuing a “subordinated” bond.

We use the terminology “subordinated” since we see this as a new liability of the banking sector with a purpose different from standard senior issuance. Whereas senior issuance has the aim of securing liquidity for a certain maturity, the subordinated debt has the purpose to provide liabilities which rank lower than senior debt and whose purpose is a benefit on capital. In what we will describe below we do envision a benefit for the economic capital, since the balance sheet variance should decrease after the issuance of this typology of debt. Hence we may achieve a benefit by reducing balance sheet variance, but no conclusions can be drawn in terms of regulatory capital.

In an ideal world, PCA Risk Management would see the purchase of long term options on the Principal Components of Risk as beneficial for the purpose of balance sheet variance reduction. Indeed, if the variance of the balance sheet is ultimately decomposed into Principal Components of Risk, then buying put options on such underlyings is ultimately variance reductive.

Led by this intuition, we seek to translate this idea into a practical example; the market may not be liquid enough in pricing options on PCR, hence we analyze the variables composing PCR and select the few where an option market has developed. We will then embed such option within a newly conceived liability, which we will call “PCR redemption linked note”. Such note may redeem, upon the discretion of the issuer

i. In cash for an amount equal to the notional amount or
ii. In terms of other securities (or payout[56]) which are closely related to PCR.

The reader may have already noticed the similarity with the construction of an ordinary convertible security. A description of the latter is beyond the scope of this work, but, in essence, the issuer of a convertible security may convert the amount borrowed into another instrument of the capital structure, typically equity (via a conversion factor).

[56] The terminology established in the option market would then refer respectively to Physical or Cash delivery upon exercise.

The analogy is useful since the subordinated debt here presented gives the the issuer the optionality to choose, at a certain date, between a redemption at 100% (or nominal value) or by delivering specified securities.

In essence, such subordinated debt can be decomposed into the sum of a standard nominal liability (i.e. a liability whereby the issuer commits to redeeming at 100% of the notional amount) and a put option on one or more securities.

The balance sheet variance will reduce simply because the bank is implicitly buying options to sell underlyings strongly related with PCR[57].

The success of this idea depends on the existence of market players whose balance sheet soundness does not depend from the same PCR that matter for the banking sector. Such players may be

a) Capable to manage such volatility since the evolution of their balance sheet is not so correlated to the PCR or with the securities to be delivered in case of conversion.
b) Long term buyers of the securities which can be delivered as a result of the conversion; such buyers may not be so sensitive to adverse movements of mark to market (such market players then achieve a significant yield enhancement as a result of the premium obtained from selling a put option on securities).

A practical example of such liability can be designed for the banking sector: it would provide a benefit especially when the funding pressure for sovereigns and local banks reaches a high level of correlation. This event is not only widely explored by literature, but also consistent with the relevance of the government yields (to be deduced by analyzing the magnitude of the loadings) when defining the principal components of risk.

[57] A variance reduction of the balance sheet requires a selection of the asset(s) with highest absolute loading in the definition of the first PCR. Then a PCR Redemption Linked note would imply to buy puts on assets with high positive loading (for the purpose of defining PCR(1)) and with a positive linear coefficient in the linear regression of the daily variation of CDS onto the first PCR (or with negative loading weight and a negative linear coefficient in the regression just mentioned).

At certain stages, volatility of financial CDS reached peaks signaling panic levels: during such turbulent times one of the most important variables in the definition of the PCR is the yield of the government securities.

Hence, a PCR redemption linked note could be designed to lower the balance sheet volatility explained by government yields; a PCR redemption linked note would require that government securities be delivered at the discretion of the issuer. An example follows, aiming at providing details of a bond embedding a put option on government securities[58]:

- 10 years maturity
- After 5 years (Exercise date) the issuer (bank) has an option to

1. Either redeem the note at 100% of the notional amount
2. Or deliver government securities (specified at the time of the issuance of the PCR redemption linked note) with a maturity of 5 years and where

Amount of securities to deliver:

$$\text{Notional Amount} * \ \text{conversion factor}$$

- Conversion factor = 100% / Forward price
- Forward Price : the price for forward purchase on the securities; tenor is equal to the Exercise Date
- Price of the PCR redemption note, which we will denote as “Offer Price”:

$$\text{Offer Price} = 100\% - \text{put price} * \text{conversion factor}$$

- Put price: to be derived via standard literature models where the key input is the realized volatility or the deliverable securities; or implied volatility, if quoted in the market.
- Coupon of the note prior to Exercise Date:

$$\text{Offer price x (euribor} + \text{CDS)}$$

- CDS: The CDS level of the bank issuing the PCR Redemption linked note, fixed once, at issuance date.

We will explore in the appendix the consistency of the PCR redemption linked note with the new Basel III framework, to assess similarities and differences

[58] The issuance with a bond with such characteristics would benefit a financial institution whose PCR(1) is defined by high loading coefficient with respect to government yields.

with existing guidelines on the theme of instruments admissible for computation as regulatory capital.

Conclusions

Last 2 chapters present a model to address risk management and Capital Management founded on the tool of Principal Component Analysis: we thus define the Principal Components of Risk. The latter are not only a decomposition of risk by means of liquid variables, but also the regressors to evaluate the sensitivity of the capital structure of a bank to a modern and market implied definition of risk. A bank exhibits an Inverted Capital Structure when its debt is more reactive than equity to the evolution of Principal Components of Risk. We then revisit the concept of risk weight adopted in the definition of Core Tier 1 Ratio and provide a measure of the latter more adherent to an economic concept of Capital (as opposed to a regulatory notion of capital). We propose economic and statistical methods to explore the soundness of banks' capital structure. These methods, based on the evolution of equity and CDS, are applied to a sample of European Banks, for dates representing the peak of the current Financial Crisis (2010- 2012).

While dealing with Balance Sheet Variance we revisit the role of subordinated debt and define a new liability conceived for the purpose of reducing balance sheet variance. We also adopt the PCA Risk management to explore the liquidity requirements imposed by Basel III (in the Appendix)

APPENDIX

Subordinated debt and Basel III: the role of COCOS

Basel III proposes a definition of the components of regulatory capital[59] by introducing various layers of capital such as

Common Equity Tier 1

Additional Tier 1 Capital

Tier 2 Capital

We do not mean to provide a definition of the components of regulatory capital: we will focus on a particular requirement established for issued securities so that they may classify as liabilities and be eligible for the purpose of computation as Additional Tier 1 Capital.

Instruments classified as liabilities for accounting purposes must have principal loss absorption through either

(i) conversion to common shares at an objective pre-specified trigger point or (ii) a write-down mechanism which allocates losses to the instrument at a pre-specified trigger point. The write-down will have the following effects:

a. Reduce the claim of the instrument in liquidation;

b. Reduce the amount re-paid when a call is exercised; and

c. Partially or fully reduce coupon/dividend payments on the instrument.[60]

Do PCA Risk Management and Basel III provide a definition of capital consistent with each other? In the section above we have identified the terms of a "subordinated" debt with the purpose of decreasing the balance sheet variance. The rational is simple enough: the conversion of a liability into variables closely related to Principal Components of Risk (the bank achieves a balance sheet variance reduction via a long position on options with underlying one or more components of the Principal Components of Risk).

[59] Readers interested in the theme should refer to the wide literature and FAQ documents published by the bank for international settlement.
60 Page 17, paragraph 55, number 11.

Hence Basel III and PCA Risk Management both rely on the optionality of Conversion. The differences arising from the 2 approaches are

The trigger mechanism and the loss absorption: both terms intuitively recall an accounting language describing the clauses of conversion, with the definition of a trigger point. Some bonds eligible for computation within Additional Tier1 Capital convert into equity once the core Tier 1 Ratio falls below a certain minimum threshold. Some others, instead, simply deduct a certain amount from principal in case the event of fall of Core Tier 1 ratio materializes. The author has emphasized that accounting allows for "latent" losses (not yet realized). Hence a trigger point defined in terms of Core Tier 1 Ratio is not guaranteed to be activated when most required, i.e., when balance sheet volatility increases; the economic value of conversion would be maximized if it could be determined on a pure economic ground. A management experiencing exceptional turbulence may not attempt to reduce balance sheet volatility, by retaining as many losses as possible, hoping for a normalization phase. In such a scenario, losses would not be realized and the conversion mechanism would not trigger, thus providing little economic benefit. A conversion mechanism not defined in terms of accounting losses is therefore to be preferred, in the author's opinion.

The converted securities: this is the main point of difference between PCR Risk Management and Basel III. Basel III disposes that the converted securities should be common shares: certainly adding equity to the bank reduces leverage, and there could be no more efficient measure to address a moment of stress. Yet a Basel III compliant contingent convertible is not a viable solution for all banks, in light of the market appetite for these instruments, limited to the strongest financial institutions only. This is the reason why Contingent Convertibles, as defined by Basel III framework, have been issued only by the soundest financial institutions and such issuance cannot be contemplated by the weakest ones. More importantly the market will judge the potential volatility of profits and balance sheet to judge the probability of conversion. Hence banks operating into fragile economies are automatically deprived of this important instrument. The author then believes that a conversion into the Principal component of risks, or some of them, is the most affordable tool to decrease balance sheet volatility. An example is provided above.

Basel 3 framework on liquidity: similarities and differences from PCA risk management

"Basel III" is a comprehensive set of reform measures, developed by the Basel Committee on Banking Supervision, to strengthen the regulation, supervision and risk management of the banking sector. These measures aim to:

Improve the banking sector's ability to absorb shocks arising from financial and economic stress, whatever the source

Improve risk management and governance

Strengthen banks' transparency and disclosures.

The reforms target:

bank-level, or microprudential, regulation, which will help raise the resilience of individual banking institutions to periods of stress.

macroprudential, system wide risks that can build up across the banking sector as well as the procyclical amplification of these risks over time.

These two approaches to supervision are complementary as greater resilience at the individual bank level reduces the risk of system wide shocks[61].

The purpose of this work is not to give a comprehensive analysis of the Basel III framework: yet we write this section to analyze if a PCA driven risk management is flexible enough to address some of the main innovations introduced by the regulatory changes introduced under the Basel III regulatory reforms.

We will discuss in this section the introduction of liquidity requirements.

Such new requirement is subject to a “transition period”, hence they are gradually being implemented, since their immediate adoption was not compatible with the balance sheet structure of the banking sector at the moment of release.

Liquidity is addressed by the introduction of two ratios, the LCR (Liquidity Cover Ratio) and the NSFR (Net stable Funding Ratio).

[61] From the web site of the Bank for International Settlement, http://www.bis.org/bcbs/basel3.htm

Basel III requires that liquidity be structurally addressed with a short term horizon (LCR) and a long term horizon (NSFR) coefficient. The first one is based on an assumption of net cash outflows in the next 30 calendar days; it thus requires an allocation of investments, at least for the amount of the net cash outflows, into "high quality liquid assets". If we believed in a PCA approach to risk management, then we would require a poor correlation between the principal components of risk and such assets. The regulatory requirements do provide some qualitative requirements in line with the main intuitions of this work, since they include, among the "Fundamental characteristics"

Low correlation with risky assets: the stock of high-quality liquid assets should not be subject to wrong-way (highly correlated) risk. For example, assets issued by financial institutions are more likely to be illiquid in times of liquidity stress in the banking sector[62].

Yet, when providing stringent criteria of the assets eligible for fulfilling this requirement, the document lists

marketable securities representing claims on or claims guaranteed by sovereigns, central banks, non-central government PSEs, the Bank for International Settlements, the International Monetary Fund, the European Commission, or multilateral development banks and satisfying all of the following conditions:

assigned a 0% risk-weight under the Basel II Standardised Approach;

traded in large, deep and active repo or cash markets characterised by a low level of concentration;

proven record as a reliable source of liquidity in the markets (repo or sale) even during stressed market conditions; and

not an obligation of a financial institution or any of its affiliated entities.[63]

It is not difficult to imagine securities which may satisfy all these requirements, yet show a strong level of correlation with the CDS of the bank addressing the liquidity risk. In such scenario it is very likely then that a period of funding stress

[62] Page 5 of "Basel III: international framework for liquidity risk measurement
[63] Page 8 of the document

for the bank may also be a period of (economic) loss on the securities selected to satisfy the requirement of the LCR. An example is given by securities issued by a government experiencing a period of difficulty in its funding program: it would fulfill the requirements here listed, yet be a poor source of liquidity during a liquidity crunch.

The rationale of the NSFR, instead, is summarized by requesting that available resources exist ("Available amount of stable funding") to face the "Required amount of stable funding". It is a longer term requirement (with respect to the LCR) which provides a weight to every liability in the balance sheet reflecting how stable such liability may be considered in providing funding. It also assigns a liquidity weight factor to every component of the asset to summarize in what extent such asset require stable funding. PCA risk management would argue in favour of a low liquidity factor to associate to assets if inversely correlated with the CDS of the bank (or with its principal components of risk).

How would a PCA driven risk management address the liquidity risk?

So far we have analyzed the regulatory framework imposing a solution ultimately made of an allocation, on the asset side, contemplating a short term stress in liquidity (LCR). Also the NSFR addresses the composition of liabilities so that there is consistency between assets and the stability of funding they require. What would a PCA driven risk management also suggest? Clearly this question is equivalent to also testing if the idea of risk management introduced in this work is robust enough to handle one of the most difficult problems of the financial crisis: liquidity.

Liquidity risk is embedded in the level of CDS quoted by the market for a given Bank (i.e. the probability of default, as expressed by the CDS market, reflects not only the event of insolvency, but also an event of liquidity scarcity). Hence a PCA driven risk management would encourage a search for variables, explanatory of the liquidity of a bank, that are inversely correlated with the CDS.

The author will use some of the conclusions drawn in a previous work where the problem of liquidity is addressed not with respect to a specific bank, but with respect to a set of financial institutions as per composition of the index Itraxx

Financial Senior. The conclusion of such work[64] points at the role of the following variables and their explanatory power on financial CDS:

a) The difference between Euribor and Eonia
b) The difference between the yield of a German Government Bond and a government bond for the same maturity issued by a country experiencing a sovereign crisis
c) The level of the cross currency EUR/USD, for a maturity below 5 years
d) The difference between the level of the CDS and the yield of the government bond for a maturity of 5 years (such difference, named government basis, is particularly relevant in last 2 years, when liquidity has worsened to the point that monetary policy has adopted monetary quantitative measures).

We will not offer a detailed description of the reasons why this empirical finding is justified, since the interested reader may explore the theme in depth by reading the aforementioned work. What is crucial to emphasize is that PCA Risk Management would assess the explanatory power of these variables on the CDS and the stock of the bank: based on the results then the bank can address how much of the volatility of CDS (and of the stock) can be justified mainly by the liquidity risk. If the stock and the debt of the bank are not reactive to these variables, then the market is pricing that the bank is robust enough against liquidity shocks. Hence liquidity requirements should be addressed with different degrees, depending on the specific situation of the bank: a unique standard is understandably imposed for the sake of clarity, yet the measures imposed are not the only way to address liquidity, which, alternatively, can be addressed also by hedging policies whose outcomes are countercyclical, on a statistical basis, with the evolution of CDS (and of the stock). Such hedging policies may involve, among others, the variables here mentioned at point (a), (b), (c), (d).

We conclude this section by noting that the main idea of risk, being summarized by the principal components of risks appears robust enough as to provide a unifying framework for all risks even if a regulatory approach may address them separately. When analyzing PCR at the beginning of this work, one of the

[64] We invite the interested reader to explore the content of the work "CDS: Liquidity shortage or structural insolvency?"

variables negatively correlated with the evolution of the CDS is the difference in yield between “Core” government bonds and “peripheral” government bonds: this is consistent both with point (b) above and with the “Market related characteristics” of the securities which may be considered “high-quality liquid assets” in the context of the definition of LCR:

Flight to quality: historically, the market has shown tendencies to move into these types of assets in a systemic crisis[65].

Hence PCA driven risk management and some requirements of LCR are proposing a common rationale in the choice of variables: in this respect PCA risk management and Basel III framework share some intuitions when addressing liquidity risk.

[65] Page 5, 22b in the document Basel III: International framework for liquidity risk measurement, standards and monitoring.

Results of the regressions of Equity and CDS on Principal Components of Risk

TABLE 21: REGRESSION OF EQUITY AND CDS ON PRINCIPAL COMPONENTS OF RISK

Banks	Intesa	Monte	Calyon	BNP	SocGen	DB	CMZB	Santander	BBVA	CS	UBS
R2(Equity)	0.45	0.195	0.424	0.574	0.491	0.573	0.262	0.441	0.47	0.446	0.411
PCR 1 Coeff	-0.004	-0.001	0.003	-0.02	-0.001	0.016	0	-0.008	-0.012	0.005	0.008
PCR 2 Coeff	0.003	0.002	-0.04	-0.115	-0.135	-0.178	-0.008	-0.008	0.005	-0.078	-0.052
PCR 3 Coeff	0.012	0.007	-0.105	-0.286	-0.352	-0.479	-0.02	0.009	0.028	-0.227	-0.151
R2(Debt)	0.672	0.609	0.707	0.724	0.668	0.384	0.418	0.624	0.638	0.631	0.597
PCR 1 Coeff (Debt)	2.301	2.951	1.205	0.854	0.972	1.17	1.3	2.113	2.338	0.461	0.361
PCR 2 Coeff(Debt)	-3.924	-5.339	-1.089	-0.305	-0.081	-2.475	-1.714	-4.089	-4.84	-0.524	-0.148
PCR 3 Coeff(Debt)	-12.3790 -	-16.708	-4.21	-1.779	-1.525	-7.294	-6.079	-12.4	-14.398	-1.511	-0.448
DW Equity	1.941	1.835	1.84	1.809	1.749	1.841	1.794	1.754	1.745	1.684	1.876
DW CDS	1.76	1.705	1.753	1.79	1.748	2.007	1.897	1.844	1.858	1.922	1.897
	Italy		France			Germany		Spain		Switzerland	

TABLE 22: TESTS ON PCR- AUGMENTED DICKEY-FULLER TEST; KWIATKOWSKI, PHILLIPS, SCHMIDT, AND SHIN (KPSS) TEST

			Critical Values	
	ADF	KPSS	ADF	KPSS
PCR1	-6.372	0.232	-2.871	0.463
PCR2	-5.584	0.24	-2.871	0.463
PCR3	-14.561	0.236	-2.871	0.463

Both tests provide statistical evidence for the conclusion that the principal components of risk, once considered as daily differences, are stationary variables.

TABLE 23: DURBIN–WATSON STATISTICS APPLIED TO THE TIME SERIES OF THE DAILY DIFFERENCES OF EQUITY AND CDS LEVELS FOR THE BANKS IN THE SAMPLE

Banks	R2(Equity)	R2(Debt)	DW (Equity)	DW (Debt)
Intesa	0.45	0.672	1.941	1.76
Monte	0.195	0.609	1.835	1.705
Calyon	0.424	0.707	1.84	1.753
BNP	0.574	0.724	1.809	1.79
SocGen	0.491	0.668	1.749	1.748
DB	0.573	0.384	1.841	2.007
CMZB	0.262	0.418	1.794	1.897
Santander	0.441	0.624	1.754	1.844
BBVA	0.47	0.638	1.745	1.858
CS	0.446	0.631	1.684	1.922
UBS	0.411	0.597	1.876	1.897

TABLE 24: TESTS APPLIED TO THE REGRESSAND VARIABLES. AUGMENTED DICKEY-FULLER TEST; KWIATKOWSKI, PHILLIPS, SCHMIDT, AND SHIN (KPSS) TEST.

Banks	R2(Equity)	R2(Debt)	ADF(Equity)	ADF(Debt)	KPSS(Equity)	KPSS(Debt)
Intesa	0.45	0.672	-16.287	-15.321	0.208	0.179
Monte	0.195	0.609	-15.319	-14.51	0.228	0.108
Calyon	0.424	0.707	-15.859	-14.167	0.35	0.22
BNP	0.574	0.724	-14.825	-13.238	0.215	0.225
SocGen	0.491	0.668	-15.783	-10.082	0.237	0.253
DB	0.573	0.384	-15.663	-12.929	0.122	0.123
CMZB	0.262	0.418	-15.127	-14.829	0.484	0.131
Santander	0.441	0.624	-16.705	-8.016	0.163	0.147
BBVA	0.47	0.638	-16.284	-8.943	0.162	0.143
CS	0.446	0.631	-15.327	-15.652	0.158	0.142
UBS	0.411	0.597	-15.622	-15.125	0.177	0.157

References

1 Abbe, E., A. Khandani, and A. W. Lo, 2011, "Privacy-Preserving Methods for Sharing Financial Risk Exposures," working paper, MIT Laboratory for Financial Engineering.

2 Acharya, V., L. Pedersen, T. Philippon, and M. Richardson, 2010, "Measuring Systemic Risk," working paper, New York University.

3 Acharya, V., and M. Richardson (eds.), 2009, Restoring Financial Stability: How to Repair a Failed System. Wiley, New York.

4 Adalid, R., and C. Detken, 2007, "Liquidity Shocks and Asset Price Boom/Bust Cycles," ECB Working Paper 732, European Central Bank.

5 Adrian, T., and M. Brunnermeier, 2010, "CoVaR," Staff Report 348, Federal Reserve Bank of New York.

6 Adrian, T., and H. S. Shin, 2009, "The shadow banking system: implications for financial regulation," Financial Stability Review, 19, 1–10.

7 Alexander, L., 2010, "Opening Remarks," working paper, Measuring Systemic Risk: A Conference Sponsored by the Milton Friedman Institute, the Chicago Fed, and the New York Fed

8 Allen, F., and D. Gale, 2000, "Financial Contagion," Journal of Political Economy, 108(1), 1–33.

9 Ang, A., and J. Chen, 2002, "Asymmetric correlations of equity portfolios," Journal of Financial Economics, 63(3), 443–494.

10 Bank of England, B., 2009, "The Role of Macroprudential Policy," Discussion paper, Bank of England.

11 Basel Committee on Banking Supervision, 2010, "Countercyclical capital buffer proposal," Consultative document, Bank for International Settlements.

12 2011, "Global systemically important banks: Assessment methodology and the additional loss absorbency requirement," Consultative document, Bank for International Settlements

13 Benston, G. J., and G. G. Kaufman, 1997, "FDICIA After Five Years," The Journal of Economic Perspectives, 11(3), 139–158.

14 Billio, M., M. Getmansky, A. W. Lo, and L. Pelizzon, 2010, "Econometric measures of systemic risk in the finance and insurance sectors," NBER Working Paper 16223, NBER.

15 Borio, C., and M. Drehmann, 2009a, "Assessing the risk of banking crises – revisited," BIS Quarterly Review, 2009(2), 29–46.

16 Boyd, J., and M. Gertler, 1994, "Are Banks Dead? Or Are the Reports Greatly Exagger- ated?," Federal Reserve Bank of Minneapolis Quarterly Review, 18(3), 2–23.

17 Boyson, N. M., C. W. Stahel, and R. M. Stulz, 2010, "Hedge Fund Contagion and Liquidity Shocks," Journal of Finance, 65(5), 1789–1816.

18 Brunnermeier, M. K., G. Gorton, and A. Krishnamurthy, 2010, "Risk Topography," working paper, Princeton University.

19 Capuano, C., 2008, "The option-iPoD. The Probability of Default Implied by Option Prices Based on Entropy," IMF Working Paper 08/194, International Monetary Fund.

20 Chan, N., M. Getmansky, S. M. Haas, and A. W. Lo, 2006a, "Do Hedge Funds Increase Systemic Risk?," Federal Reserve Bank of Atlanta Economic Review, 91(4), 49–80.

21 2006b, "Systemic risk and hedge funds," in The Risks of Financial Institutions, ed. by M. Carey, and R. Stulz. University of Chicago Press, Chicago, IL, pp. 235–330.

22 Chan-Lau, J., 2009, "Co-risk measures to assess systemic financial linkages," Imf working paper, Internanational Monetary Fund.

23 Danielsson, J., and H. S. Shin, 2003, "Endogenous Risk," in Modern Risk Management: A History. Risk Books, New York.

24 De Bandt, O., and P. Hartmann, 2000, "Systemic Risk: A Survey," Working Paper 35, European Central Bank.

25 Duffie, D., 2010, How Big Banks Fail and What to Do about It. Princeton University Press, Princeton, NJ.

26 2011, "Systemic Risk Exposures A 10-by-10-by-10 Approach," working paper, Stan- ford University.

27 European Central Bank (ECB), 2010, "Financial networks and financial stability," Financial Stability Review, 2010, 155–160.

28 Fender, I., and P. McGuire, 2010a, "Bank structure, funding risk and the transmission of shocks across countries: concepts and measurement," BIS Quarterly Review, 2010, 63–79

29 Gray, D., and A. Jobst, 2010, "Systemic CCA – A Model Approach to Systemic Risk," working paper, International Monetary Fund, Paper presented at conference sponsored by the Deutsche Bundesbank and Technische Universitaet Dresden, 28-29 October 2010.

30 Huang, X., H. Zhou, and H. Zhu, 2009a, "Assessing the Systemic Risk of a Heterogeneous Portfolio of Banks During the Recent Financial Crisis," Federal Reserve Board Finance and Economics Discussion Series 2009-44, Board of Governors of the Federal Reserve.

31 2009b, "A framework for assessing the systemic risk of major financial institutions," working paper, University of Oklahoma.

32 2009b, "Global Financial Stability Report: Responding to the Financial Crisis and Measuring Systemic Risks," working paper, IMF.

33 Khandani, A. E., A. W. Lo, and R. C. Merton, 2009, "Systemic Risk and the Refinancing Ratchet Effect," MIT Sloan School Working Paper 4750-09, MIT.

34 Kritzman, M., Y. Li, S. Page, and R. Rigobon, 2010, "Principal Components as a Measure of Systemic Risk," Revere Street Working Paper Series: Financial Economics 272-28, Revere Street Working Paper Series.

35 Laux, C., and C. Leuz, 2010, "Did Fair-Value Accounting Contribute to the Financial Cri- sis?," Journal of Economic Perspectives, 24(1), 93–118.

36 Minsky, H., 1982, Can “It” Happen Again?: Essays on Instability and Finance. M.E. Sharpe, Armonk, NY.

37 Moussa, A., 2011, “Contagion and Systemic Risk in Financial Networks,” Ph.D. thesis, Columbia University.

38 Sapra, H., 2008, “Do accounting measurement regimes matter? A discussion of mark-to- market accounting and liquidity pricing,” Journal of Accounting and Economics, 45(2-3), unting and liquidity pricing,” Journal of Accounting and Economics, 45(2-3),379–387

39 Segoviano, M. A., and C. Goodhart, 2009, “Banking stability measures,” Financial Markets Group, Discussion paper 627, London School of Economics and Political Science.

40 Upper, C., 2007, “Using counterfactual simulations to assess the danger of contagion in interbank markets,” BIS Working Paper 234, Bank for International Settlements.

41 Nassim Nicholas Taleb and George A. Martin, "The Illusion of Thin-Tails Under Aggregation"

42 Rochet, Jean-Charles and Tirole, Jean (1996) "Interbank Lending and Systemic Risk," Journal of Money, Credit and Banking, 28(4), 733-762.

43 Tarashev, Nikola, Claudio Borio, and Kostas Tsatsaronis (2009a), “Allocating systemic risk to individual institutions: Methodology and policy applications,” BIS Working Papers.

44 Vasicek, O., 1991, “Limiting loan loss probability distribution,” Kmv working paper, KMV.

45 Woolridge, J., 2002, Econometric Analysis of Cross Section Panel Data.
The MIT Press, Cambridge, MA.