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Different measures of credit risk: comparison between credit rating and CDS

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Coordinatore: Ch.mo Prof. Franco Ernesto Rubino

Firma

Supervisore: Ch.ma Prof.ssa Maria Mazzuca

Firma

Dottorando: Dott.ssa Caterina Di Tommaso

Firma Caterina Di Tommaso

Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less.

(Marie Curie)

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Sintesi della tesi

Il rapido ritmo di innovazione finanziaria che ha avuto luogo nel corso dell'ultimo decennio ha portato ad una proliferazione di nuovi e sempre più sofisticati prodotti finanziari che hanno reso il sistema finanziario incline al contagio e hanno aumentato il rischio sistemico. Inoltre, la natura globale della crisi finanziaria statunitense ha evidenziato l'integrazione delle economie e dei mercati. In questo contesto di maggiore complessità e integrazione, al fine di garantire la stabilità finanziaria dei mercati, comprendere i mercati finanziari a pieno ed essere in grado di identificare in modo tempestivo le potenziali conseguenze di eventuali nuovi sviluppi diventa una delle sfide più importanti per i policy makers e le autorità di regolamentazione.

La necessità di sviluppare una migliore comprensione del mercato dei credit default swap (CDS) ha guadagnato importanza nel contesto della crisi finanziaria globale in cui è stata dimostrata sia la difficoltà a catturare, che l'importanza di indicatori solidi del rischio di credito dei settori aziendali. Durante la crisi dei mutui subprime degli Stati Uniti, le agenzie di rating (CRAs) sono state considerate colpevoli di attribuire giudizi di rating troppo elevati. Al contrario, il criticismo delle agenzie di rating emerso durante la crisi del debito sovrano europeo è maggiormente focalizzato sulla portata e la tempistica dei downgrade, che ha contribuito a peggiorare la crisi. Questo ha sollevato il problema della stabilità del giudizio di rating dovuto ad un giudizio *point in time* che non tiene in considerazione l'impatto degli shocks economici. Quindi, l'impatto delle fluttuazioni cicliche non viene catturato dai giudizi di rating ma, tuttavia, può fornire importanti informazioni circa la solvibilità di un emittente e può avere importanti ripercussioni sulla stabilità finanziaria del sistema che assume vitale importanza se un'economia vuole raggiungere gli obiettivi di crescita sostenuta e bassa inflazione. Di conseguenza, vi è un ampio consenso sulla necessità di sviluppare misure nuove per la valutazione del merito creditizio al fine di avere migliori strumenti di analisi per le decisioni di policy. Capire l'importanza di misure adeguate del rischio di credito tempestive e comparabili tra i Paesi, così come capire l'interazione tra il sistema finanziario, il resto degli agenti e dei settori economici potrebbe essere rilevante per l'analisi della stabilità finanziaria.

Poichè l'affermazione che i giudizi di rating rappresentano metriche del rischio di default accurate è stata messa in discussione durante la crisi finanziaria e del debito sovrano e gli spreads dei CDS sono ampiamente considerati come consenso del mercato sul merito creditizio emesso dalle agenzie di rating, lo scopo principale di questa tesi di dottorato è quello di studiare e riflettere su due diverse misure del rischio di credito: il *giudizio di rating* e lo *spread dei CDS*. Tuttavia, prima di confrontare le valutazioni del rischio di credito e alla luce dei cambiamenti strutturali emersi durante la crisi finanziaria, appare fondamentale studiare la relativa importanza dei vari fattori che guidano gli spreads dei CDS. L'indagine empirica copre diverse aree geografiche (USA e Europa), diversi settori industriali, nonchè periodi di tempo diversi (periodi di alta volatilità e periodi normali). Ove possibile, gli studi hanno cercato di confrontare i risultati e indagare le ragioni delle differenze.

Il primo capitolo fornisce una panoramica del mercato dei CDS, le principali carenze evidenziate dalla crisi finanziaria e le conseguenti modifiche normative. Inoltre, esso fornisce un'overview della misurazione del rischio di credito con un focus sui modelli di rischio di credito più utilizzati. Si esaminano i due approcci principali per la modellizzazione del rischio di credito, approccio strutturale e reduced-form, e si forniscono approfondimenti sull'applicabilità dei modelli di rischio di credito nel prezzare i derivati creditizi. Dall'analisi teorica degli approcci strutturali emerge che, negli ultimi anni, ci sono almeno due importanti sviluppi nelle applicazioni empiriche di tale approccio alla modellazione del rischio di credito. Il primo, conosciuto come *credit spread puzzle*, solleva preoccupazioni sulla limitata capacità esplicativa dei modelli strutturali. Il secondo riguarda l'utilizzo dei credit default swaps al posto di rendimenti obbligazionari negli studi del rischio di credito. Considerati gli sviluppi nelle applicazioni empiriche dell'approccio strutturale, il secondo e il terzo capitolo esaminano le determinanti dello spread dei CDS con un focus sugli spreads societari e bancari. Più nello specifico, il secondo capitolo si occupa di determinare i principali fattori che influenzano gli spreads dei CDS societari. Impiegando un modello nei livelli e nelle differenze, il capitolo studia l'effetto di fattori firm-specific e macroeconomici che influenzano il rischio di credito di società statunitensi in periodi di alta e di bassa volatilità dei mercati finanziari. Seguendo l'analisi degli spreads dei CDS societari, il terzo capitolo esamina il rischio di credito delle istituzioni finanziarie americane ed europee. La crisi finanziaria statunitense ha sollevato preoccupazioni sull'importanza del rischio di credito nel settore bancario perchè il fallimento di un'istituzione finanziaria può imporre severe esternalità al resto dell'economia e, inoltre, le banche possono agire come meccanismi di trasmissione delle crisi. In questo scenario, gli spreads dei CDS possono essere visti come indicatori di debolezza della banca e, quindi, possono essere usati per estrarre le percezioni di mercato circa il grado di salute delle istituzioni bancarie, in modo particolare delle imprese bancarie sistematiche. Capire le relazioni tra gli spreads dei CDS del settore finanziario e le variabili bank-specific e di mercato è importante per valutare la stabilità finanziaria, e più di preciso diventa di cruciale importanza in termini di supervisione, regolamentazione, disciplina di mercato, così come per professionisti e accademici. Inoltre, è importante per valutare l'effetto *too big to fail*, in particolare per le grandi banche sistematiche.

Dal momento che le agenzie di rating mitigano i problemi di asimmetria informativa tra i partecipanti al mercato dei capitali, la capacità di produrre valutazioni efficienti potrebbe migliorare la loro credibilità in un mercato competitivo e potrebbe essere utile per la stabilità finanziaria. Dato che il problema specifico in questo contesto sta sollevando un notevole interesse nel mondo accademico e industriale e tra i regolatori, il quarto capitolo esamina l'impatto di un annuncio di rating sul mercato dei CDS e l'effetto di spillover sia degli upgrade che dei downgrade. Questo capitolo esamina la questione controversa per quanto riguarda il valore informativo degli annunci di rating sul mercato dei CDS dal punto di vista della stabilità finanziaria. In seguito all'analisi e ai suoi risultati, si derivano e discutono appropriate raccomandazioni di policy e ricerche future. Nel complesso, questa tesi indaga temi di attualità impiegando tecniche econometriche che contribuiscono ad arricchire il piano metodologico.

Summary of the thesis

The rapid pace of financial innovation that has taken place over the course of the last decade has brought about a proliferation of new and increasingly sophisticated financial products which made the financial system prone to contagion and increased systemic risk. Furthermore, the global nature of the US financial crisis also has evidenced the integration of economies and markets. Against this backdrop of increased complexity and integration, in order to guarantee the financial stability of the markets, understanding the financial markets as well as possible and to be able to identify in a timely fashion the potential consequences of any new developments becomes one of the most important challenges for policy makers and regulators.

The need to develop a better understanding of credit default swap (CDS) market has gained significance in the backdrop of the global financial crisis in which has been demonstrated both the difficulty of capturing, and the importance of sound indicators of credit risk of corporate sectors. During the US subprime crisis, the credit rating agencies (CRAs) were viewed as guilty of assigning excessively high ratings. In contrast, criticism of CRAs during the European sovereign debt crisis was more focused on the extent and timing of downgrades, which worsened the crisis. This has raised the question of the stability of the rating assessment due to a rating based *point in time* which does not take into account the impact of economic downturns. Hence, the impact of cyclical fluctuations is not captured by credit ratings but, it can give important information about the solvency of an issuer and can have important implications for financial stability of the system that is vital if an economy is to achieve the objectives of sustained growth and low inflation. As a result, there is a large consensus on the need to develop new measures to evaluate the creditworthiness in order to

provide policy making with improved analytic tools. Understanding the critical importance of relevant measures of credit risk that are timely and comparable across countries as well as the interaction between the financial system and the rest of the economic agents and sectors could be relevant for financial stability analysis.

As the contention that credit ratings represent accurate default risk metrics has been questioned during the financial and sovereign debt crisis and CDS spreads are widely regarded as a market consensus on the creditworthiness issued by credit rating agencies, the main purpose of this doctoral thesis is to study and reflect on two different measures of credit risk: the *credit rating* and the *CDS spreads*. However, before comparing the credit risk assessment and in the light of the structural changes that emerged during the financial crisis, it seems critical to better understand the relative importance of the various factors driving the spreads of CDS. The empirical investigation covers several geographical locations (US, Europe), industrial sectors as well as different time periods (high volatility and normal periods). Where possible, the studies tried to compare the results and investigate the reasons for the differences.

The first chapter provides an overview of the CDS market, the main shortcomings highlighted by the financial crisis and the consequent regulatory changes. Furthermore, it provides an overview of the theoretical framework for measuring credit risk with a focus on the most used credit risk models. It examines the two main approaches for modelling credit risk, structural and reduced-form approach, and provides insights into the applicability of credit risk models when pricing credit derivatives. From the theoretical analysis of the CDS market and the subsequent theoretical analysis of structural approach emerges that, in recent years, there have been at least two important developments in empirical applications of this approach to modelling credit default risk. The first,referred to us as *credit spread puzzle*, was concerned about the limited explanatory power of structural models. The second concerns the use of credit default swaps instead of bond yields in the credit risk studies. Given the developments in structural applications empirical approach, the second and third chapter examine the determinants of CDS spreads with a focus on corporate and banks CDS spreads, respectively. More specifically, the second chapter is concerned with determining the main factors which affect the corporate CDS spreads. By employing a model in levels and in differences, it studies the effect of firm-specific and macro level factors affecting the credit risk of US corporations for periods of high volatility and lower volatility of the financial markets. Following the analysis of the corporate CDS spreads, the third chapter examines the credit risk of US and European financial institutions. The US financial crisis has raised concerns about the importance of credit risk in the banking sector because the failures of financial institutions can impose severe externalities on the rest of the economy and, furthermore, banks can act as transmission mechanisms of crises. In this scenario, CDS spreads have been seen as an indicator of a banks weakness. CDS spreads may be used to extract market perceptions about the financial health of banking institutions in particular of systemic banking firms. Understanding the relationships between CDS spreads of the financial sector and banks-specific and market variables is important to evaluate financial stability, and more precisely is of crucial importance in terms of supervision, regulation, market discipline and also for practitioners and academics. Moreover, it is important to evaluate the *too big to fail* effect, in particular for systemically large banks.

Since the rating agencies mitigate the problems of asymmetric information between participants of the capital market, their ability to produce timely ratings could be useful for investors as well as for regulators because the production and dissemination of information timely could enhance their credibility in a competitive market and it could be beneficial for financial stability. Given that the specific issue in this context is raising considerable interest within academia and industry and among regulators, the fourth chapter examines the impact of a credit rating announcement on the CDS market and the spillover effect of both upgrades and downgrades. This chapter examines the controversial issue regarding informational value of credit rating announcements on the CDS market from the perspective of financial stability. Subsequent to the analysis, appropriate policy recommendations and future research are derived and discussed. Overall, this thesis investigates topical issues by employing econometric techniques in order to contribute on the methodological level.

Chapter 1

Credit default swaps (CDS): technical features, market and pricing

1.1 Introduction

During the financial crisis and, even more, during the sovereign debt crisis, credit default swaps (CDSs) are the subject of a lively discussion in the academic community. The rise of credit risk measurement and the credit derivatives market started in the early 1990s and has grown especially during the financial and sovereign debt crisis. Nowadays, credit risk is one of the most intensely debated and studied topics in quantitative finance. The introduction of financial innovations has generated a wide range of new instruments for managing and investing in credit risk. The increasing popularity of credit derivatives is due to the fact that they allow market participants to easily trade and manage pure credit risk. In fact, credit derivatives are traditional derivatives in which the underlying asset is the credit risk on an underlying bond, loan or other financial instruments (Das (2005)). In terms of credit derivatives, and more specifically in terms of credit default products, the credit default swap is the most popular instrument for trading credit risk. A CDS contract is essentially a bilateral OTC agreement used to transfer credit risk of a reference entity from one party to another. Although the CDS contracts may represent an efficient instrument to transfer or redistribute credit risk of a counterparty, the role of CDS was controversial during the financial crisis and sovereign default episodes of Greece. Being an unregulated market, CDSs have always been opaque credit risk transfer instruments, and their effective contribution to risk dispersion has always been difficult to measure and assess. In fact, during the financial crisis, the Over The Counter (OTC) nature of CDS contracts has led to an increase on systemic risk on the financial markets. On the contrary, the sovereign debt crisis has underlined another important issue of the CDS market: the *naked positions*. For these reasons, in post crisis period, the CDS market has experienced a wide regulatory overhaul both in United States and European Union.

In recent years, we have witnessed a tremendous acceleration in research efforts aimed at better comprehending, modeling and hedging credit risk. The credit risk and its management is an essential part of the business of banks and other corporations that deal with a large number of credit counterparties and have large amounts of credit outstanding. The management and the measure of credit risk has been a concern of investors from the development of financial markets. Nevertheless, over the last 20 years, this attention has taken the form of ever-more sophisticated methods of measuring and managing credit risk (Altman and Saunders (1998)). The development of credit derivatives market, bank failures and the significant credit crunch faced by banks during the global financial crisis are a stark reminder of the importance of accurately measuring and providing for a credit risk.

1.2 Credit Default Swap contracts

1.2.1 Definition

Credit Default Swap is a fixed income derivative instrument designed to isolate the risk of default on credit obligations. It is a bilateral contract between the protection buyer and the protection seller. The protection buyer pays to the protection seller a periodic premium and, in turn, the protection seller ensures the protection buyer against a contingent credit event on an underlying reference entity. The premium is defined as a percentage of the notional amount insured. It is expressed in basis points and can be paid in quarterly or semi-annually installment. The reference entity of a swap can be a single asset or a basket of assets. In the first case, the swap is called single-name CDS; whereas, in the second case, the swap is referred as basket default swap. Given their complex structure, basket default swap requires a special treatment in pricing and valuation compared to single-name CDS contracts[1].

The basic structure of a CDS contract is shown in Figure 1.1. Credit Default Swap

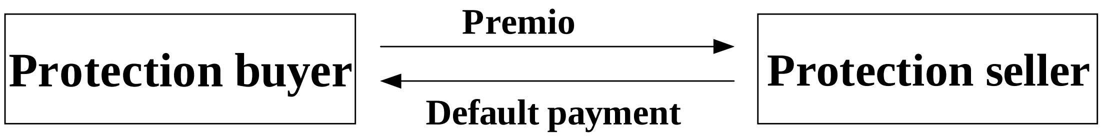


Figure 1.1: *Basic structure of Credit Default Swap.*

enables one party to transfer its credit risk exposure to another party. The maturity of the CDS does not necessarily match the maturity of the reference asset. In each case, the CDS contract is terminated if a credit event occurs and a payment is made by the protection seller to the protection buyer.

1.2.2 Triggers

The failure of a company or, more in general, an entity to meet its debt obligations is a *credit event*. A *credit event* triggers the payment by the protection seller to the protection buyer and it determines the end of the CDS contract. However, the payment by the protection seller can take place only in case the credit event is documented by public notice and notified to investors. The credit event, specified inside of the contract, is defined by ISDA (International Swaps and Derivatives Association) in 2003. ISDA considers as credit event the following events:

1. *bankruptcy*: the reference entity is dissolved, unable to pay or becomes insolvent[2];

2. *failure to pay*;

[1] In this thesis, we will refer only to the single-name CDS contracts.

[2] The CDS contracts have a special treatment in bankruptcy. On the contrary of the creditors, the derivatives counterparties have the right to sell the collateral and then, terminate the contract. This determines the possibility to have a positive credit balance (Bolton and Oehmke (2015))

3. *obligation acceleration*: one or more obligations of the reference entity have become due and payable before they would;

4. *obligation default*: one or more obligations of the reference entity have become capable of being declared due and payable before they would;

5. *repudiation-moratorium*: a reference entity or a government authority disclaim or reject the validity of the obligations;

6. *restructuring*: one or more obligations of the reference entity suffer a reduction in rate, a reduction in the amount of the premium payable at maturity or changes in currency.

1.2.3 Settlement and auction

Once a credit event occurs, a CDS can be either physically or cash settled. The cash settlement is designed to mirror the loss incurred by creditors of the reference entity following a credit event. This payment is calculated as the fall in price of the reference obligation below par at some pre-designated point in time after the credit event. Typically, the price change will be determined through the auctions mechanism. Alternatively, counterparties can fix the Contingent Payment as a predetermined sum, known as a binary settlement.

The alternative settlement method is the physical delivery of a portfolio of specified deliverable obligations in return for payment of their face amount. Deliverable obligations may be the reference obligation or obligations meeting certain specifications. The physical settlement option is not always available because credit swaps are often used to hedge exposures to assets that are not readily transferable or to create short positions for users who do not own a deliverable obligation. In case of physical settlement, the claimant holds a *cheapest to deliver* option. This option implies that he may deliver the least valuable bond among the defined set of eligible reference obligations. The cheapest to deliver option is particularly relevant in case of corporate restructuring, which is why the restructuring credit event is most critical in the pricing of CDS contracts. While in a bankruptcy or leading up to a failure to pay, all obligations should trade down to their recovery value, in a corporate restructuring there is the real possibility that the restructured obligations are traded at different levels than the non-restructured ones . As consequence, the contractual clauses attached to the restructuring credit event have been modified numerous times by ISDA. Indeed, before 2000, the only type of restructuring credit event was Full Restructuring credit event clause. It allows that any bond of maturity up to 30 years can be delivered to settle a triggered CDS commitment (1999 ISDA *Credit Derivatives Definitions*). The problems with this arrangement became clear in 2000, when the bank debt of Conseco Finance, restructured to include increased coupons and new guarantees, and thus not disadvantageous to holders of the previous debt, still constituted a credit event and triggered payments under the ISDA guidelines (Packer and Zhu (2005)). To address the problem of opportunistic behaviour, ISDA modified the CDS contract structure and, in particular, it introduced new restructuring credit event clauses. Modified Restructuring (MR) clause limits the deliverable obligations to those with a maturity of 30 months or less after the termination date of the CDS contract. In 2003, a further modification introduces Modified-modified Restructuring (MMR) clause. This clause was a response to the perception on European market that the 30 months limit on deliverable bonds, provided by the MR clause, was too restrictive. Hence, the MMR allows to deliver bond with a maturity limit of 60 months for restructured obligations and 30 months for all other obligations. Finally, contracting parties can eliminate all restructuring credit events from a CDS contract with the clause of No Restructuring (XR).

The market value of the reference obligation is determined by the *auction mechanism*. The CDS auctions were introduced by ISDA, Markit and CrediEX. CDS auctions have two stages. The first stage is composed by *initial market midpoint* and *net open interest*. Dealer banks submit bid and ask prices for a pre-defined amount and a pre-defined spread that has to stay in a predetermined maximum, usually 2% of par value. At the end of this stage, the result is an initial rate (average of the highest offers and the lowest bids), called *market midpoint* that will be the reference of the *final price*, defined in the second stage. Indeed, the *final price* can deviate from the first price in a pre-determined range. In addition, in the first stage of the auction the participants who wish to physically settle make requests to buy or sell debt at the *final price*. Then, the *net open interest* is calculated. The net open interest can be zero, to sell or to buy. If the net open interest is zero, then there are no limit orders and the final recovery price is equal to the initial market mid-point. When the open interest is to sell (buy), then dealers place new limit orders to buy (sell). At the second stage of the *Dutch auction*, the open interest is matched to the limit orders to establish a price that eliminates the excess demand for or supply of bonds. If the open interest is to sell (buy), then the highest *buy* (lowest *sell*) limit orders are used. The next step is to take the second highest buy order (lowest sell order) and match these. The process continues until all the open interest is matched, or the limit orders are exhausted. In the former case, the last limit order used to match against the open interest is the final price. If the limit orders are exhausted, then the final price is the par when the open interest is to buy and zero when open interest is to sell (Helwege et al. (2010), Augustin et al. (2014)).

1.3 CDS market

The main feature of the credit derivatives market is the Over The Counter (OTC) nature that makes the market quite opaque. In the last years, as we will see in the next section, numerous regulatory actions have taken place to increase the transparency and standardize the contracts. Despite the opacity, the credit derivatives market has experienced considerable growth over the last years. The credit derivatives appear around 1993-1994 and first, they are used by the banks. The CDS market was devised by a group of bankers at J.P. Morgan as a measure to protect the bank and clients against potential default in the late 1990s. Despite the development of the CDS market, still now, the banks and insurance companies are the main users of these instruments, as both protection buyer and protection seller. However, in the last years, the market has become attractive for hedge funds that started to use the CDS contract in their strategy. According to BBA (British Bankers Association, BBA (2006)), banks were once the primary participants in the credit derivatives market and their activity accounted for 63% of protection seller positions in 2000 but it declined of 20% in 2006.

The rapid growth of the CDS market has started in year-end 2002 when the credit derivatives market recorded an outstanding notional amount of about $2 trillion. This growth is due to the standardization of CDS contract (2003 ISDA Definitions) and the development of credit derivatives index products in 2004, including synthetic collateralized debt obligations (CDO) and credit linked notes (CLN). In 2004, the total notional amount of CDS outstanding was roughly $6 trillion. The market continued its expansion till 2007 when the CDS market recorded steady reduction. As we can see from the first graph in Figure 1.2, this reduction continued since the second half of 2015 (BIS (2015)). The gross notional amounts of CDS outstanding dropped considerably after the 2008 crisis, in particular after the Lehman Brothers and Bear Stearns default. The causes that determined the drop of CDS market size are mainly two. First of all, the CDS contract were central to the credit crisis. Second, the introduction of the clearing and counterparty risk led to a portfolio compression since the two parties cancel their existing contracts and replace them with new ones. In this process, the two parties reduce the number of contracts and the gross notional value amounts outstanding but, they maintain the same net exposure and risk profile. Finally, the contraction of the Euro and Pound Sterling against the US dollar in 2008/2009 by 30% and 12%, respectively have been an additional factor that determined the contraction of the credit derivatives market.

In line with the overall trend in OTC derivatives markets, notional amounts of CDS cleared through CCPs declined in absolute terms between end-June 2015 and end-December 2015, from $4.5 trillion to $4.2 trillion. The share of CCPs is highest for multi-name products, at 42%, and much lower for single-name products, at 28% (Figure 1.2-central panel). In the last panel of the Figure 1.2 it is possible to compare the net market values to gross market values. Net values as percentage of the gross market values had fallen from 26% at end-2011 to 21% at end-2013. This trend has since reversed, and the ratio actually rose to 27% at end-December 2015 (BIS (2016b)).

1.4 Regulatory development of CDS market

The market for CDS is going through rapid change in regulatory framework. The shortcomings highlighted by the financial crisis became useful to regulators who have proposed substantial changes in CDS market. The development of the CDS instruments de-

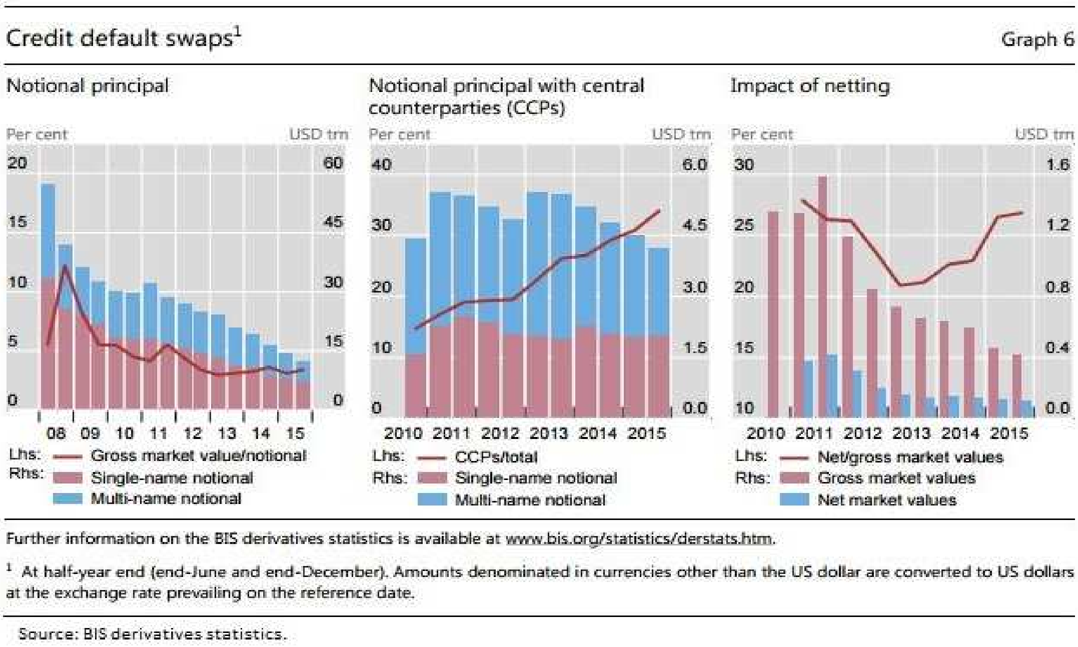


Figure 1.2: *Figures show the values of CDS market.*

termined the need to adequate the structure and, thus, the contractual details. The main concerns were related to the OTC nature of the CDS market and, as consequence, to the lack of transparency. In OTC market, trading takes place through a network of intermediaries, called dealers, who deal to facilitate the buying and selling of investors. This determines the absence of an official price and, as consequence, the absence of transparency. For these reasons, during the last decade, the regulators and, in particular ISDA have tried to improve the transparency and the standardization of CDS market, as well as the efficiency by proposing a lot of changes related to the European and US CDS market. In 2009, ISDA published two protocols: the *CDS Big Bang* for the US CDS market and *CDS Small Bang* for European CDS market. The purpose of these protocols was to improve the efficiency and the transparency of the CDS market by standardizing the contracts. More specifically, the *CDS Big Bang* and *CDS Small Bang* protocols defined the standardization of the coupon payment and the hardwiring of the auction settlement mechanism into the standard CDS documentation. To standardise coupon payments, ISDA introduced a small number of standard coupon rates, which were already paid on a quarterly basis. In combination with the standard coupon rates, ISDA introduced standard contract sizes. To compensate for any differences between the appropriate premium and the chosen standard coupon rate, counterparties exchange an upfront payment. Another change was also introduced to the first coupon. While, previously, the first coupon was either a small coupon paid on the first coupon date or a large coupon paid on the second coupon date, depending on when contracts became effective, with the introduction of the two protocols, the first coupon is full coupons, and upfront payments are adjusted accordingly (BIS (2010)). To help standardise default-contingent payments, the Big Bang harmonised across contracts the triggers of credit events and their consequences[3]. Another important change provided by the Big Bang include the introduction of auction process to determine the size of payments following credit events. The aim of the auctions is to fix the price that the protection sellers transfer to the protection buyer[4]. Finally, in order to ensure that the outstanding contracts are affected by the same events, the Big Bang protocols provide the dates on which contracts are considered to have become effective. The dates are fixed from the business day following the trade to a set of standard dates.

The very limited disclosure in OTC markets sometimes resulted in an overestimation of risks and fuelled market uncertainty. The opacity of the CDS market led to an undifferentiated rise in counterparty risk perception across financial institutions following the default of Lehman Brothers. An important example is the case of AIG in the credit default swap market. The insurance company AIG provided credit default swaps on AAA tranches in securitization on an extremely large scale. However, the downgrade of its credit rating in 2008 drove it into serious trouble (Stulz (2010)). The collapse of Bear Stearns in early 2008, the default of Lehman Brothers and the bailout of AIG motivated by the fear of a cascade of counterparty defaults in CDS markets, highlighted the fact that OTC credit derivatives carry systemic implications for the financial market. The concentration in terms of participants and the opaqueness of the CDS market, added to the spillover effects between various segments of this market given by the participation of financial institutions in most of the segments of this market, have created concerns about the counterparty credit

[3]For more details see section 1.2.2.
[4]For more details see section 1.2.3.

risk. This have determined structural reforms introduced by Title VII of the Dodd-Frank Act in the United States and similar measures in the European Union were intended to reduce dramatically the scope for counterparty risk in derivative markets to generate systemic crises. To help limit the externality created by the counterparty credit risk, in July 2010, the Dodd-Frank Act substantially expanded the roles of central clearing counterparty (CCP). The main role of the CCPs is to guarantee performance and manage the credit risk of derivative transactions. For this reason, the CCP has been seen as a way of mitigating counterparty risk in CDS contracts since it is the buyer (seller) of protection to every seller (buyer) of protection. When a clearing member fails, the CCP may use different pool of resources to absorb losses, such as margin calls, guaranty funds and its own capital. The contagion risk is mitigated since each member is immune from the default of others. However, there are reasons to be cautious about the efficacy of the CCP. Although the central clearing houses reduce the counterparty risk, it concentrates the counterparty and operational risk associated with the CCP itself. In this scenario, it needs to have top risk management practices from existing CCPs, coordination among regulators and supervisors on a global basis. Finally, contingency plans should also be coordinated to ensure that the failure of a CCP is not a systematic event that generates financial instability in associated markets. The introduction of CCPs has a pivotal importance and is likely to have the largest market impact (Acharya et al. (2009), Biais et al. (2012)). Notwithstanding, the magnitude and direction of the impact of central clearing on CDS spreads is not straightforward to determine. On the one hand, the CCPs may have increased the management costs that are likely to be passed on the end-users of the CDS contracts through higher spreads. Or similarly, by reducing counterparty risk, the introduction of CCPs may widen the CDS spreads as well. On the other hand, it is by now accepted that imbalances in information flows lead to liquidity shortages in the financial markets. Therefore an increase in liquidity of the centrally cleared CDSs as well as an increase in counterparty risk, as some argue, may widen CDS spreads.

More recently, there were suspicions of manipulation in sovereign CDS market. More specifically, the concerns were about the *naked CDS* positions that refer to having a CDS contract without owning an exposure to the underlying reference entity. In this case, the function of the naked CDS contract is to speculate on the reference entity and it may help the speculators destabilize the debt market. The scandalous landmarks in the CDS market were the default episodes of Greek and Argentina in which the naked CDS buyers had the principal role (Amadei et al. (2011)). Given the concerns about the manipulations of the default in sovereign CDS market and the moral hazard problems, the European regulators in 2011 decided to ban these positions. The effect of the ban is unambiguous. From one hand, the possibility to sell debt short helps the market efficiency and improves the pricing efficiency. Smart traders in the market reveal information, and the market can provide information when the bond markets are illiquid (Portes (2010)). On the other hand, it appears that unbridled short selling contributes to the sudden price declines in the securities unrelated to true market valuation (Khanna and Mathews (2009)). Other important regulatory changes were proposed by ISDA in 2014. These changes were mainly related to the European financial and global sovereign CDS. In particular, it incorporated a new credit event triggered by a government-initiated bail-in and a provision for delivery of the proceeds of bailed-in debt or a restructured reference obligation, and more delineation between senior and subordinated CDS. This credit event is similar to a restructuring credit event, but the trigger has to be the result of an action by a government or a governmental authority. Furthermore, it also introduced the ability to settle a credit event by delivery of assets into which sovereign debt is converted and the adoption of a standardized reference obligation across all market-standard CDS contracts on the same reference entity and seniority level.

CDS contracts occupy a prominent position in global financial regulation, including in the Basel III guidelines of the Bank for International Settlements. Through the use of CDS contract, the banks can manage the regulatory capital ratios. However, whereas banks may appear safer if they raise their regulatory capital ratios by reducing their risk-weighted assets, banks' use of CDS can create systematic risk because banks are both major buyers and sellers of CDS and are usually at the core of the CDS dealer network. Basel III aimed to close some loopholes that banks have exploited using CDS contracts. Basel III raises the capital buffers backing these exposures, reduce procyclicality and provide additional incentives to move OTC derivative contracts to central counterparties[5], thus helping reduce systemic risk across the financial system. Basel III is supporting the efforts of the Committee on Payments and Settlement Systems (CPSS) and the International Organization of Securities Commissions (IOSCO) to establish strong standards for financial market infrastructures, including central counterparties (BCBS (2010)). They also provide incentives to strengthen the risk management of counterparty credit exposures. Banks must determine their capital requirement for counterparty credit risk using stressed inputs. This will address concerns about capital charges becoming too low during periods of compressed market volatility and help address procyclicality.

The above discussion suggests that a lot of work remain to do on regulatory framework. The market is severely affected by the new regulations but the effects of DoddFrank act and Basel III on CDS markets remain largely under-researched so far.

1.5 CDS vs bond spreads

The credit spreads represent the margin relative to the risk-free rate designed to compensate the investor for the risk of default on the underlying security. Theoretically, the CDS premium (or spread) is roughly equal to the bond spread for the same borrower and maturity. The credit spreads (s) is calculated as the difference between the yield security or loans (y) and the yield of corresponding risk-free security (r). That is

$$s = y - r \tag{1.1}$$

The absence of arbitrage, in a efficient market, implies that the credit risk should be priced similarly across the cash and synthetic credit derivative markets (Augustin et al. (2014), Coudert et al. (2010)). In other word, the *CDS-bond basis* of a risky company, given by the difference between CDS and bond spreads, must be zero to do not present any arbitrage opportunities. In normal periods, the *CDS-bond basis* is closed to zero whereas, after the default of Lehman Brothers, the *CDS-bond basis* rarely has been zero with a clear difference between corporate and sovereign bonds. While the *CDS-bond basis* of a corporate bond is,

[5]Basel III and DoddFrank reforms require banks to hold more capital for non-centrally cleared, single-name CDS.

on average, negative (Fontana (2011), Garleanu and Pedersen (2011)), the *CDS-bond basis* of a sovereign bond is, on average, positive with the exception of Greece in which the *CDS-bond basis* has been negative persistently (Fontana and Scheicher (2010)). However, some recent evidences show that also the corporate *CDS-bond basis* is positive when the firm is AAA-rated whereas, it continues to be negative when the firm is rated with a credit rating BBB or less. Therefore, the corporate CDS-bond basis is correlated to the creditworthiness of the firm, whereas the sovereign CDS-bond basis is independent from the sovereign credit rating. One possible explanation for the CDS spread exceeding the bond spread are *flight to liquidity* effects, which specifically lower government bond spreads in periods of market stress. The main exceptions to this pattern are Portugal, Ireland and Greece where the *CDS-bond basis* is temporary negative in 2009 and early 2010.

Empirical literature has shown that this parity relationship may not hold exactly in practice for various reasons. First of all, economists usually make some assumptions to simplified the model, such as the constancy of the interest rate risk-free (Duffie and Singleton (1999)) that may not be satisfied in practice, causing deviation from the above equivalence relationship. In fact, in reality and especially in period of high volatility, it moves randomly. Moreover, the CDS premia can differ from bond spreads either temporarily or in a more persistent manner because of institutional factors. First, the protection buyer usually needs to pay the accrued premium when a default occurs. Therefore the CDS premium tends to be lower after taking account of this accrued premium payment. Second, the existence of the cheapest-to-deliver option in physical delivery that allows the protection buyer to choose the deliverable asset from a large pre-specified pool, implies that CDS premia would be higher. Third, the definition of credit events, a very controversial topic in this area, can have an important impact on CDS pricing. This difference could cause the CDS market to respond more quickly than the bond market to changes in the underlying credit risk, generating price discrepancies in the short run. In fact, Blanco et al. (2005) and Hull et al. (2004) provide evidence that the changes in the credit quality of the reference entity are likely to be reflected more quickly in the default swap spreads that in bond yield spreads. Finally, the liquidity of bond and CDS market can affect the *CDS-bond basis* (Nashikkar et al. (2011)).

Although, from an economic point of view, CDS premia and bond spreads represent the price of credit risk at market value, using CDS spreads rather than bond yield spreads in pricing the credit risk has a number of important advantages. By their nature, the CDS contracts provide researchers with a near-ideal way of directly measuring the size of the default component in corporate spreads because CDS spreads do not require the specification of a benchmark risk-free yield curve. On the contrary of bond yield spreads, they already represent the pure credit risk of a firm. This avoids any added noise arising from the choice of the risk-free yield curve (Ericsson et al. (2009)). Additionally, the illiquidity, tax and various market microstructure are known to have a marked effect on corporate bond yield spreads (Longstaff et al. (2005), Ericsson and Renault (2006)) that can lead to biased estimates. Finally, CDS market is much more liquid than the bond market. In effect, the swap data can be collected at a daily frequency while the corporate bonds typically can be collected at a monthly frequency. In this regard, Fisher (1959) and, more recently, Longstaff et al. (2005) documented the existence of an illiquidity component in bond yield spreads. Consequently, the CDS market is able to incorporate on a continuous basis the changes of the corporate credit risk.

1.6 CDS and related markets: corporate bonds and stocks

Innovation in financial markets, and within that the development of new financial instruments such as credit derivatives, is generally to be welcomed as increasing market efficiency, enabling better diversification of portfolios, providing a wider range of techniques for risk management and favoring information generation and dissemination, as well as liquidity. Nevertheless, such innovations could create negative externalities, such as the possibility of arbitrage, and cause an adverse impact on the rest of the market. Certainly, the introduction of the CDS contracts has created an alternative avenue through which investors in the fixed income market can trade credit risk. This may have altered the information flow and the way in which the information are incorporated into prices, liquidity and market efficiency on both parts of capital structure, bonds and equity.

Credit risk instruments typically change the relationship between borrowers and lenders and establish new relationships between lenders and those to whom they may pass on credit risk. This implies in particular changes in the incentives which the different parties to a credit transaction face. The development of the credit derivatives market has been credited as a source of substantial improvements to the financial system. Since CDSs create new hedging opportunities, it seems that these instruments could indeed impact on the bond market. The bond market is inefficient for various reasons, including asymmetric information between borrowers and lenders, restrictions on short-sales and low liquidity. The introduction of the CDS market can mitigate or aggravate some aspects of bond market inefficiencies. In terms of benefits, CDS trading can lower the cost of bond issuance and improve the liquidity in the bond market by completing the credit market and by revealing new information about firms. For example, Duffie (2008) suggests that CDSs increase the liquidity of credit markets, lower credit risk premia and offer investors a wide range of assets and hedging opportunities. Ashcraft and Santos (2009) identify two channels through which trading in the CDS market can lead to a reduction in the credit spreads: diversification or hedging channel and the information channel. The first refers to the situation in which firms that have traded CDSs give their creditors added opportunities to hedge their risk exposures, so that they can issue bonds at lower spreads. Second, since CDSs offer investors risk-trading opportunities that are hard to replicate in the secondary loan or bond markets, CDS prices are a potentially important source of new information on firms that could contribute to reduce their cost of debt. In terms of costs, the asymmetric information could lead to agency problems and thus it could negatively affect the cost of debt financing. Since banks typically have informational advantages on borrower's credit quality and they can transfer the risk to other investors, concerns have been raised about the incentive to monitor and mitigate the default risk of bank loans.

The growth of credit derivatives markets has brought increasing attention to important questions regarding the impact of derivatives on liquidity and market efficiency. Given that the CDS market poses a systemic risk to financial market stability, market participants and regulators are interested to the potential effects that CDS might have on equity market. The introduction of CDS contracts can create two important potential benefits to equity market: the management of risk and the price discovery. CDS are valuable hedging tools through which investors can efficiently manage the risk of their positions in other securities. Additionally, they can provide information flow that can facilitate price discovery. The pricing relationship between debt and equity which arbitrageurs can use to identify and correct any mispricings is described by the Merton model. Although the introduction of CDS contract can generate benefits, it also creates costs by decreasing the price efficiency. For example, the information flow from CDS market is restricted for some firms and some days (Acharya and Johnson (2007)). Furthermore, heterogeneity in investors' access to markets and thus, the different trading motives in the equity market can cause investors to trade in different directions in response to similar information, which can generate a decline in price informativeness (Goldstein et al. (2014)). Equity markets can also become less liquid if the ability to hedge in CDS markets increases the willingness of risk-averse informed traders to trade equity, driving out uninformed liquidity traders (Dow (1998)). In a more extreme case, the introduction of securities market can cause the collapse of the existing market (Bhattacharya et al. (1995)). Given the theoretical ambiguity of the impact of derivatives markets on equity market quality, the dominant effect of CDS is an empirical question among academics and researchers.

1.7 Credit risk models

During the past years, many sophisticated credit risk models have been developed. The development of these models are due to the increased importance regarding the management of credit risk as well as the growth of financial innovations such as credit derivatives and other structured products.

Different authors provide the theoretical foundation for measuring credit risk and focus on the application of credit risk models. The most known models are the structural, the reduced-form and the Z-score models. The first two models consider that the default of a firm can be observed at any time. The main difference between these two models concerns the definition of distance to default. Structural models are developed by Black and Scholes (1973) and Merton (1974) whereas reduced-form models are developed by Jarrow and Turnbull (1992). The Z-score models, developed by Altman (1968), use a number of variables to produce a credit score that gives information about the credit quality of a firm[6]. We start by presenting a rather brief overview of structural and reduced-form approach. In the first approach the price of credit risk is linked to the firm's economic fundamentals, such as capital structure and asset value. For this reason, the structural approach is frequently referred to as the firm value approach. On the contrary, in the reduced-form approach the capital structure and the asset value of a firm are not modeled at all since this approach considers some exogenous process. Among the reduced-form model, we have to distinguish the intensity-based models and the credit migration models. The intensity-based models consider a random time of default while the credit migration models consider the possibility to migrate in another class of rating.

1.7.1 Structural models and Merton model

The structural model is a model based on the value of the firm. Structural model contains economic information on how default is triggered. In the structural model the value of the firm is measured in terms of market value. Therefore, a corporate bond is essentially regarded as a contingent contract written on the company's assets. The structural model, developed by Black and Scholes (1973) and Merton (1974), is used to derive the fair value of the bond. In the first model of Black and Scholes (1973) and Merton (1974) the default can only occur upon the maturity date of the debt. Merton (1974) considers the capital structure of a firm as the sum of equity and zero-coupon bond. At the maturity, we can observe two different situations. First, the firm's assets are sufficient to repay all creditors in full. The creditors will receive the face value of the zero-coupon bond. By contrast, it is possible that the firm's assets are not sufficient to repay the creditors. It means that the firm asset value is lower than the face value of the zero-coupon bond. In this case, the shareholders will exercise their option to default and receive nothing while, the creditors get the full asset value.

More formally, the equity of a firm E is a call option in Merton's model. On the maturity date T, stockholders get $E_T = max(V_T - F; 0)$ where V is the value of the assets and F

[6] We decide to exclude the Z-score models from the analysis in this chapter because they do not provide default probabilities that can be directly used for modeling credit risk.

is the face value of the debt whereas the bondholders get $D_T = F - max(F - V_T; 0)$. The original Merton Model assumes that the firm belongs to the bondholders and the equity holders own a European call option on the firm's assets. Another core assumption in the Merton model, as well as in all other structural models, is the process describing the value of the firm that follows a geometric Brownian motion under the risk-neutral probability measure.

$$dV_t = rV_t dt + \sigma_V V_t dW_t \tag{1.2}$$

where r is the interest rate, assumed to be deterministic in Merton's model and σ is the standard deviation of the return on the firm. Using standard option valuation developed by Black and Scholes (1973), one obtains

$$E_t = V_t N(d_1) - \exp^{-r(T-t)} DNd_2 \tag{1.3}$$

at time t<T, where

$$d_1 = \frac{\log(V_t/D) + (r + \sigma^2/2)(T-t)}{\sigma\sqrt{T-t}} \tag{1.4}$$

$$d_2 = d_1 - \sigma\sqrt{T-t} \tag{1.5}$$

and *N(x)* is the standard normal cumulative distribution function evaluated in x.
The original Merton's model uses several restrictive hypothesis: the term structure of interest rate is deterministic and thus it is known; default can occurs only at the maturity; the liabilities are homogenous and do not pay coupon; the volatility of the firm's assets is constant over the time; the markets are complete and efficient. Given these restrictive hypothesis and the difficulty to implement the model [7], different are the models that have tried to overcome and relax some of the restrictive assumptions. For example, the extension of Geske (1977) concerns coupon bonds. In particular, in case of Merton's model the defaults on different payments are not independent while in Geske the shareholders have the option to default at each coupon date. A second extension of Merton's model concerns the concept of default and it is developed by Black and Cox (1976). The default in Merton's model can occurs in payment date (as an European option) while in Black and Cox (1976) the bankruptcy can occurs at any time during the life of the debt. The model of Black and

[7] It is not easy to find the market value of liabilities. In addition, the firm's asset value and the volatility of its dynamics are not direct observable if options on that equity are not traded.

Cox (1976) is the basis for numerous extensions. Longstaff and Schwartz (1995) try to relax the assumption about the term structure and define the interest rates as a mean-reverting process and not constant. In addition, they define the default depending by an exogenous barrier. While the structural models assume that the default boundary is constant over time, in practice the firm changes its capital structure in response to changes in asset value. Collin-Dufresne and Goldstein (2001) try to overcome this problem and introduce a framework where the leverage ratio is modeled as a stationary process.

The structural approach is widely used in credit risk modeling. So far empirical tests show mixed evidence. Regarding the level of credit spreads, Eom et al. (2004) demonstrate, by comparing five different models (Merton (1974), Geske (1977), Longstaff and Schwartz (1995), Leland and Toft (1996) and Collin-Dufresne et al. (2001)), that the structural model predicts spreads too lows. The same conclusion can be found in Jones et al. (1984) and Wei and Guo (1997). Nevertheless, the problem of the structural model is the accuracy of the predictions. Indeed, the predictions tends to overestimate the credit risk of riskier bonds and underestimate the safest bonds. The poor performance shown by the structural models in explaining the credit spreads leads to the problem referred to as *credit spread puzzle*. In this scenario, recent works identify other factors that affect the credit spread, in general, and the CDS spreads, in particular. For example, Gamba and Saretto (2013) solve the credit spread puzzle with a structural model of firms policies that endogenously replicates the empirical cross-section of credit spreads.

1.7.2 Reduced-form models

The link between the structural model and the information of the balance-sheet of the firm makes difficult the implementation of this model since the data are available at most four times per year to the public and there are some firms that are not listed. In contrast to structural model, reduced form model bypasses these problems by using directly market data.

Reduced form models, represented by Jarrow and Turnbull (1992) and Duffie and Singleton (1999), assume that the probability of default and the recovery rate are unpredictable and random. Therefore, the main hypothesis is that the default does not depend on the value of the firms but it is an exogenous event. In this framework, the event of default can happen at each instant and varies randomly over time. For this reason, the reduced-form model requires less information of the firm's balance sheet than the structural model. Jarrow and Turnbull (1992) assume that the intensity process and the recovery rate are constants. The difference between the reduced-form models comes from different assumptions about the correlation between the default probability, the recovery rate and the interest rate.

Although the reduced-form model overcomes the problems related to the balance-sheet data, they present some limitations. The implementation of this model requires less information than the structural model but, at the same time, these models do not possess an economic rationale when the model defines a default process.

A more sophisticated model has been developed in recent years combining reduced-form models and structural-form models: the incomplete information models. Duffie and Lando (2001) and Giesecke (2006) develop these models by determining a default stopping time and a filtration that represents the information of investors concerning the balance sheet of a firm. The investors can observe some values of the firms and the default barrier but they cannot predict the event of default [8]. The model filtration can be generating from the lagged observation of the asset value and the barrier of default. In conclusion, the incomplete information models take the definition of default of structural models and the concept of stopping time of reduced-form models.

In the literature, the reduced form model has been split so far into different approaches: intensity-based approach, credit migration approach and spread approach.

Intensity-based approach assumes that the default is unexpected and it can occur in every time. In contrast to structural model, the default in this approach is not related to the asset value but it is a random process related to an external specified intensity process. For this reason, the intensity-based approach is more closed to the real word since the default of a firm comes without announcement but it happens because suddenly something changed.

The default intensity is the hazard rate ($\lambda(t)$) defined by the instantaneous rate of default

[8] In structural models investors can fully observe the firm assets, so we are in a complete information model where the stopping time is predictable. In reduced-form models, investors cannot observe the firm assets or the default barrier and the stopping time is unpredictable.

conditional on the survivorship:

$$\lambda(t) = \frac{f(t)}{S(t)} \tag{1.6}$$

When $S(t)$ is continuous with $f(t) = (-d(1 - S(t)))/dt$, we obtain:

$$\lambda(t) = \frac{-dS(t)}{S(t)dt} = -\frac{d[log(S(t))]}{dt}, S(t) = \exp\left(-\int_0^t \lambda(s)ds\right) \tag{1.7}$$

$\lambda(t)$ is treated as stochastic. Thus, the default time τ is doubly stochastic. Lando (1998) adopted the term "doubly stochastic Poisson process" (or Cox process) to refer to a counting process with possibly recurrent events.

The intensity-based approach is a term-structure model and thus, it is strictly related to the literature of the interest-rate modeling with reference to Vasicek (1977), Cox et al. (1985) and Duffie et al. (2000).

The credit migration model, proposed by Das and Tufano (1995) and Duffie and Singleton (1998), is an extension of the intensity-based approach since the credit migration approach considers the possibility of migrations between the rating classes as a cause of the default. Therefore, this last approach extend the single credit rating model (intensity-based model) to the case of multiple credit rating classes.

The credit migration approach assumes that the credit quality of a firm can be quantified into a finite number of credit rating classes. The set of classes (κ) is composed by a finite number of elements κ=1,...,k. As observed in practice, the credit quality of a firm or corporate debt can change over the time. Thus, the credit quality migrates between rating classes. The credit migration process is frequently modeled in term of Markov chain, denoted by C, with finite number of migration and discrete or continuous time. In this approach, it needs to calculate the transition intensities matrix for the migration process, both under the risk-neutral and the real-world probabilities. These models are based on the Cox processes and the intensities of default and/or migrations are specified as functions of both macro and micro-economic factors.

The spread approach, developed by Duffie and Singleton (1998), consider risk-free interest rate and default rate (and in some cases also the recovery rate) to be stochastic and to follow a standard Wiener process. The pricing process is basically the sum of three stochastic processes. Duffie and Singleton (1998) determine that the yield on risky debt is a function of a short-rate process, a liquidity process, and a process governing expected loss in the event of default. They underline that these processes are different across credit classes and thus, they suggest to estimate a term structure model for each credit class by avoiding to find the correlation between the different rating classes.

1.8 Main challenges and future researches

Despite the relatively short history of the CDS market, the development of academic research on CDS is surprising since other derivatives such as interest rate swap or foreign exchange forwards do not attract similarly strong reactions. It may be due to the evidence that the CDS market is able to affect the price of the underlying securities and the decision making. Furthermore, both financial and sovereign debt crises have highlighted several shortcomings that have stimulated a useful debate about the market structure and regulatory changes.

Although the CDS pricing is one of the most studied issues of the literature and we have a good understand of CDS pricing, the financial crisis exhibits a structural shift on the determinants of the CDS premium (Galil et al. (2014)), with a substantial regulatory overhaul, which itself may have a significant impact on the CDS market. More specifically, the existing literature has underlined the scarce explanatory power of the structural variables and has focused on the impact of market variables on the CDS spreads by focusing the attention on the credit-spread puzzle. The global financial crisis has determined new challenges on this topic. A deeper examination may be of interest for regulators and market participants of the impact of the new regulatory framework on the pricing of credit risk and on the consideration of the consequences that such regulation may have on CDS princing. Additionally, the purpose of regulators to increase the standardization and the efficiency of the CDS market, indirectly, have created some benefits in terms of data. An increase in the availability of the data and the financial turmoil could validate or invalidate the existing findings through replication of studies on the effect of CDS trading on the firm characteristics across regions or countries and over the time. This, in turn, generates the possibility to better understand how liquidity and counterparty risk impact on corporate bond market. Having detailed information could also allow to study why the bond and CDS markets are imperfect integrated (Augustin et al. (2014)).

The European sovereign debt crisis has shown the need to better understand the relationship between banks and sovereign risk. Looking ahead, the monitoring of sovereign-financial risk spillover and feedback loops could avoid the speed and the scope of the previous crises. Therefore, a careful study about the spillover effect between sovereign and financial risk could reveal if that nexus has been sufficiently disarmed by the new policy initiatives or could offer additional tools to reduce it. Additional concerns during the European sovereign crisis were related to the naked positions and empty creditor[9] since in these two cases, the CDS contracts can be used as vehicles for speculating against other investors's assets by accelerating default on the underlying debt. In this scenario, some academics and commentators discuss the social efficiency of CDS (Bolton and Oehmke (2011)). The analysis of the welfare implications of CDS contracts is one of the main challenges in CDS literature because they have real effects on agency conflicts of financial intermediaries and impact on prices, liquidity and efficiency of related markets (bond and equity markets).

With regarding to the banks, Basel III, the new bank capital and liquidity regulations, introduces the incentives of banks to use CDS to manage regulatory capital. Different authors focus on risk management enabled through CDS. For example, Yorulmazer (2013), by analyzing the use of the CDS for regulatory capital relief and systematic risk, shows that the CDS allows to invest in good projects if the cost of capital is high. Hirtle (2009), by focusing on the relationship between the use of credit derivatives and the credit supply of a bank, underlines how the use of the credit derivatives contracts in a bank can have a limited benefit on the credit supply. Shan et al. (2014) examine the effects of CDS on bank capital adequacy and they show that it exists a negative relationship between the capital ratios and the use of CDS. These empirical studies suggest that the use of CDS contracts can impact on different ways on the banking sector. Since the aim of Basel III is to close

[9]Empty creditors, coined by Hu and Black (2008), refer to the separation of cash flow rights from control rights. It is closely related to the concept of empty voter. In distress situation , these creditors would favor bankruptcy over a renegotiation of the terms of the bonds, even though it may be socially inefficient. See Bolton and Oehmke (2011) for a theoretical discussion and Subrahmanyam et al. (2016) for an empirical analysis.

some loopholes that banks used to exploit using CDS contracts, it might be of interest to focus on the impact of the new regulation on the credit supply and capital ratios of banks that use the CDS contracts to manage their credit risk.

Finally, a careful focus should be on the credit rating agencies and on the impact of their opinions on the financial stability of the system. During and after the financial crisis, important concerns were raised with regard to the accuracy of credit ratings and, in particular, whether the credit ratings represent accurate risk assessments. Studies have focus on the issue of whether changes in ratings convey information not already incorporated into prices from other sources. Since the empirical evidence (Hull et al. (2004), Norden and Weber (2004), Kiff et al. (2012), Drago and Gallo (2016)) has shown that the CDS market is able to anticipate the credit rating announcements, especially the downgrade announcements, the resulting question is on the role of CDS for macro-prudential regulation. For example, authors such as Flannery et al. (2010) provide evidence that the CDS market is more quickly to incorporate new information than the equity market and credit ratings. Therefore, they propose to substitute the credit ratings with CDS spreads in financial regulations. Similarly, Hart and Zingales (2011) design a new capital requirement for large financial institutions. Future researches can examine the real distance between CDS spreads and credit ratings and thus, the implications of CDS-based regulations.

Chapter 2

Determinants of CDS premium: What is the impact of the financial crisis?

Abstract

This chapter analyses the determinants of credit default swap. By using a regression model in levels and differences, we study the impact of firm-specific and market variables on the CDS spreads of US companies over the period 2007-2015. We identify as key variables leverage, option implied volatility and term structure of interest rates. We analyse the impact of the financial crisis overall and sector by sector. The empirical analysis shows a structural change in pricing the credit risk due to the financial crisis. We find that the financial crisis shifted the price of credit risk from an idiosyncratic to a systematic perspective. In the aftermath of the financial crisis, the investors become more skeptical about the credit rating issued by rating agencies in both cyclical and counter-cyclical sectors.

2.1 Introduction

The rapid growth of CDS market has led to the increasing attention of investors in these products that allow them to buy or sell credit risk. The investors are interested in the factors that can affect CDS spreads because the changes in these factors can impact on their decisions. Nevertheless, finding appropriate determinants and understanding their impact on CDS spreads is crucial not only for the investors but also for analysts, regulators and policy makers. The growing degree of both financial and economic integration in global and the significant credit problems faced by banks during the financial turmoil are a stark reminder of the importance of accurately measuring and providing for a credit risk. Increased attention has been paid to CDS determinants since the financial crisis burst underlined the integration between idiosyncratic and systematic factors. In the recent US crisis, the transmission of shocks was rapid and powerful. In few months the financial crisis became a crisis of real economy in US and Europe because financial interlinkages are strong and the investors' confidence has been shown to be an important transmission mechanism. Additionally, the financial crisis has highlighted that macroeconomic policies, issued by the Central Bank to solve the financial turmoil and to avoid a crisis of overall economy, can have significant spillover effects (López-Salido et al. (2016)). This generated the need for researchers and policy makers to discover influence of selected factors on credit spreads. A crucial question is to what extent the credit spread reflects shocks of the financial markets and firm-specific variables. Empirical work on the determinants of credit spread has traditionally looked at corporate spreads rather than CDS spreads. The development of the CDS market and the advantages, described in Section 1.5, in using the CDS spreads to price the credit risk has attracted researchers' interest in analyzing whether factors that determine corporate spreads are also relevant for CDS spreads.

The aim of this chapter is to build upon the literature about the determinants of the CDS spreads and to shed light on the effect of the financial crisis in pricing credit risk. Therefore, following the existing literature and using a Panel data of monthly CDS spreads across 312 firms from US market, from January 2007 to July 2015, we empirically test the importance of firm-specific and macroeconomic factors. Moreover, we control for the credit ratings. We study the CDS determinants by using a regression in levels and differences. Our approach is similar to Collin-Dufresne et al. (2001), Ericsson et al. (2009) and Galil et al. (2014). This chapter makes several contributions to the related literature. First, from an econometrical point of view, we try to overcome the problem of serial autocorrelation of the error term in regression in levels by using a Generalized Least Square model (GLS) because it is relied on the assumption that the error terms are uncorrelated. Second, our research extends the previous studies both in terms of analysis period and in terms of focus of analysis. Our sample is one of the first sample that takes into account crisis and post-crisis period. The volatility of the markets and their evolution could affect the perception of the credit risk and thus, the variables that are able to capture it. It implies that, in period of high volatility of the financial market, the perception of the credit risk and, as consequence, the price of the credit risk may depend on some factors that, in normal periods, marginally impact on the credit spreads. Moreover, it is one of the few studies focused on the sectorial CDS spreads. To the best of our knowledge, only Di Cesare and Guazzarotti (2010) have a little focus on the sectorial determinants of CDS spreads. Nevertheless, our study differs from that of Di Cesare and Guazzarotti (2010) because of the analysis period. Most of existing literature (see, for example, Avramov et al. (2007) and Ericsson et al. (2009)) investigates the determinants of CDS spreads by credit rating classes. We are conscious of the influence of the credit ratings in pricing of credit risk; however, because of the spillover effects observed in crisis period, we believe that it could be more interesting to study the impact of financial crisis on the different economic sectors instead of the impact on the different rating classes.

The resulting research questions can be summarized as follows:

1. *What are the determinants of credit default swap spreads?*
2. *What is the impact of the financial crisis in pricing of credit risk? Did the financial crisis increase the importance of systematic factors?*
3. *What are the CDS determinants in each economic sector? Could financial turmoil have exacerbated the differences between the firms belonging to different sectors in pricing of credit risk?*

The results of the empirical analysis show that the key determinants of the CDS spreads are firm-specific and market variables. Financial turmoil determined a structural change in pricing of the credit risk. After the financial crisis, the sensitivity of CDS spreads to market variables is much stronger than during the financial crisis. Therefore, the investors incorporate the systematic factors in pricing the credit risk. The empirical analysis by economic sectors shows that the determinants of CDS spreads differ from sector to sector. In counter-cyclical sectors, the price of credit risk is closely related to the firm-specific variables. In contrast, cyclical sectors incorporate both idiosyncratic and systematic factors in CDS premium. Interestingly, the financial crisis does not have impact in some sectors that record a structural stability in pricing of credit risk. Financial crisis generates a structural change in pricing of credit risk in Communication, Consumer, Energy and Industrial sector. Finally, our results suggest that the investors do not incorporate the credit ratings in CDS premium after the financial crisis. This confirms the debate about the validity of the credit rating (Jacobs Jr et al. (2016)) and the capability of credit rating to add information on the market (Kiff et al. (2012), Drago and Gallo (2016)).

The remainder of the chapter is organised as follows. Section 2.2 presents a review of the relevant literature. Section 2.3 discusses methodology and data. Section 2.4 presents empirical results. Finally, Section 2.6 summarises the results and concludes the chapter.

2.2 Literature review

Several papers, instead of studying the direct pricing of credit spreads using one of the formal models described in Section 1.7, use observable variables suggested by the structural models to explain credit spreads empirically. According to the theory of Merton, the credit spreads depend on three factors: risk-free interest rate, firm's leverage and volatility of the firm's assets. Empirical studies on the determinants of corporate bond spreads generally do not confirm that structural default factors are able to completely explain the credit spreads but, there are several other factors that help to explain the credit spreads. For example, Collin-Dufresne et al. (2001) use the variables of the Merton model as independent variables of the regression to explain the changes of bond credit spreads. They enrich the analysis examining the changes in the probability of future default and changes in the recovery rate. They find that the explanatory power of these variables is small and, by running a principal component analysis, they find that the residuals are driven by a systematic common factor which is not related to pricing theory. Furthermore, by studying monthly changes of 688 companies in the period July 1988- December 1997, they conclude that liquidity, macroeconomic and financial variables explain the variation of bond credit spread. As in Collin-Dufresne et al. (2001), Avramov et al. (2007) study monthly bond credit spreads of 2375 companies in the period 1990-2003 by focusing on the firm-specific factors rather than macroeconomic factors. Indeed, they replace macroeconomic factors in Collin-Dufresne et al. (2001) with firm-specific factors, where it is possible. Vix index and returns of S&P 500 are replaced with equity volatility and stock return, respectively. Avramov et al. (2007) find an explanatory power of 54% and they show an higher explanatory power for the riskier companies.

The studies about the determinants of CDS spreads are related to those about corporate bond spreads. Therefore, as the described literature on the credit spreads, the studies focusing on the CDS spreads rely on the Merton variables to try to explain empirically the determinants. The literature on the determinants of CDS spreads have two different focuses. The first is on sovereign CDS[1] and the second on corporate CDS spreads. Given the objectives of this chapter, we will focus on the literature about the corporate CDS. The literature focused on corporate CDS has mixed evidence about the explanatory power of structural variables. For example, by using a sample of US non-financial companies over the period 2002-2009, Di Cesare and Guazzarotti (2010) find that the structural variables explain a large portion of the changes in CDS spreads, both before and during the financial crisis. They also document that the CDS spreads are highly sensitive to the leverage in crisis period, while, in pre-crisis period, they are much more sensitive to the volatility. In further analysis, Di Cesare and Guazzarotti (2010) show that the model is better in explaining the CDS spreads of cyclical sectors. However, in crisis period, the model performance sharply increases for firms belonging to counter-cyclical sectors. As Di Cesare and Guazzarotti (2010), Ericsson et al. (2009) show that leverage, volatility and risk-free rate explain 60% in levels and 23% in differences regressions. They indicate as determinants of CDS spreads leverage and volatility that are able to explain a large portion of the CDS

[1]The literature on sovereign CDS spreads has assumed importance with the European sovereign debt crisis. A number of papers suggest that CDS spreads are largely dominated by global factors. For example, Pan and Singleton (2008), Hilscher and Nosbusch (2010), and Beirne and Fratzscher (2013), Heinz and Sun (2014).

spreads. In addition, they find that company's rating does not have impact on the explanatory power of the model. Whereas Ericsson et al. (2009) find a great explanatory power of structural variables, Imbierowicz (2009), by analysing CDS market over the period January 2002- April 2008, shows that these variables are not sufficient to fully explain the pricing of credit risk and thus, he highlights the importance of market and liquidity variables. As Imbierowicz (2009), many other papers have considered firm-specific variables and, in addition, aggregate economic variables as potential explanatory variables of credit conditions. For example, among the firm-specific or industry specific variables, some papers include the corporate leverage, ROA, ROE, dividend payout, liquidity, option implied volatility, default probability and credit rating. Furthermore, some others incorporate the aggregate level of interest rates, inflation, unemployment, aggregate measures of indebtedness, GDP growth rates, market liquidity premium, the ratio of high yield debt to total debt outstanding, and returns as well as volatility of equity indices (Imbierowicz (2009), Tang and Yan (2007), Pu and Zhao (2010), Ericsson et al. (2009), Greatrex (2008), Galil et al. (2014)). Results of the empirical importance of macroeconomic and firm-specific variables on CDS market have been mixed. Pu and Zhao (2010), by studying the correlation in CDS spread changes, show that firm-specific (such as stock return, volatility and leverage), market (such as Vix index and market leverage) and macroeconomic (such as growth of GDP) variables cannot fully explain the correlation in CDS spread changes. Furthermore, they find that credit risk correlation is higher during economic downturns and higher among firms with low credit ratings than among those with high credit ratings. In a more recent study, Galil et al. (2014) highlight that the market variables become statistically significant only if the firm-specific variables are used as control variables. Additionally, they find that the global financial crisis have determined a structural change in pricing of CDS market. This change concerns mainly investment-grade rather than speculative-grade companies. As consequence, better is credit rating, better will be the CDS premium predicted by the model.

Another strand of literature focuses on the effects of equity volatility on the CDS spreads (e.g. Benkert (2004), Cremers et al. (2008), Zhang et al. (2009) and Cao et al. (2010)). In particular, these authors study the impact of historical volatility and forward-looking information embedded in equity option, such as at-the-money implied volatility and put skew. Benkert (2004) includes variables such as credit rating, liquidity, leverage, historical volatility and option implied volatility and he finds that the historical and option implied volatility are relevant in the presence of credit ratings but the option implied volatility has a stronger effect than the historical volatility. The same conclusion is given by Cao et al. (2010) that, by using a regression analysis, underline how the option implied volatility is able to dominate the historical volatility in pricing the CDS spreads. Cremers et al. (2008) rely on the at-the-money implied volatility and put skew and find that these measures are able to explain a large portion of the CDS spreads. Zhang et al. (2009) focus on equity volatility and jump risk measures and they highlight that these measures as well as macroeconomic conditions and firm-specific information have significant impact on CDS spreads. In a more recent study, Pires et al. (2015), by using a quantile regression approach, confirm the high capability of implied volatility and put skew in explaining the CDS spreads. In addition to the traditional variables (implied volatility, put skew, leverage, historical stock return, profitability and ratings), their results indicate that CDS spreads are strongly determined by CDS illiquidity costs. The quantile regression approach reveals that the model performs better for high-risk firms than for low-risk firms.

2.3 Methodology and Data

We use a framework similar to that of Ericsson et al. (2009) and Galil et al. (2014) to explain the determinants of credit spreads. We investigate the ability of firm-specific and market factors to explain the CDS spreads in levels and in differences because, as shown subsequently, levels and changes of CDS premium are both stationary. We run a simple Pooled OLS regression of CDS premium on all explanatory variables.

Before running the multivariate regressions in levels and in differences, we test the stationarity of dependent and independent variables by using two unit-root tests (Augmented Dickey-Fuller and Philip-Perron test). The firm-specific variables are tested for each firm separately (Table 2.4). Since the tests show that the data are stationary in differences, we can run the following model:

$$\Delta CDS_{it} = \alpha + \beta(\Delta X_{it}) + \gamma(\Delta Z_t) + \varepsilon_{it} \tag{2.1}$$

In Eq.(2.2), i and t are firms and time periods (months), respectively. ΔCDS_{it} is the changes in CDS premium of a firm in basis points (bps). ΔX_{it} is a vector of changes in firm-specific variables that includes: leverage ($lev_{i,t}$), volatility ($\sigma^2_{i,t}$) and stock price ($price_{i,t}$). ΔZ_t is a vector that takes into account the changes in US macroeconomic conditions. It includes risk-free interest rate ($r_{5,t}$), risk premium ($premium_t$) and slope of the yield curve ($slope_t$). A detailed description of the variables is reported in Table 2.1. Finally, we include two 0-1 dummy variables that seek to capture, respectively, the impact of the global financial crisis and the credit rating class of the firms because they may have impacted the perceived credit risk of US companies.

As in Galil et al. (2014), for measuring the impact of the financial crisis, we run cross-sectional regressions on two periods: crisis period and post-crisis period. According to the full timeline of the financial crisis in the web site of the Federal Reserve Bank, we define the period between March 2007-March 2009 as crisis period and the period between April 2009-July 2015 as post-crisis period. In addition, we conduct a cross-sectional analysis to examine the ability of firm-specific and market variables to explain the sectorial CDS spreads. Doing so allows us to understand the sectors that suffered a structural change in pricing the credit risk[2]. For those sectors that recorded a structural change, we run an additional analysis to explore the changes in key factors of CDS premium after the financial turmoil.

Before estimating the multivariate regression model, to test whether variables result correlated, we use a Pearson correlation test (Table 2.5). We also check and exclude multicollinearity problems by analyzing tolerance and VIF (all variables have VIF<3).

Since the error terms in time series data can exhibit serial correlation, that is, the covariance between two error terms, ε_i and ε_j, is different from zero, $E(\varepsilon_i \varepsilon_j \neq 0)$, we check the presence of autocorrelation of the error terms generated by a first-order autoregressive process observed at equally spaced time periods by using Durbin-Watson test and Breusch-Godfrey test under the null hypothesis of no first-order autocorrelation and no serial correlation, respectively. In our regressions in levels, we reject the null hypothesis of both tests at the first order autocorrelation and we conclude that the errors are autocorre-

[2] We use the Chow test under the null hypothesis of structural stability.

lated in regression in levels. In order to have efficient estimates of our regression parameters, we follow an established approach in the CDS literature, the first differences approach (absolute change during one month), to cope with serial autocorrelation. Additionally, we introduce a Generalized Least-Squares method for regressions in levels. The GLS method assumes that the error terms follow a first-order autoregressive process (AR(1)). We use the Prais-Winsten model (Prais and Winsten (1954)) that derives the error term by an AR(1) model. Under this assumption, the linear model can be written as:

$$CDS_{it} = \alpha + \beta(X_{it}) + \gamma(Z_t) + \varepsilon_{it} \tag{2.2}$$

where the error term ε_{it} satisfies the following equation:

$$\varepsilon_{it} = \rho \cdot \varepsilon_{it-i} + e_{it} \tag{2.3}$$

e_{it} is the error term that is independent and identically distributed $e_{it} \sim N(0, \sigma^2))$. As robustness test, we implement a Cochrane and Orcutt (1949) model that has the same logic of the Prais and Winsten (1954) model but with a different definition of lags.

The use of the GLS method have some advantages:

1. *the GLS method keeps the simplicity of the OLS method.* The interpretation of the coefficients is the same of the OLS method;
2. *the estimators are consistent and unbiased.* The autocorrelation determines a biased variance of the estimators.

$$Var(\beta^{\widehat{OLS}}_{autocorr}) = Var(\beta^{\widehat{OLS}}_{No\ autocorr}) + 2 \cdot f(\rho) \tag{2.4}$$

   where $f(\rho)$ is a function of number of lags ρ. This implies that the estimators are consistent but not efficient;
3. *the error terms are homoscedastic and not serial autocorrelated.* The interactions to compute the error term determines that the estimated error terms are i.i.d ;

2.3.1 Explanatory variables

Dependent variable

Credit default swap ($CDS_{i,t}$). We downloaded the data from Bloomberg dataset. We analyze the five-year CDS written on senior debt of the company, since this instrument is the most liquid in the CDS market (Meng and Gwilym (2008)). In line with Collin-Dufresne et al. (2001), Avramov et al. (2007) and Greatrex (2008), we use monthly quotes because daily quotes are more contaminated by temporary shock on supply and demand. Bid, ask and mid price are treated separately. Nevertheless, they give the same results and they lead to the same conclusions.

Independent variables

We use the variables suggested by the literature. Furthermore, we add some variables that affect the corporate credit risk theoretically and some indicators of the economic conditions. We divide the set of variables into two subsets: firm-specific and macroeconomic variables.

Firm-specific determinants

Leverage ($lev_{i,t}$). Since the data obtained from Bloomberg are quarterly and we need monthly data, we use a different definition of the leverage to fill this gap (e.g. Collin-Dufresne et al. (2001), Ericsson et al. (2009) and Galil et al. (2014)). We use leverage at market value defined as

$$lev_{i,t} = \frac{BVD_{i,t}}{BVD_{i,t} + MVE_{i,t}} \tag{2.5}$$

where $BVD_{i,t}$ is the book value of debt and $MVE_{i,t}$ is the market value of equity. $MVE_{i,t}$ assures that the leverage has a monthly frequency. In Merton approach, the leverage is the barrier to the default. Therefore, an increase of leverage narrows the distance from the default and, as consequence, the probability of corporate default increases. For this reason, the expected relationship between leverage and CDS premium is positive.

Stock price ($price_{i,t}$). We include information from the stock market. Specifically, we include the monthly stock price of each company. The relationship between the stock price and CDS premium is negative. In Merton's model, a higher value on the firm's asset value indicates a greater distance to the default threshold, decreasing the probability of default and hence decreasing CDS premium[3] (Pires et al. (2015)).

Option implied volatility ($\sigma^2_{i,t}$). As Pires et al. (2015), Cao et al. (2010), Carr and Wu (2009) and Cremers et al. (2008), we use at the money put implied volatility. We obtain the data from Bloomberg. Option implied volatility by individual equity options is

[3] The stock price becomes stock return when we consider the regression in differences.

a forward looking measure of volatility, thus it is a timely warnings of credit deterioration. The expected sign is positive because the volatility is a measure of corporate risk and thus, an increase on it determines an increase of the probability of default.

Macroeconomic determinants

Risk premium($premium_t$). Risk premium is calculated as difference between 10 years interest rate swap (IRS) and 10 years Treasury constant maturity (CM). Data are downloaded from the web site of Federal Reserve (FRED). This measure is a proxy of the market risk since it represents a possible measure of the risk premium required from the market. Ceteris paribus, an increase of the risk premium is characterized by an increase of the market risk that, on turn, increases corporate risk. Therefore, a positive relationship is expected.

Risk-free rate ($r_{5,t}$). To be in line with the maturity of the CDS premium, the risk-free interest rate of our model is measured by 5 years Treasury bond (Greatrex (2008) and Avramov et al. (2007)). The structural model predicts a negative relation between the probability of default and the risk-free interest rate.

Slope ($slope_t$). As in Greatrex (2008), Ericsson et al. (2009) and Galil et al. (2014), the slope of the yield curve is defined as the difference between the 10 years Treasury bond and 2 years Treasury bond. This variable is a proxy of the future economic conditions of the market and it carries information about future interest rate levels. The relationship between CDS premium and slope of the yield curve is not clear. Following Fama and French (1989) and Aunon-Nerin et al. (2002), a higher slope might imply an anticipated improvement of the overall economy, resulting in lower default probabilities and therefore decreasing CDS spreads. In contrast, following Zhang et al. (2009), the higher slope could trigger increasing inflation rates, which might cause a deterioration in the overall macroeconomic conditions and result in higher CDS premiums.

The variables included in Eq.2.2 and the corresponding predicted signs are summarized in Table 2.1.

Description of variables			
Variable	Description	Source	Expected sign
Panel A: Firm-specific determinants			
Leverage	Ratio between debt and book value of debt added to the equity market value	Bloomberg	+
Price	Share price of the company.	Bloomberg	-
σ^2	Put option implied volatility.	Bloomberg	+
Panel B: Macroeconomic determinants			
Premium	Difference between 10Y IRS and 10Y CM.	Authors's calculation	+
r_5	5 years Treasury bond.	FRED	-
Slope	Difference between 10Y and 2Y Treasury bond.	Authors's calculation	+/-
Panel C: Dummy variables			
Crisis	1, if the period is between March 2007- March 2009 and 0, otherwise.		
Speculative	1, if the rating is less than *Ba1* and 0 otherwise.		

Table 2.1: *Variable description, data source and expected coefficient signs.*

2.3.2 Descriptive statistics

Our study on the determinants of CDS premium is focused on the US market. We use a Panel Data of CDS premium across the companies that are listed on S&P 500. Nevertheless, we delete from the sample the companies that do not have sufficient number of observations. Therefore, our sample includes 312 US firms over the period January 2007-July 2015. To have a clear idea about the composition of our sample, we present in Table 2.2 the descriptive statistics of the CDS premium divided by industry and year. We identify 8 industries: Basic Material, Communication, Consumer, Energy, Financial, Industrial, Technology and Utility. The number of observations varies across the year. In particular, the number of observations increases after the financial crisis. Additionally, Table 2.2 shows that CDS premiums have been declining after 2009 across all industry groups. In 2009, the CDS premium of all industry groups reaches its peak and reverses its trend. Furthermore, the descriptive statistics show that across the period of our sample the sector *Basic Material* is perceived as the riskiest industry. In each year, the average CDS premium in this sector is highest compared to the other sectors.

Table 2.3 provides the descriptive statistics overall of firm-specific and macroeconomic variables. The monthly mean of CDS premium is 139 basis points (bps) with a

Average CDS premium by industry and year									
		Cyclical Sectors				Counter-Cyclical Sectors			
Year		Bm[1]	Ind[2]	Cons[3]	Techno[4]	Comm[5]	Energy	Fin[6]	Utility
2007	Mean	78.41	27.30	76.67	50.59	48.72	28.02	35.34	29.20
	Obs	27	98	179	37	43	46	109	32
2008	Mean	384.10	124.42	221.81	141.33	298.04	153.35	283.46	154.09
	Obs	31	42	80	9	22	32	72	19
2009	Mean	285.73	135.64	196.27	170.84	296.93	161.13	354.19	167.85
	Obs	143	354	938	86	168	295	448	169
2010	Mean	151.10	85.42	123.66	107.89	157.64	123.67	169.75	116.76
	Obs	95	253	651	76	116	206	297	112
2011	Mean	141.06	104.90	134.11	123.62	145.74	116.96	168.15	127.66
	Obs	133	368	969	121	174	300	463	192
2012	Mean	184.09	102.85	133.36	160.56	149.58	147.69	161.59	133.49
	Obs	106	313	855	94	154	271	409	156
2013	Mean	267.58	68.79	93.61	96.89	131.85	110.51	95.27	93.43
	Obs	43	96	355	47	75	108	184	72
2014	Mean	220.52	41.85	72.93	61.47	93.30	91.40	62.48	66.83
	Obs	44	62	224	33	47	43	152	35
2015	Mean	198.81	38.00	72.46	57.30	82.13	206.75	65.71	106.17
	Obs	10	23	70	14	24	6	43	2

Table 2.2: *Table presents summary statistics of CDS premium (in basis points) divided by industry and year.* [1] *Basic material;* [2] *Industrial;* [3] *Consumer;* [4] *Technology;* [5] *Communication;* [6] *Financial.*

large standard deviation while the monthly mean of CDS changes is 3.81 bps. Panel A describes the firm-specific variables in levels. On average, the financial leverage is 59.19%. It indicates that the firms have an high debt or a lower market value of equity. This implies that the firms are highly risky. Additionally, stock monthly prices mean is 49.94 US $. The share price ranges from 3.79 US $ to 1199.6 US $. The high volatility in stock price is due to the situation in crisis and post-crisis period. Panel B outlines the descriptive statistics of the macroeconomic variables. These variables depict the bad conditions of US economy and the quantitative easing of the Central Bank.

Table 2.4 shows the results of Augmented Dickey-Fuller test and Philip-Perron test for CDS premium and the main explanatory variables. In Panel A of Table 2.4 we report the number of firms for which unit-root is not rejected (the time series is non-stationary) and the number of firms for which unit-root is rejected (the time series is stationary). The results of both tests lead to the conclusion that the firm-specific variables tend to be stationary in

Summary statistics						
Variables	Obs	Mean	Median	Std	Min	Max
Dependent variable						
CDS premium	12331	139.42	78.629	214.25	4.162	593.38
$\Delta CDSpremium$	12331	3.81	-0.11	54.17	-194.77	147.055
Panel A: Firm-specific determinants (%)						
Leverage	12331	59.19	30.13	99.670	0.00	99.80
Price (US \$)	12331	49.94	39.23	57.89	3.79	1199.6
σ^2	12331	31.65	28.595	15.860	9.85	25.64
Panel B: Market determinants (%)						
Premium	12331	0.15	0.14	0.16	-0.18	0.90
r_5	12331	1.70	1.65	0.856	0.55	5.15
Slope	12331	1.88	1.772	0.60	-0.16	2.89

Table 2.3: *Table presents the descriptives statistics of the variables for the period January 2007-July 2015. CDS premium are reported in bps and the variables of Panel A and B are reported in percentage.*

differences but not in levels, for the majority of firms. Unit-root of CDS premium in levels is rejected for 275 firms according to the Augmented Dickey-Fuller test and for 294 firms according to Philip-Perron test. Panel B of Table 2.4 shows that the market variables are stationary in both levels and first differences. The tests strongly reject (at 1% level) the null of non-stationary. We run Eq.2.2 by including all firms and by excluding the firms that present a non-stationary time-series. The results and hence the conclusions do not change. Therefore, we report the results that include all observations available.

Before running our regressions in levels and differences, we explore the relationship between monthly CDS premium and each variable. We calculate a Pearson correlation matrix (Table 2.5). The correlation coefficients between the CDS premium and each of the independent variable have the expected sign. The leverage and option implied volatility are the firm-specific variables with the strongest and statistically significant correlation with monthly CDS premium. This is a support to the Merton model because leverage and volatility are the key inputs of structural framework. However, the correlation between CDS premium and macroeconomic determinants confirms that adding systematic factors to the Merton variables helps to explain the CDS premium. The correlation matrix does not show a significant influence between the independent variables.

Unit root tests					
Panel A: firm-specific variables		CDS premium	Leverage	Price	σ^2
Augmented Dickey-Fuller test					
Levels	Non-Stationary	275	266	278	291
	Stationary	37	46	34	21
First Differences	Non-Stationary	16	6	5	9
	Stationary	296	306	307	303
Phillip-Perron test					
Levels	Non-Stationary	294	271	279	297
	Stationary	18	41	33	15
First Differences	Non-Stationary	14	10	4	11
	Stationary	298	302	308	301
Panel B: market variables			Premium	Treasury	Slope
Augmented Dickey-Fuller test					
Levels	Z		-10.665	-12.457	-11.483
	P-value		(0.000)	(0.000)	(0.000)
First Differences	Z		-18.543	-21.109	-20.172
	P-value		(0.000)	(0.000)	(0.000)
Phillip-Perron test					
Levels	Z-Rho		-10.662	-12.485	-11.528
	P-value		(0.000)	(0.000)	(0.000)
First Differences	Z-Rho		-26.539	-29.8	-27.81
	P-value		(0.000)	(0.000)	(0.000)

Table 2.4: *Table reports Stationarity test based on Augmented DickeyFuller (ADF) and PhillipsPerron (PP) Tests using one lag and a single mean. Panel A summarizes the results of 312 individual firm-level variables using both ADF and PP tests. The reported numbers are of firms for which the tests failed to reject the null hypothesis (non- stationary) and the number of firms for which the tests rejected the null hypothesis (stationary). Panel B provides the test statistics (Z) and associated p-values for the market explanatory variables.*

2.3.3 Time-series analysis

Figure 2.1 presents the time-series plots of monthly mean bid CDS premium versus the various independent variables. The plots confirm the expected sign in our hypothesis. Panel A, B and C describes the relationship between the bid CDS premium and the firm-specific variables. Whereas, Panel D, E and F plot the relationship between the mean CDS premium and the macroeconomic variables.

Panel A shows the relationship between CDS spreads and mean leverage ratio. The behaviour of these two variables is the same. The plot seems to show the ability of the CDS premium to anticipate changes in leverage especially when the volatility of the market is high. As a matter of fact, both variables record a pick in 2008-2009; the leverage reaches the pick in March 2009 while CDS spread in November 2008. Panel B plots the relationship between the mean stock price and the mean CDS spread. Although after the financial turmoil the relationship between CDS premium and stock price is more

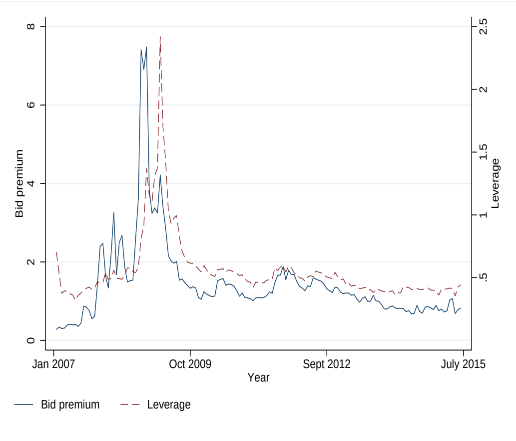
Correlation Matrix													
	Bid		Leverage		Price		σ^2		Premium		r_5		Slope
Bid	1.00												
Leverage	0.26	***	1.00										
	(0.00)												
Price	-0.01	*	-0.02	***	1.00								
	(0.09)		(0.00)										
σ^2	0.49	***	0.27	***	-0.01	***	1.00						
	(0.00)		(0.00)		(0.00)								
Premium	0.06	***	-0.01	***	-0.03	***	0.01	*	1.00				
	(0.00)		(0.00)		(0.00)		(0.06)						
r_5	-0.01		0.01	*	-0.01		0.06	***	0.06	***	1.00		
	(0.39)		(0.06)		(0.22)		(0.00)		(0.00)				
Slope	0.13	***	0.02	***	0.01		0.24	***	-0.14	***	-0.15	***	1.00
	(0.00)		(0.00)		(0.23)		(0.00)		(0.00)		(0.00)		

Table 2.5: *Table shows the Pearson correlation matrix among all variables in Eq. 2.2. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively.*

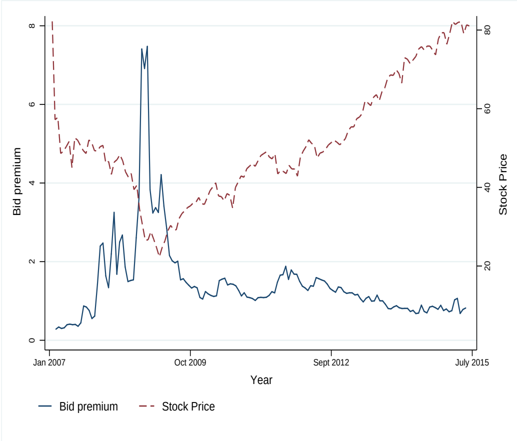
pronounced, the general trend describes a negative relationship between these two variables. Panel C depicts the relationship between the implied put volatility and the CDS spread. As hypothesis, Panel C seems to depict the implied put volatility generally moving in the same direction to CDS premium. Panel D plots the relationship between mean CDS premium and risk premium. Generally, this relationship is positive but, in periods of higher volatility of the financial market, Panel D seems to describe a negative relationship. On the contrary, it is obvious the negative relationship with the 5Y Treasury bond (Panel E). The behaviour of these two variables is mirrored. Therefore, a restrictive monetary policy determines a decrease on CDS premium. Panel F shows a positive relationship between CDS premium and slope of the yield curve. This connection is much clear during the financial crisis.

2.4 Results

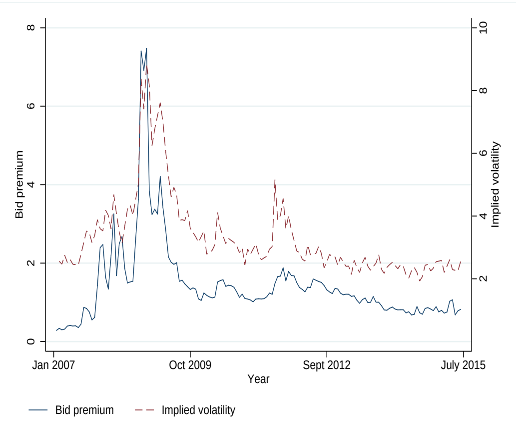
We begin by assessing the relative importance of our explanatory variables in levels and differences. Our model includes all the explanatory variables defined in the previous section because the sample does not show multicollinearity problems. Additionally, we include a dummy to control for the credit ratings (*speculative*). We first discuss the results overall and then, in order to assess the impact of the financial crisis in pricing the credit risk



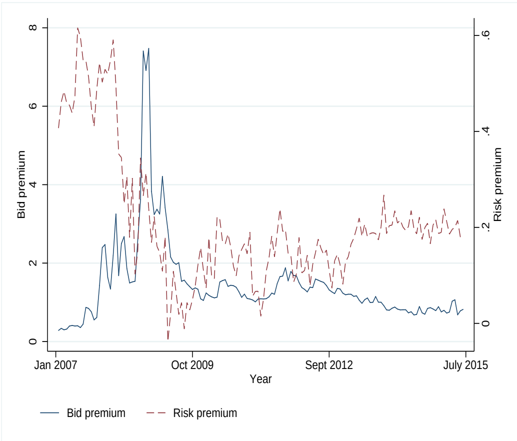
A: CDS vs Leverage



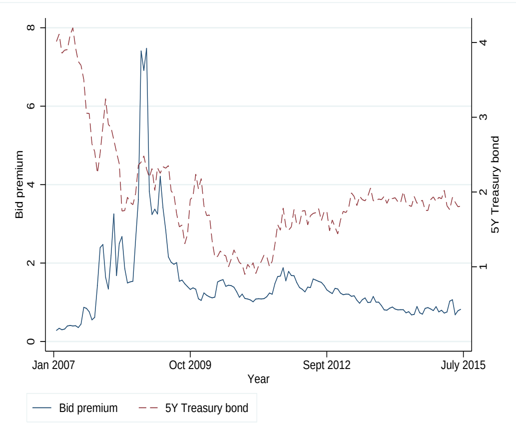
B: CDS vs Stock Price



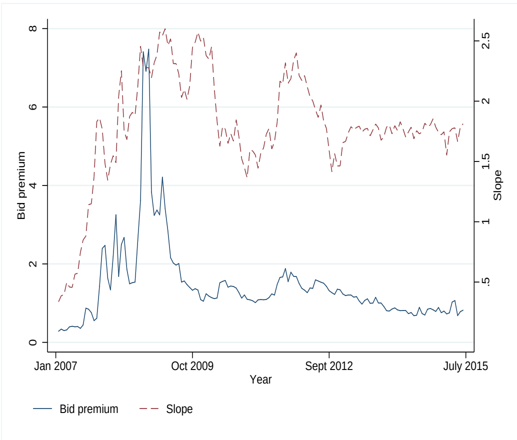
C: CDS vs Option Implied Volatility



D: CDS vs Risk Premium



E: CDS vs 5Y Treasury bond



F: CDS vs Slope of the yield curve

Figure 2.1: *Time-series graphs*

we split up the results for crisis and post-crisis period. Finally, we run a sectorial analysis to understand the industrial sectors that have suffered most from the financial crisis.

2.4.1 Analysis overall

Table 2.6 reports the results of Eq.2.2. Model (I) and Model (II) report the results of the regressions in levels. Model (III) reports the results of the regression in differences. The signs on firm-specific and market variables coefficients generally accord with our expectations from the literature. The results, in levels and in differences, show as key factors leverage, option implied volatility and slope of the yield curve. Therefore, we find that two of the structural variables are important in pricing the credit risk. CDS premium widens in response to a tightening of leverage, an increase in option implied volatility and an increase in slope of the yield curve. As in Pires et al. (2015), the results show that the coefficients on option implied volatility and leverage are strongly statistically different from zero in all specifications. The response rates for option implied volatility and leverage are around 0.20 and 0.16, respectively. We highlight the significant and positive effect of the slope of the yield curve on the credit risk (Ericsson et al. (2009)). The investors consider as indicator of economic activity the short-term interest rate rather than the longer-term interest rate. The market participants embed the expectation about the future interest rate levels inside of corporate credit risk by forecasting an economic environment with a rising inflation rate and a tightening of monetary policy. Nevertheless, it needs to take into account that in the studied period the slope of the yield curve was sensibly affected by the Quantitative Easing policy issued by the Federal Reserve that exerted a strong influence on the corporate credit risk by triggering increases in the level of credit risk associated to the credit default swap instruments. The liquidity injections of the Federal Reserve have been perceived as negative signal by the market participants. Our result confirms that the Quantitative easing policy does not only impact on the countries (as showed by Albu et al. (2014)) but it also has a significant effect on corporate CDS spreads. Furthermore, we find that CDS premium widens during the financial crisis. The generalized increase of the financial market volatility has determined an increase of more than 1 bp in corporate CDS market. Additionally, the Chow test in last row of Table 2.6 demonstrates that the

US corporate CDS market recorded a structural change in pricing of credit risk. Credit ratings contribute to explain the CDS premium. The coefficient on *speculative* is positive and statistically significant. This suggests that a firm rated as *speculative* is perceived as risky by the market participants. In particular, a rating downgrade from *investment* to *speculative* rating classes will induce a very steep increase in CDS premium (Pires et al. (2015)). The CDS premium will increase of around 3-4 bps when the company shifts from an investment to a speculative rating class.

The coefficients in Table 2.6 can be mis-leading if one omits the standard deviations from the analysis. In column (IV), we report the normalized betas of the regression in differences that allow us to compare the impact of the independent variables on pricing of credit risk. The option implied volatility has a greater impact on the CDS premium. Although the coefficient on slope of the yield curve in Table 2.6 column (III) is bigger than the coefficient of option implied volatility and leverage, the normalized beta shows that the greater change in CDS premium is determined by the change in option implied volatility while, the impact of the slope, leverage, financial crisis and speculative rating class on the CDS premium is more or less the same. We can conclude that the option implied volatility is the most important determinants of the CDS premium and it is the dominant key factor. A one standard deviation increase of option implied volatility implies an increase of more than 1/4 of standard deviation of CDS premium relative to its own trend.

Overall, our results are in line with the previous literature. The findings reported in this section are not inconsistent with those of Ericsson et al. (2009) and Greatrex (2008). They find that the leverage and the volatility have substantial explanatory power and they indicate them as key variables of CDS spread changes. As Di Cesare and Guazzarotti (2010), we find that the investors in pricing the credit risk consider the short-term interest rate rather than the long-term interest rate. Finally, the statistical significance of the macroeconomic variables support the findings of Galil et al. (2014) that the firm-specific variables inspired by structural model do not capture all the systematic variation in CDS spread changes but the market variables contribute on the explanation of CDS premium.

Results overall								
	Regression in levels				Regression in differences			
Bid premium	Prais-Winsten (I)		Cochrane-Orcutt (II)		OLS (III)		Normalized beta (IV)	
Lev	0.1509	***	0.1908	***	0.1577	***	0.0288	
	(0.048)		(0.052)		(0.022)			
Price	0.0131		0.0150		0.0310		0.0220	
	(0.0128)		(0.0127)		(0.0204)			
σ^2	0.2215	***	0.1902	***	0.2176	***	0.2835	
	(0.007)		(0.007)		(0.038)			
Premium	-0.0995		-0.0536		0.0441		0.0016	
	(0.245)		(0.242)		(0.114)			
r_5	0.0736		0.0663		0.0736		0.0116	
	(0.060)		(0.059)		(0.052)			
Slope	0.2992	***	0.3071	***	0.3155	***	0.0331	
	(0.090)		(0.089)		(0.046)			
Crisis	1.9080	***	1.3908	***	1.3037	***	0.0255	
	(0.381)		(0.380)		(0.351)			
Speculative	3.9971	***	4.6474	***	4.2995	***	0.0145	
	(1.257)		(1.081)		(1.082)			
Constant	-5.9338	***	-3.8854	***	-0.1003	***		
	(0.339)		(0.745)		(0.030)			
Rho	1.014		0.954					
N	12331		12331		12331			
R^2	0.4181		0.3932		0.3488			
VIF	1.29		1.31		1.09			
Chow-test					(0.004)			
Durbin-Watson	1.658		1.663		1.599			

Table 2.6: *Table reports the coefficients estimates across all companies . Robust standard errors in parenthesis below the coefficient estimates. Columns (I) and (II) report the results of the regressions in levels for the Prais-Winsten and Cochrane-Orcutt model, respectively. Column (III) report the results of the regression in differences. Column (IV) presents the normalized beta of the regression in differences. VIF quantifies the multicollinearity problems. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively. Chow-test reports the p-values for the null hypothesis of a structural stability. Durbin-Watson reports the statistics for the null hypothesis of no first-order autocorrelation.*

2.4.2 Analysis by period

Crisis period

The impact of the financial crisis in pricing of credit risk is a matter of debate. The previous findings underline the importance of firm-specific variables in pricing the credit risk and a structural change caused by the financial crisis (Chow test in Table 2.6). However, the higher volatility of the financial market and the generalized increase of the CDS premium might have caused a shift in its determinants. After the financial turmoil, the CDS premium might be independent by the firm-specific variables and might be strongly related to systematic risk factors. To assess the impact of the financial crisis in the key factors of CDS premium, we run Eq.2.2 for crisis and post-crisis period. Table 2.7 reports the results of the regressions in levels (Prais-Winsten model) and in differences in both periods. Columns (I) and (III) show the results in crisis period (March 2007- March 2009) in levels and in differences, respectively. In this period, the key factors of the CDS premium are firm-specific variables. In particular, the CDS premium is affected by leverage and option implied volatility. We find a marginal impact of the risk premium in regression in differences. This indicates that the empirical relationship between CDS premium and default factors is no longer described by the market variables. Furthermore, the empirical analysis shows that the CDS premium of *speculative* firms is greater than the CDS premium of *investment* firms. If we focus on column (IV) of Table 2.7, we can observe the economic impact of the financial crisis in the determinants of CDS premium. We observe that the changes of option implied volatility dominate the changes of other independent variables. In fact, a change of one standard deviation in option implied volatility generates a change in CDS premium 4 times bigger than a change of one standard deviation in leverage.

The results for crisis period suggest that the determinants of the CDS premium is mainly idiosyncratic factors. Hence, during the financial turmoil, the investors seem to be aware to firm-specific risks that are incorporated in pricing of credit risk.

Post-crisis period

Columns (II) and (IV) in Table 2.7 show the results in post-crisis period (April 2009- July 2015) in levels and in differences, respectively. The estimated coefficients have the expected signs. After the financial crisis, the CDS premium seems to be driven not so much from the idiosyncratic factors but it seems to be related to the systematic factors. Therefore, the financial turmoil have shifted the attention of the investors from idiosyncratic to systematic factors. In particular, the empirical analysis highlights the high statistical significance of the slope of the yield curve. Additionally, the long term interest rate appears to be statistically significant in explaining the changes in CDS premium. On the contrary, the firm-specific variables and, more precisely, the variable *leverage* partially impacts on the CDS premium (10% level) in both regression in levels and differences. Surprisingly, the credit rating does not have impact on the levels and changes of CDS premium after the financial crisis. This finding could be an empirical evidence to the sub-prime debate that questions the validity of credit ratings issued by the rating agencies. The market participants have started to question the capability of rating agencies to rate mortage credit and, as spillover effect, they have applied such inability to the corporate credit market especially when the market enter a phase of abundant credit and low volatility (Jacobs Jr et al. (2016)). Following the financial crisis and sub-prime debate, the investors became more aware to systematic risk factors and skeptical about the credit rating issued by rating agencies. In column (VI) of Table 2.7 we can observe the impact of each variable on the changes of CDS premium in term of standard deviation. After the financial crisis, the changes in option implied volatility continues to dominate the other variables. However, the impact of this variable is smaller than during the financial crisis. A change of one standard deviation of option implied volatility generates an increase of 0.23 standard deviations in CDS premium. The change of one standard deviation in leverage and slope of yield curve produces an increase on CDS premium of 0.14 and 0.05 bps, respectively. It provides valuable guidelines on how options market information can be fruitfully incorporated into the calibration of credit risk models.

As in Galil et al. (2014), we find that leverage and option implied volatility retain their ability to explain the CDS premium after the financial crisis. However, we observe that the effect of option implied volatility actually decreases after 2009 and, the link between market factors and corporate CDS premium is significantly stronger. Hence, the higher volatility of the financial markets highlighted the shift from an idiosyncratic credit risk perspective to a systematic credit risk perspective. Moreover, Galil et al. (2014) highlight that the ability of credit ratings to explain the CDS premium after the financial crisis is halved. Our results about the inability of credit ratings to explain the CDS premium after the financial crisis partially confirm the results of Galil et al. (2014). The fact that investors price the credit risk independently from the credit ratings could be the empirical proof of the loss of investor's confidence in the credit rating issued by agencies.

2.4.3 Analysis by industrial sector

Before running the sectoral analysis, we classify the sectors as *cyclical* and *counter-cyclical*. By definition, a cyclical sector is a sector whose performance is highly correlated to the economic activity. Conversely, the counter-cyclical sector is a sector whose profit has a lower or negative correlation to the economic activity. Nevertheless, identifying whether a sector is cyclical or counter-cyclical is not easy. To classify an industry as cyclical or counter-cyclical, we plot (Figure 2.2) the relationship between the annual performance of each sector and US GDP growth[4]. As we observe in Panel A of Figure 2.2, the *cyclical sector* (Basic Material, Industrial, Consumer and Technology) has the same pattern of US GDP whereas, Communication, Energy, Financial and Utility industries (in Panel B), defined as *counter-cyclical* sectors, show a negative correlation to the US GDP growth.

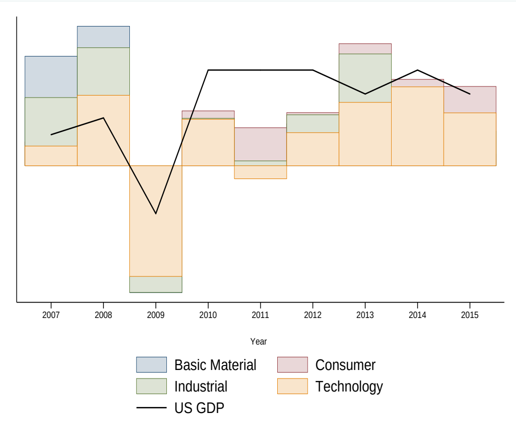
Table 2.8 reports the results of the regression in levels for the sectoral analysis[5]. Overall, the coefficient on option implied volatility is positive and highly statistically significant. Additionally, in all but two sectors (Technology and Financial) the coefficient on leverage is positive and highly statistically significant. Not surprisingly, the cyclical sectors, with the exception of Basic Material sector, rely the price of credit risk to the common mar-

[4]GDP data are downloaded from World Bank Data. The stock market's performance of each sector is downloaded from Bloomberg.

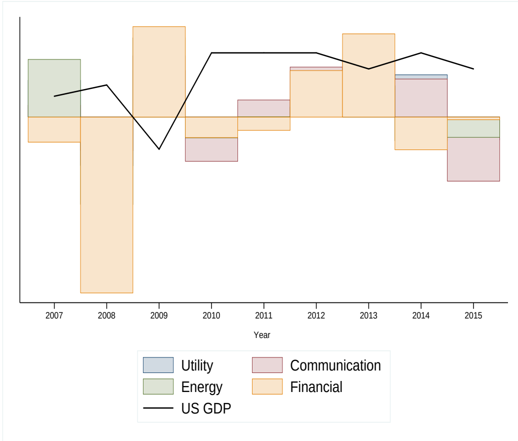
[5]The results of the regression in differences are reported in Appendix A, Table A.12. The results of the estimates in levels are confirmed by the estimates in differences.

Results by period										
	Regression in levels				*Regression in differences*					
Bid premium	Crisis (I)		Post-Crisis (II)		Crisis (III)		Beta (IV)	Post-Crisis (V)		Beta (VI)
Lev	0.204	***	0.642	*	0.329	**	0.093	1.4179	*	0.143
	(0.025)		(0.004)		(0.131)			(0.757)		
Price	0.056		0.001		0.055		0.022	0.023		0.019
	(0.089)		(0.011)		(0.173)			(0.014)		
σ^2	0.297	***	0.157	***	0.340	***	0.397	0.172	***	0.232
	(0.032)		(0.007)		(0.075)			(0.018)		
Premium	-1.084		-0.001		1.334	*	0.025	0.290		0.012
	(1.880)		(0.214)		(0.725)			(0.242)		
r_5	0.164		0.065		0.066		0.005	-0.091	*	-0.017
	(0.499)		(0.052)		(0.705)			(0.055)		
Slope	-0.611		0.399	***	-0.733		-0.035	0.435	***	0.054
	(0.773)		(0.078)		(0.712)			(0.088)		
Speculative	7.190	***	0.503		3.099	***	0.009	-0.142		-0.029
	(0.065)		(1.138)		(0.215)			(0.211)		
Constant	6.443		4.713	***	0.1635			-0.1182	***	
	(6.401)		(0.725)		(0.423)			(0.037)		
Rho	0.931		0.940							
N	882		11449		882			11449		
R^2	0.508		0.350		0.533			0.353		
VIF	1.34		1.67		1.16			1.093		
Durbin-Watson	1.574		1.520		1.653			1.721		

Table 2.7: *Table reports the coefficients estimates across all companies divided by period. Columns (I) and (III) show the results for crisis period (March 2007- March 2009) for regression in levels and differences, respectively. Columns (II) and (V) show the results for post-crisis period (April 2009- July 2015) for regression in levels and differences, respectively. Columns (IV) and (V) report the standardized coefficients. VIF quantifies the multicollinearity problems. Robust standard errors are in parenthesis below the coefficient estimates. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively. Durbin-Watson reports the statistics for the null hypothesis of no first-order autocorrelation.*



A: Cyclical sectors and US GDP growth



B: Counter-cyclical sectors and US GDP growth

Figure 2.2: *Behaviour of annual performance of each industry and US GDP growth.*

kets risk factor as well as to the firm-specific variables; on the contrary, the key factors of the CDS premium in counter-cyclical sectors are exclusively firm-specific variables. The strong impact of the monetary policy on credit risk of cyclical sectors is shown by the significance of the coefficient on term-structure of interest rate. The Quantitative Easing policy of the Central Bank triggered a negative effect on the CDS premium. The market participants have perceived the Quantitative Easing policy as a worsening economic situation and have incorporated this economic context in CDS premium by triggering an increase of the corporate credit risk. The credit rating do not have a significant impact on pricing the credit risk. The increase of CDS premium in Basic Material and Energy industrial sector (3.99 and 5.16 bps, respectively) is significant when switching from investment to non-investment grade firm. In line with Narayan (2015), in some sectors, such as Consumer and Energy we find a negative and significant impact of the stock price. Furthermore, we find that the financial crisis raises the CDS premium. The financial crisis has a different impact on the sectoral credit risk. The technology industry was the sector that have suffered most from the crisis. In fact, during the financial turmoil, the CDS premium of technology firms was around 6.07 bps higher than in normal periods.

We note that, across sectors, the model explains the highest proportion of variation for companies in cyclical sectors which are also the ones that have suffered the economic turmoil more than counter-cyclical sectors given the strong and significant link with the macroeconomic determinants. This implies that the cyclical firms have been perceived as relatively riskier than the counter-cyclical firms that, conversely, marginally suffered the impact of the financial crisis given the weak link with the economic conditions. Therefore, we have empirical evidence of the greater capacity of the model to price the credit risk of riskier sectors. This finding is in line with the previous literature (Greatrex (2008), Di Cesare and Guazzarotti (2010)) that underlines the highest explanatory power of firm-specific and market variables for riskier firms.

In order to dig deeper into the impact of financial crisis on the determinants of CDS premium, we run a Chow test under the null hypothesis of structural stability in pricing the credit risk for each sector. We do not have a unique result for cyclical and counter-cyclical sectors. The Chow test, in the last row of Table 2.8, shows that the financial crisis has caused a structural change in pricing the credit risk of Industrial, Consumer, Communication and Energy sector. The results are robust with the previous findings. In fact, the sectors that recorded a significant increase of CDS premium during the financial crisis are those in which we find a structural change whereas, in the other sectors we find a structural stability in pricing the credit risk.

Analysis by industrial sector and by period

In the previous section we find that Consumer, Industrial, Communication, and Energy experienced a structural change in pricing of credit risk. In this section we investigate, for these sectors, the determinants of the CDS premium during and after the financial crisis. We report the empirical results of the regression in levels in Table 2.9[6]. We find that the key factors differ in particular periods and sectors. In general, during the financial crisis, the key factors of all sectors are leverage, option implied volatility and the credit rating class. We do not have statistical evidence on the effect of macroeconomic variables during the financial crisis. Surprisingly, this result is also confirmed in cyclical sectors. After the financial turmoil, we observe an opposite trend. In fact, the macroeconomic variables and,

[6]The results of the regression in differences are reported in Appendix A, Table A.13. The results of the estimates in levels are confirmed by the estimates in differences.

Results by industrial sector								
	Cyclical Sectors				*Counter-cyclical sectors*			
Bid premium	Basic Material (I)	Industrial (II)	Consumer (III)	Technology (IV)	Communication (V)	Energy (VI)	Financial (VII)	Utility (VIII)
Lev	0.416 ***	0.106 ***	0.126 ***	0.088	0.090 ***	0.093 ***	0.0001	0.063 ***
	(0.111)	(0.011)	(0.006)	(0.073)	(0.022)	(0.021)	(0.001)	(0.017)
Price	0.153	0.009	-0.037 *	0.086	0.041	-0.081 ***	0.017	0.039
	(0.147)	(0.018)	(0.019)	(0.135)	(0.085)	(0.028)	(0.041)	(0.079)
σ^2	0.245 **	0.087 ***	0.134 ***	0.120 **	0.197 ***	0.124 ***	0.246 ***	0.097 ***
	(0.104)	(0.014)	(0.012)	(0.050)	(0.029)	(0.021)	(0.019)	(0.029)
Premium	1.811	0.736 *	-0.150	2.647 *	0.296	-0.609	0.207	-0.673
	(2.674)	(0.410)	(0.329)	(1.559)	(0.871)	(0.673)	(0.883)	(0.590)
r_5	-0.413	0.024	0.123	0.419	-0.203	0.213	0.027	-0.044
	(0.699)	(0.101)	(0.080)	(0.323)	(0.213)	(0.159)	(0.216)	(0.155)
Slope	0.664	0.727 ***	0.621 ***	0.243	0.126	0.225	0.623 *	-0.006
	(1.060)	(0.150)	(0.119)	(0.498)	(0.322)	(0.247)	(0.326)	(0.227)
Speculative	3.992 ***	-1.184	0.719	8.592	0.247	5.383 *	-2.760	4.081
	(1.324)	(1.422)	(2.126)	(7.004)	(1.333)	(2.883)	(8.495)	(15.814)
Crisis	2.488	2.028 ***	3.232 ***	6.070 **	3.495 **	2.703 **	3.158 **	0.974
	(4.562)	(0.589)	(0.529)	(2.380)	(1.459)	(1.125)	(1.355)	(0.854)
Constant	-13.545	3.161 *	14.357 **	2.222	4.172	2.647	8.511 **	2.820
	(15.953)	(1.690)	(5.723)	(2.402)	(5.067)	(3.264)	(3.350)	(3.222)
Rho	1.040	1.050	1.012	1	1	1.046	1	1
N	671	1678	4500	572	1037	1255	2268	776
R^2	0.073	0.218	0.342	0.233	0.182	0.161	0.196	0.154
VIF	1.49	1.70	1.89	1.06	1.32	1.57	1.86	1.65
Durbin-Watson	1.356	2.055	2.268	2.096	1.753	2.081	1.907	1.911
Chow-test	0.348	0.021	0.004	0.877	0.035	0.048	0.332	0.354

Table 2.8: *Table reports the coefficients estimates by running the regression in levels for each sector with robust standard error in parenthesis. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively. Chow-test reports the p-values for the null hypothesis of a structural stability. Durbin-Watson reports the statistics for the null hypothesis of no first-order autocorrelation.*

more precisely the term structure of interest rate, have a significant impact on the CDS premium. This may be due to the unconventional monetary policies of the Central Bank that have clearly influenced the dynamic of the CDS instruments.

The most striking difference across periods are that the decision makers and risk managers are very careful to the macroeconomic variables also in sector that we identify as *counter-cyclical*. It seems that the financial turmoil have caused a shift from an idiosyncratic to a market perspective of the credit risk. In fact, after the financial turmoil, the market participants have started to incorporate the market variables in pricing the credit risk of both cyclical and counter-cyclical sectors. We continue to observe the significant impact of leverage and option implied volatility but, we also observe the significant effect of the term structure of interest rate. Although the effectiveness of Quantitative Easing on the financial markets is still open to considerable doubt, we have found it to have a significant and economically important impact on the CDS market, especially after the financial crisis and in those sectors that record a structural change in pricing the credit risk. The counter-cyclical sectors seem to suffer most from the unconventional monetary policies of the Central Bank. In fact, we note that the impact of slope of the yield curve is bigger in counter-cyclical sectors than in cyclical sectors. As discussed in the previous section, we do not observe a significant impact of the credit rating on the perceived credit risk. The investors incorporated the credit rating in CDS premium during periods of high volatility but, in the subsequent period, they do not consider the credit rating as source of additional information to price the credit risk. Finally, in each sector, our model seems to better capture the variability of the CDS premium in period of high volatility. In fact, during this period, the explanatory power is around 20% in each sector. On the contrary, after this period, the model performance sharply decreases.

Results by industrial sectors and period

	Cyclical Sectors				*Counter-cyclical sectors*			
	Consumer		Industrial		Communication		Energy	
Bid premium	crisis	post crisis	crisis	post crisis	crisis	post crisis	crisis	post crisis
Lev	0.084 ***	0.114 ***	0.077 ***	0.195 ***	0.015	0.099 ***	0.085 **	0.125 ***
	(0.024)	(0.014)	(0.031)	(0.005)	(0.128)	(0.024)	(0.040)	(0.027)
Price	0.122	-0.008	0.038	-0.037 **	-0.234	0.044	-0.001	-0.090 ***
	(0.078)	(0.017)	(0.168)	(0.016)	(0.670)	(0.087)	(0.130)	(0.028)
σ^2	0.093 *	0.072 ***	0.150 **	0.133 ***	0.517 **	0.135 ***	0.093 *	0.128 ***
	(0.056)	(0.014)	(0.066)	(0.011)	(0.208)	(0.029)	(0.048)	(0.023)
Premium	-1.086	0.856 **	-3.156	-0.095	-10.625	0.651	-1.949	-0.803
	(2.170)	(0.394)	(2.828)	(0.278)	(11.222)	(0.850)	(3.399)	(0.666)
r_5	-0.137	0.048	-0.501	-0.171 **	0.878	-0.419 **	-0.097	0.222
	(0.579)	(0.096)	(0.681)	(0.068)	(3.851)	(0.197)	(0.725)	(0.160)
Slope	-0.705	0.317 **	-1.003	0.325 ***	3.372	0.627 **	0.085	0.720 ***
	(0.930)	(0.142)	(1.077)	(0.100)	(4.565)	(0.307)	(1.075)	(0.248)
Speculative	5.246 ***	-0.072	3.484 ***	1.277	8.351 ***	1.234	2.252 ***	3.263
	(1.051)	(1.535)	(0.912)	(1.582)	(0.916)	(7.371)	(0.194)	(2.985)
Constant	1.020	3.638	1.909	2.739 ***	51.200	3.801	7.097	0.683
	(9.037)	(2.805)	(7.543)	(0.971)	(66.556)	(2.545)	(13.465)	(5.775)
N	298	4202	141	1537	81	956	92	1163
R^2	0.2434	0.1851	0.2332	0.1778	0.2289	0.1696	0.2084	0.1525
VIF	1.45	1.89	1.32	1.12	1.58	1.97	1.02	1.50
Durbin-Watson	1.24	1.67	2.10	1.13	1.76	1.67	1.46	1.49

Table 2.9: *Table reports the coefficients estimates by running the regression in levels for Communication, Industrial, Consumer and Energy sectors. Robust standard error are in parenthesis below the coefficient estimates. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively. Durbin-Watson reports the statistics for the null hypothesis of no first-order autocorrelation.*

2.5 Robustness tests

In this section, to further verify our results, we implement some robustness tests concerning the model specification. The Tables 2.10 and 2.11 report the results of the regression in levels[7].

First, we use alternative measures of the CDS premium to check whether our results are sensitive to our choice of bid CDS premium. As dependent variable we use ask and mid CDS premium. The results (Table 2.10) are qualitatively similar to those obtained previously (Table 2.6 and 2.7). Our main results are confirmed by both robustness tests: i) the key factors of CDS premium are leverage, option implied volatility and slope of the yield-curve; ii) in crisis period the CDS premium is related to the firm-specific variables and the *speculative* firms have higher CDS premium; iii) the financial crisis determined a structural change; iv) after the financial crisis, the macroeconomic variables are relatively important in determining the CDS premium and the credit rating does not impact on the CDS premium. Second, given the importance shown by the option implied volatility in explaining the CDS premium, we perform the model by using another measure of volatility. As suggested by previous literature, we use historical volatility of the stock price. In particular, we run Eq. 2.2 by using the 90 days historical stock volatility (*Vol_90days*)[8]. Table 2.11 in columns (I), (II) and (III) reports the result of the estimates in levels. The coefficient on 90 days volatility is not statistically significant overall and during the financial crisis. It becomes statistically significant after the financial crisis. This indicates that the corporate CDS premiums are more sensitive to the option implied volatility than to the volatility of the past returns of the security. This result is consistent with Benkert (2004) and Cao et al. (2010) that underline the importance of option implied volatility in explaining the CDS premium.

Third, since the CDS premium seems to be related to the short-term interest rate, we use the US Treasury-bill rate as proxy of the monetary policy of Central Bank rather than 5Y Treasury-bond. The results are partially confirmed (Table 2.11, columns (IV),

[7]The results of the regression in differences are reported in Appendix A, Table A.14 and A.15. The results of the estimates in levels are confirmed by the estimates in differences.

[8]It is downloaded from Bloomberg.

	Ask CDS Premium			*CDS premium mid*		
	(I) Overall	(II) Crisis	(III) Post-Crisis	(IV) Overall	(V) Crisis	(VI) Post-Crisis
Lev	0.082 ***	0.052	0.105 ***	0.084 ***	-0.102	1.172 ***
	(0.022)	(0.034)	(0.031)	(0.029)	(0.065)	(0.116)
Price	-0.000	0.000	-0.001	-0.024 ***	-0.002	-0.030 ***
	(0.001)	(0.002)	(0.001)	(0.007)	(0.019)	(0.008)
σ^2	0.017 ***	0.014 ***	0.018 ***	0.104 ***	0.156 ***	0.077 ***
	(0.002)	(0.005)	(0.003)	(0.005)	(0.021)	(0.005)
Premium	-0.040	-0.061	-0.039	-0.253	-1.649	-0.185
	(0.107)	(0.297)	(0.119)	(0.195)	(1.186)	(0.179)
r_5	0.035	-0.064	-0.051 *	-0.140	-0.084	-0.175 ***
	(0.025)	(0.070)	(0.027)	(0.473)	(0.353)	(0.042)
Slope	0.486 ***	-0.013	0.164 ***	0.247 ***	-0.217	0.338 ***
	(0.037)	(0.102)	(0.041)	(0.072)	(0.494)	(0.065)
Crisis	0.844 ***			0.987 ***		
	(0.111)			(0.254)		
Speculative	1.621 ***	3.627 ***	0.1398	3.430 ***	3.268 ***	4.081
	(0.144)	(0.617)	(0.148)	(0.799)	(0.275)	(5.857)
Constant	0.724 ***	0.967 **	0.728 ***	3.308 ***	4.186	3.409 ***
	(0.137)	(0.441)	(0.155)	(0.662)	(2.667)	(0.785)
Rho	0.666	0.712	0.658	0.936	0.887	0.952
N	9483	1268	8215	9483	1268	8215
R^2	0.238	0.464	0.134	0.283	0.427	0.185
Chow-test	0.002			0.001		
Durbin-Watson	1.314	1.749	1.146	1.280	1.089	1.138

Table 2.10: *Table reports the coefficients estimates in levels by using ask and mid CDS premium. Columns (I) and (IV) report the results overall. Columns (II), (V) report the results for crisis period (March 2007- March 2009). Column (III) e (VI) report the results for post-crisis period (April 2009- July 2015). Robust standard errors are in parenthesis below the coefficient estimates. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively. Chow-test reports the p-values for the null hypothesis of a structural stability. Durbin-Watson reports the statistics for the null hypothesis of no first-order autocorrelation.*

(V) and (VI)). When we consider all the sample, the coefficient on US Treasury-bill rate is statistically significant at 5% level whereas, the coefficient on 5Y Treasury-bond does not appear to be statistically significant. In both cases, the coefficient on interest rate appears statistically significant after the financial crisis but the long-term interest rate is partially significant (10%) whereas the short-term interest rate is statistically significant at 5% level. We can conclude that the market participants focus on a short-term structure rather than a long-term structure. The link between short-term structure and price of credit risk could be related to the Quantitative Easing policy of the last decade. Therefore, this result has to be contextualized because the interest rate fluctuations might have enlarged the effects on the CDS premium of the short-term interest rate and reduced those of the long-term interest rate.

2.6 Conclusion

This chapter analyzes the determinants of the CDS premium to discover the factors that affect the price of the credit risk. Using monthly CDS premium of US firms from January 2007 to July 2015, we investigate in levels and in differences the determinants of CDS premium. We study the impact of firm-specific (leverage, stock prices and option implied volatility) and market (risk premium, risk-free rate 5Y and slope of the yield curve) variables. We test the impact of these variables by using a GLS methodology in levels and an OLS regression in differences. We find that the variables are able to explain 41.81% and 34.88% of the variation in CDS spread in levels and in differences, respectively. We identify as key variables of the CDS premium option implied volatility, leverage and slope of the yield curve. However, we find that the option implied volatility is the variable that dominates the other variables in explaining the CDS premium hence, we have evidence of the economically meaningful effects of option implied volatility on credit spreads. As Cao et al. (2010), we interpret these findings as broadly consistent with an important role for options market information in the process of price discovery across the options and credit markets. The information content of option implied volatility becomes even more evident in crisis period. The empirical analysis shows that the slope of the yield curve has a significant

Robustness tests												
Bid premium	Overall (I)		Crisis (II)		Post-Crisis (III)		Overall (IV)		Crisis (V)		Post-Crisis (VI)	
Lev	0.158	**	-0.088		1.730	***	0.920	***	-0.186		1.340	***
	(0.071)		(0.146)		(0.143)		(0.063)		(0.140)		(0.138)	
Price	-0.078	***	-0.161	***	-0.068	***	-0.040	***	-0.027		-0.039	***
	(0.013)		(0.060)		(0.012)		(0.012)		(0.056)		(0.011)	
Put							0.163	***	0.235	***	0.128	***
							(0.010)		(0.041)		(0.010)	
Vol_90g	0.056		-0.024		0.098	***						
	(0.117)		(0.043)		(0.010)							
Premium	0.460		-1.965		0.257		0.347		-1.422		0.342	
	(0.347)		(2.452)		(0.274)		(0.294)		(2.042)		(0.262)	
r_5	0.068		-0.017		0.045							
	(0.084)		(0.622)		(0.066)							
Treasury Bill							-1.832	**	0.015		-2.157	**
							(0.817)		(2.336)		(1.089)	
Slope	0.340	***	-0.901		0.400	***	0.275	***	-0.777		0.362	***
	(0.126)		(0.959)		(0.099)		(0.097)		(0.721)		(0.086)	
Crisis	3.407	***					1.004	**				
	(0.586)						(0.501)					
Speculative	7.648	***	-0.893		7.602	***	6.668	***	2.810		6.640	***
	(1.895)		(8.342)		(1.779)		(1.691)		(6.894)		(1.668)	
Constant	11.336	***	-1.905		9.146	***	7.169	***	18.402		7.614	***
	(1.317)		(1.491)		(1.295)		(1.264)		(29.146)		(1.183)	
Rho	0.929		1		0.944		0.939		0.979		0.940	
N	12331		882		11449		12331		882		11449	
R^2	0.214		0.413		0.233		0.240		0.467		0.242	
Chow-test	0.000						0.000					
Durbin-Watson	1.889		0.630		1.750		1.869		0.811		1.896	

Table 2.11: *Columns (I), (II) and (III) report the results overall, in crisis and post-crisis period when we use historical volatility as asset volatility. Columns (IV), (V) and (VI) report the results overall, in crisis and post-crisis period when we use the Treasury-bill as interest rate. Robust standard errors are in parenthesis below the coefficient estimates. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively. Chow-test reports the p-values for the null hypothesis of a structural stability. Durbin-Watson reports the statistics for the null hypothesis of no first-order autocorrelation.*

effect for exploring the credit risk. An higher slope triggers increasing inflation rates, which cause a deterioration in the overall macroeconomic conditions and result in higher CDS premiums. The Quantitative Easing policy of Central Bank in the last years has played an important role on the price of credit risk. The financial crisis and the credit rating contribute in explaining the CDS premium. The results suggest that during turbulence period, the credit risk is priced higher than in normal periods. The investors incorporate the volatility of the markets and the information of the credit ratings in CDS premium.

The chosen theoretical determinants have high explanatory power, but the power of individual variables differs in particular periods and sectors. The empirical analysis shows that the financial crisis has determined a structural change in pricing of credit risk. We find that CDS premium is related to the firm-specific variables during the crisis but, although the firm-specific variables continue to be significant explanatory variables, after the financial crisis we record the high statistical significance of the market variables.

The power of individual variables also differs across the sectors. Credit risk of cyclical sectors are related to both market and firm-specific variables while the counter-cyclical sectors rely the CDS premium to the firm-specific variables. Given the weak link with the economic conditions, an important result is that the sensitivities of credit spreads of counter-cyclical sectors strongly depend on the term structure of the interest rate after the financial turmoil. In fact, during period of financial crisis, the magnitude of the latter coefficient becomes larger for counter-cyclical sectors than cyclical sectors. Therefore, the strong effect of the unconventional monetary policies of the Federal Reserve on the counter-cyclical sectors does not leave doubt on the fact that the financial crisis did not exacerbate the differences between the firms belonging to different sectors but, on the contrary, it seems that the financial turmoil have reduced the differences between cyclical and counter-cyclical sectors. The dimension of the crisis and its effects led to a systematic perspective of credit risk. Although during the financial crisis, the price of credit risk reflected the main features of the cyclical and counter-cyclical sectors, after the financial crisis, the existing differences among the sectors have been eliminated. The focus, in evaluating the credit risk in each sector, is shifted to the market. Finally, our results highlight that the investors become more skeptical about the credit rating issued by rating agencies. In fact, after the financial crisis, the CDS premium is not sensitive to the credit rating changes. This finding feeds the sub-prime debate about the rating agencies. During the financial crisis, the rating agencies came under scrutiny. The market participants started to question the ability of rating agencies to rate the corporate credit risk especially when the markets enter a phase of abundant credit and low volatility.

These findings might be an additional tool for regulators and policymakers to assess the effectiveness of their policies contagion and the development of macroprudential tools for financial stability surveillance. Additionally, understanding the behaviour of determinants and selection of suitable ones, especially divided by sectors and periods, can be beneficial for investors, as well as for analysts, risk managers and decision makers.

Appendix A

In Appendix A, we provide the results of the regressions in differences.

A.1. Results by industrial sectors

Results by industrial sector								
ΔBid premium	*Cyclical Sectors*				*Counter-cyclical sectors*			
	Basic Material	Industrial	Consumer	Technology	Communication	Energy	Financial	Utility
ΔLev	0.4171 ***	0.9886 ***	0.1195 ***	0.1391 ***	0.7991 ***	0.1341 ***	0.0115	0.6856 ***
	(0.116)	(0.159)	(0.019)	(0.036)	(0.282)	(0.030)	(0.246)	(0.138)
Return	0.1862	-0.0242 **	-0.0393 ***	0.0341	0.0722	-0.0491 **	0.0221	0.0742
	(0.271)	(0.010)	(0.012)	(0.056)	(0.068)	(0.022)	(0.038)	(0.053)
$\Delta\sigma^2$	0.3635 *	0.0744 ***	0.1452 ***	0.1178 ***	0.1801 ***	0.1117 ***	0.2593 ***	0.0998 ***
	(0.189)	(0.012)	(0.014)	(0.027)	(0.044)	(0.033)	(0.051)	(0.028)
ΔPremium	1.3953	0.4618 **	0.0559	0.9714 **	-0.3152	-0.2055	0.1329	-0.2320
	(2.672)	(0.190)	(0.135)	(0.401)	(0.553)	(0.362)	(0.683)	(0.258)
Δr_5	-0.1964	-0.0901 **	-0.1187 ***	-0.1784 *	0.0081	-0.0490	0.1041	0.1106
	(1.125)	(0.040)	(0.037)	(0.096)	(0.086)	(0.169)	(0.119)	(0.080)
ΔSlope	1.0178	0.1144 *	0.2380 ***	0.1980	0.1213	0.1252	0.5878 ***	-0.0457
	(1.468)	(0.066)	(0.063)	(0.170)	(0.129)	(0.204)	(0.212)	(0.109)
Crisis	5.2811	0.7604 ***	1.0299 ***	0.0114	3.1956 *	0.6243 *	0.3073	-0.3301
	(3.476)	(0.250)	(0.263)	(0.468)	(1.752)	(0.338)	(1.081)	(0.281)
Speculative	-0.1786	-0.2497	-0.2798	0.0179	0.3217	-0.0805	3.4045 *	-0.1278
	(1.276)	(0.160)	(0.193)	(0.517)	(0.665)	(0.280)	(1.805)	(0.267)
Constant	0.1041	-0.0319	-0.0264	-0.0198	-0.1935 **	0.0089	-0.2699 **	-0.1098
	(0.644)	(0.030)	(0.031)	(0.088)	(0.083)	(0.058)	(0.132)	(0.072)
N	632	1609	4321	517	823	1307	2177	789
R^2	0.0735	0.2884	0.3498	0.1901	0.1693	0.1651	0.1345	0.1660
VIF	1.19	1.10	1.09	1.16	1.15	1.10	1.12	1.17
Chow-test	0.738	0.032	0.003	0.767	0.055	0.052	0.133	0.325
Durbin-Watson	1.6369	1.6396	1.5946	1.6886	1.6479	1.6005	1.6788	1.7366

Table A.12: *Table reports the coefficients estimates by running the regression in differences for each sector with robust standard error in parenthesis. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively. Chow-test reports the p-values for the null hypothesis of a structural stability. Durbin-Watson reports the statistics for the null hypothesis of no first-order autocorrelation.*

A.2. Results by industrial sectors and period

Results by industrial sectors and period								
	Cyclical Sectors				*Counter-cyclical sectors*			
ΔBid premium	Communication		Industrial		Consumer		Energy	
	crisis	post crisis	crisis	post crisis	crisis	post crisis	crisis	post crisis
ΔLev	1.5111	1.1014 ***	0.7797 ***	1.1028 ***	0.3617	0.9987 ***	0.6302	1.6017 ***
	(0.938)	(0.181)	(0.251)	(0.245)	(0.728)	(0.304)	(0.459)	(0.348)
Return	0.0603	-0.0326 ***	0.0306	-0.0266 ***	-0.1101	0.0231	-0.0898 *	-0.0624 **
	(0.0623)	(0.0116)	(0.0348)	(0.0102)	(0.2433)	(0.0430)	(0.0522)	(0.0244)
$\Delta\sigma^2$	0.1559 ***	0.1378 ***	0.0710 *	0.0737 ***	0.3926 **	0.1275 ***	0.0501	0.1216 ***
	(0.038)	(0.014)	(0.040)	(0.012)	(0.155)	(0.025)	(0.033)	(0.039)
ΔPremium	-1.3560	0.1735	1.8458 *	0.3525 *	-0.8561	0.5149	2.5274 *	-0.1720
	(0.916)	(0.130)	(0.964)	(0.185)	(0.590)	(0.390)	(1.428)	(0.358)
Δr_5	-0.0523	-0.1382 ***	-0.2772	-0.1158 ***	0.2406	0.0705	-0.1138	-0.0589
	(0.162)	(0.037)	(0.340)	(0.036)	(1.041)	(0.076)	(0.267)	(0.194)
ΔSlope	-0.2414	0.2836 ***	-0.5727	0.1607 ***	2.1169	0.2059 *	0.0290	0.0998 ***
	(0.327)	(0.063)	(0.638)	(0.057)	(1.803)	(0.117)	(0.364)	(0.022)
Speculative	3.5234 ***	-0.0710	2.0753 ***	-0.2219	4.1863 ***	0.0137	2.2351 **	-0.0123
	(1.323)	(0.186)	(0.091)	(0.163)	(0.425)	(0.651)	(1.009)	(0.289)
Constant	-0.4277 *	-0.0611 **	-0.7283 **	-0.0292	-3.0891	-0.1874 **	-0.3836	0.0086
	(0.228)	(0.030)	(0.321)	(0.030)	(2.009)	(0.077)	(0.283)	(0.059)
N	267	4108	127	1526	54	769	94	1271
R^2	0.5111	0.2952	0.2896	0.2681	0.1239	0.1986	0.2045	0.1703
VIF	1.08	1.09	1.19	1.12	1.52	1.15	1.4	1.11
Durbin- Watson	2.010	1.836	1.985	2.027	1.121	1.955	1.930	1.589

Table A.13: *Table reports the coefficients estimates by running the regression in differences for Communication, Industrial, Consumer and Energy sectors in crisis and post-crisis period. Robust standard error are in parenthesis below the coefficient estimates. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively. Durbin-Watson reports the statistics for the null hypothesis of no first-order autocorrelation.*

A.3. Robustness tests

	ΔAsk CDS Premium						ΔCDS premium mid					
	Overall (I)		Crisis (II)		Post-Crisis (III)		Overall (IV)		Crisis (V)		Post-Crisis (VI)	
ΔLev	0.1674	***	0.6608	***	0.8259	***	0.2437	***	0.2810	***	0.1326	***
	(0.041)		(0.038)		(0.014)		(0.031)		(0.011)		(0.019)	
Return	0.0106		0.0144		0.0001		0.0062		0.0310		0.0017	
	(0.0644)		(0.022)		(0.006)		(0.0038)		(0.024)		(0.004)	
$\Delta\sigma^2$	0.0253	***	0.0344	***	0.0183	***	0.0249	***	0.0419	***	0.0188	***
	(0.005)		(0.005)		(0.003)		(0.004)		(0.014)		(0.003)	
ΔPremium	-0.0460		-0.0618		-0.0390		-0.2608	**	-0.4609	**	-0.2226	**
	(0.159)		(0.180)		(0.183)		(0.105)		(0.199)		(0.110)	
Δr_5	0.0294		-0.0885		-0.0648	**	0.0320		-0.1030		-0.0472	***
	(1.240)		(0.139)		(0.033)		(0.102)		(0.095)		(0.013)	
ΔSlope	0.0664	**	0.1175	***	0.1046	**	0.0637	**	-0.0548		0.0199	
	(0.033)		(0.012)		(0.053)		(0.031)		(0.109)		(0.032)	
Crisis	0.0621	*					0.0566	*				
	(0.038)						(0.034)					
Speculative	4.0176	***	3.1667	***	-0.0040		3.8027	***	2.2266	***	-0.0021	
	(0.040)		(0.438)		(0.040)		(0.010)		(0.117)		(0.007)	
Constant	-0.0157	***	0.0190	***	-0.0161		0.0083	*	0.0399		-0.0134	***
	(0.005)		(0.004)		(0.015)		(0.005)		(0.059)		(0.004)	
N	9483		1268		8215		9483		1268		8215	
R^2	0.243		0.48		0.128		0.2501		0.411		0.1369	
VIF	1.07		1.31		1.09		1.07		1.08		1.07	
Chow-test	(0.000)						(0.001)					
Durbin-Watson	1.683		1.726		1.701		1.608		1.628		1.651	

Table A.14: *Table reports the coefficients of the regression in differences by using ask and mid CDS premium. Columns (I) and (IV) report the results overall. Columns (II), (V) report the results for crisis period (March 2007- March 2009). Column (III) e (VI) report the results for post-crisis period (April 2009- July 2015). Robust standard errors are in parenthesis below the coefficient estimates. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively. Chow-test reports the p-values for the null hypothesis of a structural stability. Durbin-Watson reports the statistics for the null hypothesis of no first-order autocorrelation.*

Robustness tests						
ΔBid premium	Overall (I)	Crisis (II)	Post-Crisis (III)	Overall (IV)	Crisis (V)	Post-Crisis (VI)
ΔLev	0.1514	0.3434 **	0.1408 ***	0.9279 ***	0.6119 ***	2.2499 **
	(0.22)	(0.137)	(0.018)	(0.323)	(0.156)	(0.954)
Return	0.0306	0.0592	0.0230	-0.0581	-0.0290	-0.0548
	(0.0213)	(0.1729)	(0.0145)	(0.101)	(0.131)	(0.148)
$\Delta\sigma^2$	0.2197 ***	0.3493 ***	0.1723 ***			
	(0.038)	(0.080)	(0.019)			
ΔVol_90days				0.0310	-0.0191	0.0351 *
				(0.023)	(0.075)	(0.018)
ΔPremium	0.0645	1.2982 *	0.2969 *	-0.1451	4.5663 ***	0.3077
	(0.118)	(0.721)	(0.152)	(0.185)	(1.666)	(0.253)
ΔT-bill	-2.0785 **	-0.1714	-1.5705 **			
	(0.974)	(2.163)	(0.714)			
Δr_5				0.1012	-1.1411	-0.1244 **
				(0.086)	(0.845)	(0.059)
ΔSlope	0.2767 ***	0.1793	0.3871 ***	0.3518 ***	0.1793 **	0.4877 ***
	(0.051)	(0.812)	(0.081)	(0.076)	(0.082)	(0.091)
Crisis	1.4216 **			1.6101 ***		
	(0.603)			(0.388)		
Speculative	4.2825 ***	2.8532 ***	-0.1420	5.4706 ***	1.3081 ***	-0.1463
	(0.083)	(0.021)	(0.211)	(0.096)	(0.017)	(0.216)
Constant	-0.1035 ***	0.1628	-0.1031 ***	-0.2435 ***	-1.7062 ***	-0.2219 ***
	(0.033)	(0.815)	(0.039)	(0.058)	(0.425)	(0.042)
N	12331	882	12331	12042	838	11204
R^2	0.2567	0.5823	0.2567	0.269	0.376	0.2567
VIF	1.18	1.1	1.04	1.05	1.09	1.09
Chow-test	(0.000)			(0.000)		
Durbin-Watson	1.597	1.707	1.716	1.621	1.666	1.633

Table A.15: *Columns (I), (II) and (III) report the results of the regression in differences overall, in crisis and post-crisis period when we use the Treasury-bill as interest rate. Columns (IV), (V) and (VI) report the results overall, in crisis and post-crisis period when we use historical volatility as asset volatility. Robust standard errors are in parenthesis below the coefficient estimates. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively. Chow-test reports the p-values for the null hypothesis of a structural stability. Durbin-Watson reports the statistics for the null hypothesis of no first-order autocorrelation.*

Chapter 3

What determines bank CDS spreads? Evidence from European and US banks

Abstract

This chapter analyses the determinants of banks credit default swap. It examines the determinants of CDS spreads for a sample of European and US banks. The key balance-sheet determinants are capital adequacy, leverage, credit quality, and bank size, and the key market determinants are equity returns, market volatility, risk-free interest rate, the term structure of interest rates and bank-specific and host country sovereign credit risk. Our results would appear to confirm the applicability of Merton (1974)-type models extended to include market variables to the understanding of bank credit risk.

3.1 Introduction

The recent financial crisis reveals that much work remains to better understand the sources of credit risk and to improve monitoring and measuring tools. The link between systematic risk and banking credit risk suggests that during a period of financial stress, bank credit risk displays complex dynamics. However, understanding the determinants of bank credit risk is of fundamental importance, as failures of financial institutions can impose severe externalities on the rest of the economy (Acharya et al. (2010)). In order to contain systematic risk, national and prudential authorities have undertaken a number of measures, such as regulatory policies to strengthen the existing capital requirements (Basel III) and introduce new prudential rules. Since the banks have played a crucial role in the recent global financial crisis and their failure has a number of repercussions on the whole system[1], the stability assessment is of major importance for Central Banks and supervisory authorities. The regulators aim to prevent costly banking system crisis and the associated negative effects on the real economy. They are interested to a safe and sound banking system to ensure the optimal allocation of capital resources. In late 2007 and 2011, the US and European financial system appeared to be on the brink of a default. One of the greatest concern was the systemic risk of the global banking system. In particular, the sovereign crisis determined a deep crisis of the banking European system and thus, a strong instability in the financial market and, more in general, in the real economy. The contagion observed between sovereigns and banking crisis requires careful consideration of how this link can be diminished or broken. Uncertainty about the financial health of banks is also fuelled by negative interest rates and the future path of monetary policy. If a sovereign default were to lead to a failure of a systemically-important bank, the resulting financial instability could be disastrous[2]. This type of scenario highlights the need for identifying and understanding the credit risk of banks and thus, their potential probability to failure in the financial system (Erce (2015)).

The study about the CDS spreads determinants in banks is important because of bank role in the financial system and the special nature compared to other firms. CDS spreads should reflect market perceptions about the financial health of banks and they could be used by regulators to extract warning signals regarding the financial stability (Annaert et al. (2013)). Given the systemic importance of financial stability and the possible relationship between the fragility of the individual bank to economic shocks and the overall

[1]Collapse of Lehman Brothers, in September 2008, was a seminal event that greatly intensified the 2008 crisis and contributed to the erosion of close to $10 trillion in market capitalization from global equity markets at the end of 2008.

[2]The market has experienced this financial instability with the collapse of Lehman Brothers.

vulnerability of the system, an appropriate ex ante measurement of financial risk of banks is crucial both for market participants and supervisory authorities. The global financial crisis has raised another important concern about the crucial role of banks in triggering and propagating shocks in the whole financial system. More specifically, an increase in banking default risk is typically transmitted to the whole financial system and, in the worst situations, to the real economy because banks are strictly interconnected to each other. As consequence, the default of a bank might produce a spillover effect that could be dangerous to the whole economy since the effects might be on volume and pricing of loans and deposits and on the financial soundness of several banks. Therefore, understanding the determinants of CDS spreads in banking sector is important to develop supervision on a micro-level that might be used to promote financial stability and to avoid systemic macro-instability. Furthermore, identifying the factors that affect the credit default risk of banks might provide a fundamental based surveillance tool for banks and might potentially help the authorities to develop early warning systems (Podpiera and Ötker (2010)).

The main aim of this chapter is to better understand the determinants of the banking CDS spreads in order to model the credit risk of these institutions. To this purpose, we run a Panel regression analysis over the period Q1 2007- Q1 2016 of 63 European and US banks to investigate the impact of banks-specific and market variables on the CDS spreads. This study contributes to the CDS literature in several ways. First, this chapter focuses only on the banking industry by testing the balance-sheet, market and rating variables for pricing credit risk. Therefore, it extends the analysis that earlier studies did in industrial companies to financial institutions. Second, we focus on the risk measures widely used in the banking industry to examine whether they provide incremental information to price bank credit risk beyond structural variables. We deeper focus on the capital ratios because of concerns raised by financial and sovereign crisis. Third, our study is based on a set of quarterly European and US data over the past decade. Therefore, our sample has greater cross-sectional and time-wise variations relative to earlier studies that focus on a single country or region (Annaert et al. (2013), Podpiera and Ötker (2010)). We present results from a sample that offers greater time (Q1 2007-Q1 2016) and cross-country (USA, Core euro area countries, Non-core or Periphery euro area countries, and Non-euro adopting European countries) variation than has been typical in the other banking studies. Because our sample includes different countries that are widely different in terms of economic development, institutions, banking structure, risk and regulations, we account for those country differences using market index returns, market volatility, risk-free rate, slope of the yield curve, risk premium and credit risk of each geographical area. Fourth, we test the impact of US crisis and European crisis to shed light on the perception of the banks credit risk during financial and economic distress periods. To the best of our knowledge, it is the first study about the impact of the European sovereign crisis on the banks credit risk. Finally, we contribute to understand the drivers of the default risk of banks among Euro and US zones. Our study is the first that compares the key determinants of different zones to try to understand if the systematic risk of the different areas can affect the determinants of the banks CDS spreads.

Although experience with bank spreads appears to differ across countries, our key results suggest that less capital for undercapitalised banks, greater leverage, poor credit quality, a weak current and prospective business environment, and a low bank-specific credit rating are all associated with a widening of banks CDS spreads. In addition, bank size and sovereign risk rating also appear to be important determinants of CDS spreads. Our cross-country evidence supports the claim that adding the common systematic components helps to address the *credit-spread puzzle* in bank CDS because the balance-sheet variable group is dominated in their impact on CDS spreads by the market variable group and the onset of the US financial crisis and sovereign debt crisis. Our findings imply a serious reflection about the capital adequacy ratio. Results are shown to be robust to alternative dependent variables. The impact of US financial crisis and European sovereign debt crisis reveals that the impact of some variables on the CDS spreads is even more evident during turmoil periods and some others disappear after the turmoil periods. The capital ratios and funding structure are key factors only in crisis periods.

The remainder of the chapter is organized as follows. In Section 3.2 we discuss the relevant literature. In Section 3.3 we describe our methodology. In Section 3.3.1 we analyse the explanatory variables in our model. In section 3.4 and 3.5 we present and discuss the empirical analysis and the robustness tests. Finally, in Section 3.6 we summarize our findings and conclude.

3.2 Literature review

During the last decade, the literature on the determinants of the CDS spread are growing rapidly, mainly due to the global financial crisis and the development of the credit derivatives market. Nevertheless, the papers on the determinants of the CDS spreads focus on the corporate sectors rather than the banking sector because of its particular features and its opaqueness (Annaert et al. (2013)). In this chapter, we want to contribute to the literature on the determinants of banks CDS spreads that has not received wider attention in the past.

Empirical literature on the banking determinants of the CDS spreads are still scarce. Recent results by Chiaramonte and Casu (2013) and Angelini and Ortolano (2016) shed light on the impact of bank balance-sheet ratios on the CDS spreads. Chiaramonte and Casu (2013) use as explanatory variables the balance-sheet ratios referring to asset quality, capital, operations and liquidity over the period 2007-2011. Their sample is composed by 57 international banks, 43 of which European, 7 US, 4 Australian and 3 Japanese. They show that banks CDS spreads reflect the risk captured by bank balance-sheet ratios. Surprisingly, the capital ratios that *as prior* are expected to be a determinant of CDS spreads, are not strongly statistically significant across all specifications. Additionally, they find that the determinants vary across time. They show that the determinants are different in relation to the financial and economic conditions. In general, the key factors of the CDS spreads are the asset quality and operations indicators. However, during and after the global financial crisis liquidity ratios are able to explain the CDS spreads. The study of Angelini and Ortolano (2016) is focused only on a sample of Mediterranean European banks for the period 2009-2014. They find that the market participants in evaluating credit risk take into account the quality and profitability of banks' assets and the short-term liquidity. Contrary to the study of Chiaramonte and Casu (2013) and Angelini and Ortolano (2016), the specification of the CDS spreads model of other studies on this topic is based on the theory developed by Merton (1974) for the corporate bond credit spreads. However, recent literature extends the framework by some additional factors such as market variables and business cycle indicators that, theoretically, are able to affect the price of the credit risk.

These additional variables are used as response to the so called *credit spread puzzle* that is the moderate portion of credit spreads that the structural variables are able to explain (Duffee (1998) and Collin-Dufresne et al. (2001)).

Düllmann and Sosinska (2007), by analysing only the three largest German banks, investigate the impact of idiosyncratic credit risk, systematic credit risk and liquidity risk. They show that the systematic risk impacts on the bank CDS spreads in three different way. First, through the overall state of the economy. A second component is related to the risk of the internationally active banking sector and the third is an unobservable systematic factor. They conclude that structural models based on equity prices and reduced-form models based on the prices of credit derivatives have their specific advantages and drawbacks. Together they can provide a more comprehensive assessment of the riskiness of the institution monitored.

Raunig et al. (2009) compare the market pricing of banks to industrial firms and study whether investors discriminate between the riskiness of banks and other type of firms by requiring different risk premia or by modifying their expected loss measures. To this purpose, they study the 41 major banks and 162 non-banks among the largest banks in the US and Europe. They find that market participants perceive the banks as less risky than other firms but, with the outbreak of the global financial crisis in 2008, the investors start to evaluate the credit risk of a bank in a different way. Raunig et al. (2009) show that, after the global financial crisis, the market participants perceive banks to be at least as risky as other firms.

In Annaert et al. (2013), the study is focused on the European banking determinants of the credit risk. They focus on the CDS spreads of 32 listed euro area banks. They include the variables suggested by the structural model, market variables and business cycle. They show that market variables have an important role in explaining credit spread changes. Their results confirm that the determinants change across the time but not so much across the rating classes. They underline the importance of the liquidity indicators before and after the global financial crisis. Additionally, their results highlight a structural change given by the global financial crisis. Indeed, the variables suggested by structural credit risk models became significant drivers of CDS spreads mostly after the start of the crisis.

Hasan et al. (2015) analyses the CDS spreads of 161 global banks in 23 countries. They focus on Merton model variables, CAMELS factors[3], country-level economic, governance and regulatory factors to price global bank credit risk. They highlight the importance of the structural model variables in pricing the banks CDS spreads but, in addition to them, asset quality, cost efficiency, and sensitivity to market risk, contain incremental information for bank CDS prices. Including both structural variables and CAMELS improves the model fit from 20% to 30%, suggesting that structural variables and CAMELS indicators contain complementary information about bank credit risk. Among structural variables and CAMELS, Hasan et al. (2015) underline that the asset quality are the most important determinants of the banks CDS spreads and that the volatility of the stock market and the financial conglomerates restrictions tend to decrease the price of credit risk of the banks. The impact of the CAMELS indicators is also studied by Podpiera and Ötker (2010). However, this study exclusively focuses on the fundamental determinants of 22 European Large Complex Financial Institutions (LCFI) over the period 2004-2008. By using a dynamic panel data analysis, they show the importance of business models, earnings potential, and overall economic uncertainty on banks CDS spreads. However, they caution that the generalization of the results to other banks or countries might require adjustments despite the connection across markets and countries.

In a more recent study, Samaniego-Medina et al. (2016) focus on the determinants of the CDS spreads of 45 European banks over the period 2004-2010. They use a Panel model in which they include both bank-specific and market variables. They find that the market variables are good factors for the CDS spreads of European banks both in pre-crisis and crisis periods. They underline that the market variables are able to explain a large portion of the variability of the banks CDS spreads, especially during the financial crisis.

[3]The CAMELS factors are: Capital Adequacy, Asset Quality, Management, Earnings, Liquidity and Sensitivity to Market Risk.

3.3 Methodology and Data

Our baseline model is typical of the CDS spreads literature:

$$CDS_{i,t+1week} = \alpha + \beta(X_{i,t}) + \gamma(Z_{j,t}) + \varepsilon_{i,t} \tag{3.1}$$

In Eq. 3.1, i, j and t are banks, geographical areas and time periods (quarter), respectively. $CDS_{it+1week}$ is the banks CDS spreads in basis points (bps) one week after the end of each quarter. We focus on spreads one week after the end of the quarter on the assumption that bank balance sheet data are not immediately available at the end of the quarter. To test the hypothesis that the information transmission of the balance-sheet variables affects the pricing of CDS spreads in European and US banks, as robustness test, we carry out the same model in Eq. 3.1 by using the CDS spreads at time t (end of each quarter) and at the time *t+2 weeks*. The data are recorded in percentages, so a regression coefficient of 1.50 represents 1.50% or 150 bps.

X_{it} is a vector of bank-specific variables that includes: bank capital adequacy ratio, leverage, loan quality ratio, credit quality ratio, bank size and funding stability ratio (Podpiera and Ötker (2010), Chiaramonte and Casu (2013), Annaert et al. (2013), Hasan et al. (2015)) and banks' credit rating. Because our sample is composed by 15 countries and 63 banks, the cross-country sample varies widely in terms of economic development, regulations and market risk, we account for those country differences using country-level and market variables. Z_{it} is a vector of market variables that includes the Central Bank policy interest rate, the volatility of US and European market, the growth prospects of the economy, the overall current European and US economic climate, the risk premium and the sovereign rating. Finally, we include two 0-1 dummy variables that seek to capture, respectively, the impact of the global financial crisis and the impact of the sovereign debt crisis since they may explain the widening of CDS spreads in periods of high volatility. To control for these explanatory variables, we estimate Eq. 3.1 using a Panel model with fixed effects in levels. In all our regressions, we use bank-clustered, heteroskedasticity robust standard errors.

As in Hasan et al. (2015), we develop a stepwise selection method to keep the most important determinants. First, we use the balance-sheet variables and successively, we add the market variables and the dummy variables that capture the impact of the US and European crises.

3.3.1 Explanatory variables

Our study on the determinants of the banks CDS spreads is focused on US and European banks. The decision to investigate the determinants of the banking sector had an impact on sample size, since the banks that have the quote of senior CDS spreads at 5 years are only large banks. The final sample is composed by 63 US and European banks, 54 of which European[4] and 9 US banks. The CDS spreads and market variables are obtained from Datastream whereas the balance-sheet variables are sourced from Bankscope for the period Q1 2007-Q1 2016.

Dependent variable

Five-year CDS spread data on senior CDS contracts was chosen because it is the most liquid of the spread tenors and the CDS contracts are all quoted in U.S. dollars to avoid exchange rate challenges. The CDS spreads are expressed in basis points (bps). As in Chiaramonte and Casu (2013), we use quarterly data. By using the quarterly frequency, we overcome the problem of autocorrelation of the error terms.

Figure 3.1 shows quarterly developments in CDS spreads during the sample period by geographic location. CDS spreads of euro-periphery banks moved sharply higher than those of banks in the other countries from 2009 and remained well above them for the rest of the sample period[5]. Bank spreads in the other countries for the most part moved closely together and were lowest for banks in non-euro adopting countries and the US. A clear pattern is shown in Figure 3.1. The impact of the financial crisis was observed overall but the sovereign crisis affected mostly the perceived credit risk in European countries.

Explanatory variables

This study uses as explanatory variables balance-sheet and market data. Quarterly data were selected to make available an higher number of observations for analysis. Among

[4]Among the European banks, we distinguish Euro-Peripheral, Euro-Core and Non-euro banks.

[5]Developments in CDS spreads in the euro-periphery countries were driven mainly by Greek banks for which the spread averaged 965.40 basis points over the sample period and reached 2378.97 basis points in late 2011.

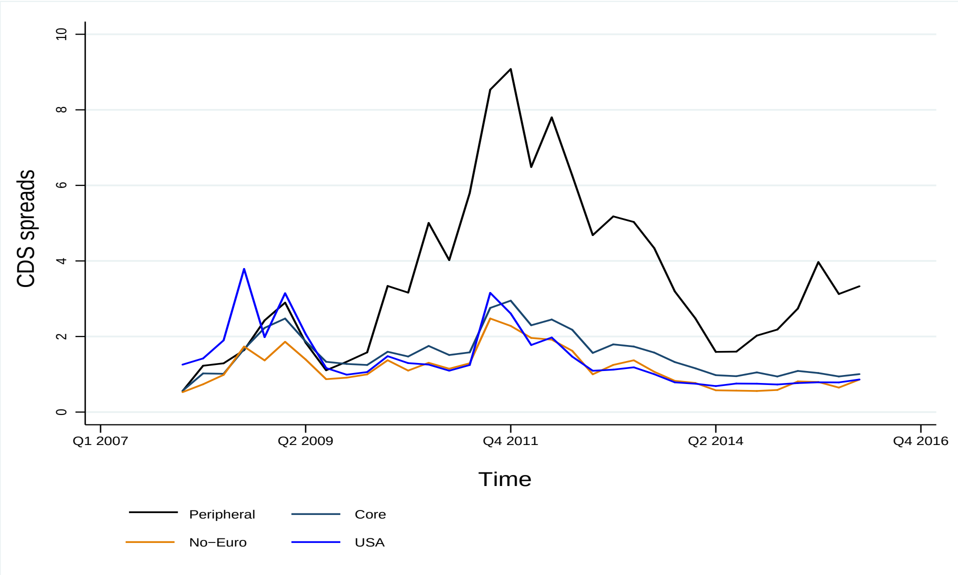


Figure 3.1: *Average CDS spreads in 54 European and 9 major US banks.*

the balance-sheet variables, we include capital adequacy ratio, leverage ratio, loans quality ratio, credit quality ratio, size and funding ratio.

Balance-sheet variables

Capital adequacy. This ratio is proxied by Tier 1 ratio calculated under the Basel II and III rules. Tier 1 ratio is used to grade the bank's capital adequacy and to measure the bank's capability to absorb losses and cope with exogenous shocks. It provides a cushion against fluctuations in earnings so that banks can continue to operate in periods of loss. In addition to meeting regulatory capital requirements, maintaining additional capital beyond the statutory requirements is critical for banks to survive during a crisis and better cope with exogenous shocks (Hasan et al. (2015)). The relationship between CDS spreads and Tier 1 ratio is ambiguous. On one hand, CDS spreads and Tier 1 ratio should be negatively related because Tier 1 ratio serves as an ex-ante buffer against potential losses. A higher value of this ratio should lower the CDS spreads. On the other hand, regulatory actions impose stricter requirements on riskier banks and, as consequence, a positive relationship should be expected. In line with Altunbas et al. (2011), Perotti et al. (2011) and the proposal of Basel Committee, we account for the possible non-linear effect of bank capital on credit risk. To this purpose, we construct the variable *Undercapitalised* that is the interaction between Tier 1 ratio and a dummy variable for banks with Tier 1 ratio below 8% (minimum threshold required by Basel III).

Leverage. It is one of the standard indicators included in the structural approach to the pricing of default risk and it captures bank indebtedness and risk appetite. Different from the previous studies on bank CDS spreads that use the balance-sheet leverage ratio (e.g. Podpiera and Ötker (2010) and Chiaramonte and Casu (2013)) or stock returns as a proxy of leverage (e.g. Annaert et al. (2013)), we adopt a definition of financial leverage market-based (Hasan et al. (2015)), defined as the ratio between book value of liabilities to the sum of book value of liabilities and the market value of equity. Hasan et al. (2015) highlight that the asset and liability structure of a bank is different from that of a corporation because, by definition, the leverage in a bank is greater than those in other corporate sectors. In general, banks rely on deposits and other sources to fund their assets. It implies that the leverage ratios are considerably greater than those in other corporate sectors. The ability to draw on more deposits is a signal of greater growth potential but, at the same time, too much debt to equity can lead a bank to failure. The relationship between leverage and CDS spreads should be positive because an increase on leverage ratio implies more risk and thus an higher CDS spreads.

Loan quality. Loan quality is proxied by the ratio between impaired loans and total assets (Shehzad and De Haan (2013) and Angelini and Ortolano (2016)). Under IFRS, impaired loans are considered the best measure of problem loans. This indicator should be correlated positively with the credit risk since an increase of this ratio is a signal of an increase of problem loans.

Credit quality. As in Hasan et al. (2015) and Podpiera and Ötker (2010), it is measured as the ratio of loan loss provisions to total loans. Banks with lower loans loss provisions should have a lower ratio that indicates a better credit quality and thus a lower probability to default. A positive sign is expected.

Size It is measured as the natural log of bank i's total assets (Samaniego-Medina et al. (2016)). Size allows us to capture the effects of diversification and other economies of scope (such as access to markets) related to reduced levels of risk for larger banks. Alternatively, larger banks may be more prone to concerns about being too big to fail, or be too complex to manage. They may also suffer more severely from the effects of greater inefficiencies in their internal capital markets and thus become riskier (Altunbas et al. (2011)). Therefore, the expected sign is not clear.

Funding. The funding ratio is measured by the ratio of retail customer deposits to total assets and it is a proxy of funding structure (Altunbas et al. (2011)). This indicator indicates the funding stability. We expect retail deposits to be a more stable source of funding than wholesale markets since they are typically insured by the government (Shleifer and Vishny (2010)). Therefore, a negative sign is expected.

Market and country variables

The market risk is represented by common market factors. The values of market variables are differentiated in relation to the geographical areas. We identify two geographical areas: Europe and USA. To test the impact of systematic risk on banks CDS spreads we include in our model:

MIR. Following the previous literature (Annaert et al. (2013)) we control for the market stock index returns. We use Euro Stoxx and S&P 500 index for the European and US banks to calculate the stock returns, respectively. A negative relationship is expected because the defaults probabilities should decrease when the general business climate increases.

Market volatility As in Collin-Dufresne and Goldstein (2001) and Galil et al. (2014), we include the implied volatility indexes as control variable. We use different indexes taking into account the two geographical areas in our sample. Specifically, we use VIX for US, VSTOXX for Europe. A higher volatility implies a higher economic uncertainty, an increase in investors' risk aversion (Annaert et al. (2013)) and, therefore, a higher risk. As a consequence, a positive relationship with the CDS premium is expected.

Risk-free rate. To be in line with the maturity of the CDS spreads, we use as proxy of risk-free interest rate the 5-year government bond yield. We proxy the European risk-free interest rate with European IRS 5Y and the US risk-free interest rate with the 5Y US-Treasury bond. The expected relationship is negative because the interest rates are positively related to economic growth and negatively to default risk. However, the relationship could be positive across countries because banks have higher borrowing costs in countries with greater risk-free rates (Hasan et al. (2015)).

Term structure. The term structure of interest rates is the difference between 10 years and 2 years treasury bond yields. The slope of the yield curve is an indicator of economic prospects. The relationship between CDS spreads and slope of the yield curve should be negative. A higher slope of the yield term structure is generally associated with better economic growth prospects and lower default risk. Moreover, the slope carries information about future interest rate levels. An increase in slope would then indicate higher future interest rates which implies lower credit risk (Hasan et al. (2015), Annaert et al. (2013)).

Credit rating variables

Bank rating We use the numerical value of S&P credit rating. In line with Ismailescu and Kazemi (2010), Norden and Weber (2004), we use a numerical 17 grade scale to calculate the impact of bank rating on the perceived credit risk. We assign value 1 to a bank rating *CC or less than CC* and value 17 to a bank rating AAA. Given the construction of the variable, the expected sign is negative. Higher bank rating implies lower bank risk and, therefore, lower banks CDS spreads.

Country rating. We also include the bank host country sovereign credit risk rating, because of bank-sovereign linkages through bank holdings of government debt and the potential for troubles banks to burden the public finances. In line with Ismailescu and Kazemi (2010), Norden and Weber (2004), we use a numerical 17 grade scale to calculate the impact of sovereign rating on the banks CDS spreads. We assign value 1 to a sovereign rating *CC or less than CC* and value 17 to a sovereign rating AAA. Given the construction of the variable, the expected sign is negative. Higher country rating implies lower country risk and, therefore, lower banks CDS spreads.

The sources of the data for the variables, the construction of the variables, and the expected signs on the estimated coefficients are set out in Table 3.1.

3.3.2 Descriptive statistics

Panel A of table 3.2 reports the summary statistics of the dependent variable (CDS spreads) overall and divided by zones. The sample is composed by European and US

Variable	Description	Source	Sign
Panel A: Balance-sheet determinants			
Capital adequacy	Tier 1 ratio.	Bank Scope	-
Undercapitalised	Interaction term between dummy variable (1 indicates a bank with a Tier 1 ratio below 8%) and Tier 1 ratio.	Authors's calculation	+/-
Leverage	Ratio of liabilities to the sum of liabilities and equity.	Bank Scope	+
Loan quality	Ratio between impaired loans and total assets.	Bank Scope	+
Credit quality	Ratio between loan loss provisions and loans.	Bank Scope	+
Size	Natural logarithm of total assets.	Bank Scope	+/-
Funding	Ratio between retail customer deposits and total assets.	Bank Scope	-
Panel B: Macroeconomic determinants			
MIR	Market index stock returns.	Datastream	-
Market volatility	Stock market volatility.	Datastream	+
Risk-free rate	5 years interest rate.	Datastream	+/-
Term structure	Difference between 10Y and 2Y Treasury bond.	Authors's calculation	-
Panel C: Rating determinants			
Bank rating	Index ranging from 1 (S&P's rating CC or less than CC) to 17 (S&P's rating AAA).	Bank Scope	-
Country rating	Index ranging from 1 (S&P's rating CC or less than CC) to 17 (S&P's rating AAA).	Bank Scope	-
Panel D: Dummy variables			
Crisis Europe	1, if the period is between Q2 2011-Q2 2012 and 0, otherwise.		
Crisis USA	1, if the period is between Q2 2007-Q2 2009 and 0, otherwise.		

Description of variables

Table 3.1: *Variable description, data source and expected coefficient signs. Panel A, Panel B and Panel C describe the balance-sheet, market and rating variables, respectively. Panel D describes the dummy variables.*

banks[6]. Average banks CDS spread is 178.56 bps. In Euro-Peripheral countries, the CDS spread is on average 366.52 bps. Not surprisingly, the Greece banks have the highest CDS spreads (965.40 bps). Our sample reflects perfectly the situation of the markets between 2007-2016 by showing the Euro-Peripheral banks as the riskiest banks, in particular, those of Greece, Ireland and Portugal. The Euro-Core, Non-Euro and US banks show more or less the same CDS spreads on average. Euro-Core banks show, on average, CDS spreads of 156.09 bps. The 14 Non-Euro banks have, on average, CDS spreads of around 117.18 bps. While the 9 US banks show, on average, CDS spreads of 125.63 bps.

Panels B, C and D of Table 3.2 shows the mean of explanatory variables included in Eq. 3.1 overall and divided by zones. In Panel B we report the mean of balance-sheet determinants. The most striking differences across countries are that US banks were substantially less leveraged than European banks, the poorer loan quality of euro-periphery banks, and the lower sovereign credit rating of euro-periphery countries. The majority of sample banks exhibits a capital adequacy ratio well above the minimum regulatory threshold

[6] The countries are Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, Switzerland, United Kingdom and USA.

(Basel III). In term of size, the Non-Euro and US banks are the largest in the sample. The funding ratio shows that the US banks have a higher portion of retail customer deposits compared to the total assets than the European banks. The market variables (Panel C) are differentiated in relation to the geographical areas: European and US area. The market index returns in Europe is higher than in USA. The monetary policy of European Central Bank and Federal Reserve has been the main character of the period between 2007-2016. The risk-free interest rate highlights the monetary policy of ECB and FED. The European risk-free interest rate is higher than the US risk-free interest rate. Finally, in Panel D we report the mean of banks and countries credit rating. The Euro-Peripheral banks are those more risky. On average, the Euro-core countries show the lower sovereign risk rating whereas, USA show a sovereign risk rating equal to Aaa. Correlation coefficients between the dependent variables (Table 3.3) are lower than 50%, suggesting that multicollinearity is unlikely to be a problem for the regression estimates. However, we use Variance Inflation Factor (VIF) to test the multicollinearity problems in our regressions[7].

3.4 Results

In this section we report the estimates from panel regressions with time and bank fixed effects. As dependent variable we use the bank CDS spreads at time *t+1 week*. As independent variables we use various risk drivers. To assess the importance of various risk drivers (Düllmann and Sosinska (2007) and Annaert et al. (2013)), we decompose the share of explained variance into contributions by groups of regressor variables. More specifically, we measure the marginal contributions (mc_k) of *4th* variables blocks (balance-sheet, market, rating variable groups and US/European crisis) to the total explanatory power.

$$mc_k = \frac{R^2 - R_k^2}{\sum_{k=1}^{4}(R^2 - R_k^2)} \tag{3.2}$$

where R_k^2 is the explanatory power of the regressions by using only one of the *4*th variables blocks. R^2 is the explanatory power of the complete model in Eq.3.1 (Table 3.4).

First of all, we assess the impact of the balance-sheet variables on the CDS spreads.

[7]We find VIF values well below ten (cutoff value identified by Neter et al. (1985)).

Summary statistics						
	No. of banks	*Observations*	*Mean*	*Min*	*Max*	*STD*
Panel A: CDS spreads						
All banks	63	734	178.56	33.00	2646.39	207.93
Euro-Core	19	193	366.52	39.88	3105.00	414.00
Euro-peripheral	21	159	156.09	34.7	1375.00	107.67
Non-euro	14	198	117.18	33.00	387.77	65.17
USA	9	184	125.63	54.88	250.69	51.45
Variable mean						
	All banks	*Euro-Peripheral*	*Euro-Core*	*Non-Euro*	*USA*	
Panel B: Balance-sheet determinants (%)						
Capital adequacy	12.08	12.07	10.96	13.03	12.27	
Undercapitalised	1.14	1.50	1.34	0.90	0.77	
Leverage	93.48	92.29	95.46	95.73	89.92	
Loan quality	2.82	6.19	2.39	1.30	1.06	
Credit quality	0.67	0.94	0.68	0.36	0.70	
Size	19.87	18.98	19.56	20.60	20.41	
Funding ratio	56.40	59.16	55.11	50.55	61.58	
Panel C: Macroeconomic determinants (%)						
MIR	5.18	5.66	5.66	5.66	5.18	
Mrk volatility	26.67	27.55	27.55	27.55	21.36	
Risk-free rate	1.93	2.20	2.20	2.20	1.93	
Term structure	1.78	1.78	1.78	1.78	1.73	
Panel D: Rating determinants						
Bank rating	11.94	9.40	12.53	13.71	11.86	
Country rating	14.99	16.80	10.60	16.79	17.00	

Table 3.2: *Summary statistics for 63 European and US banks, Q1 2007- Q1 2016.*

In model (I) of Table 3.4, we observe the role of the balance-sheet variables (undercapitalised, leverage, credit quality and size) that exhibit significant correlation in the expected directions. More specifically, credit risk appears to be higher for more leveraged banks (a 1% point increase in leverage raising spreads by 167.6 basis points) and banks that have a large portion of problem loans; and it is lower for larger banks, possibly reflecting economies of scope and a belief among market participants that larger banks are too big to fail. Banks capital appears to play no direct role in the determination of spreads, which may be indicative of the misleading nature of capital adequacy ratios given that they are subject to bank manipulation through the management of risk weights (e.g., Admati and Hellwig (2014)). Furthermore, the limited efficacy of the capital index Tier 1 ratio is confirmed by

Matrix correlation

	CDS	Tier 1	Under	Leverage	Loans Q	Credit Q	Size	Funding	MIR	Mrk vol	r_5	Term structure	Bank R	Country R
CDS	1													
Tier 1	-0.025	1												
	(0.45)													
Under	-0.098	-0.361	1											
	(0.00)	(0.00)												
Leverage	0.035	-0.175	-0.149	1										
	(0.24)	(0.00)	(0.00)											
Loans Q	0.391	-0.072	-0.130	-0.025	1									
	(0.00)	(0.04)	(0.00)	(0.46)										
Credit Q	0.315	-0.065	-0.094	0.078	0.385	1								
	(0.00)	(0.04)	(0.00)	(0.01)	(0.00)									
Size	-0.235	0.001	-0.063	-0.244	-0.302	-0.233	1							
	(0.00)	(0.98)	(0.04)	(0.00)	(0.00)	(0.00)								
Funding	0.233	-0.109	-0.031	0.270	0.232	0.098	-0.190	1						
	(0.00)	(0.00)	(0.32)	(0.00)	(0.00)	(0.00)	(0.00)							
MIR	-0.065	-0.028	0.197	-0.320	0.175	-0.117	-0.120	-0.074	1					
	(0.00)	(0.36)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)						
Mrk vol	0.171	-0.153	0.185	-0.269	-0.042	0.031	-0.086	-0.109	-0.214	1				
	(0.00)	(0.00)	(0.00)	(0.00)	(0.21)	(0.30)	(0.00)	(0.00)	(0.00)					
r_5	0.001	-0.358	0.618	-0.178	-0.287	-0.052	-0.001	-0.089	0.134	0.384	1			
	(0.98)	(0.00)	(0.00)	(0.00)	(0.00)	(0.08)	(0.97)	(0.00)	(0.00)	(0.00)				
Term structure	-0.053	0.134	-0.354	0.041	0.094	0.069	-0.010	0.017	-0.374	0.215	-0.231	1		
	(0.02)	(0.00)	(0.00)	(0.15)	(0.00)	(0.02)	(0.72)	(0.55)	(0.00)	(0.00)	(0.00)			
Bank R	-0.484	-0.167	0.362	-0.282	-0.608	-0.362	0.326	-0.296	-0.018	0.230	0.474	-0.075	1	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.41)	(0.00)	(0.00)	(0.001)		
Country R	-0.529	-0.048	0.053	-0.113	-0.643	-0.223	0.359	-0.209	-0.167	0.027	0.159	0.006	0.535	1
	(0.00)	(0.13)	(0.09)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.19)	(0.00)	(0.77)	(0.00)	

Table 3.3: *Table shows the Pearson correlation matrix among all variables in Eq. 3.1.*

Basel III that focuses, in December 2010, on improving the quality of regulatory capital (BCBS (2010)). Nevertheless, the results suggest that capital adequacy ratio is important for undercapitalised banks, as indicated by the negative and significant coefficient. This non-linear relationship between capital adequacy and credit risk is in line with Altunbas et al. (2011) and the proposal of Basel Committee. The role of this group of variable is also confirmed by the explanatory power. The bank balance-sheet variables explain 21.38% of the variability of the banks CDS spreads.

In model (II), we test the model including the market variables. The results confirm the statistical significance of the undercapitalised, leverage, credit quality and size. Among the market variables, the estimates show that the significant impact of market index returns, market volatility, risk free interest rate and term structure of interest rates (Annaert et al. (2013)). Specifically, banks CDS spreads narrow in response to improvements in the stock market and an upward sloping yield curve (Podpiera and Ötker (2010)), signaling an improvement in economic prospects, and widen as stock market volatility increases, signaling an improvement in uncertainty about economic prospects (Samaniego-Medina et al. (2016));

and widen in response to risk free interest rate. The significant effect of market volatility provides cross-country evidence that systematic risk in a country is important for credit risk pricing of global bank (Hasan et al. (2015)). Although in the previous chapter, we observe a negative relationship between risk free interest rate and CDS spreads, we find a significant but positive impact of risk free interest rate on the banks CDS spreads. It implies that banks in countries with higher government yields, and thus higher cost of funds, are likely to have higher CDS spreads. An alternative explanation is that there is a spillover effect from sovereign bonds to bank bonds (Hasan et al. (2015)). Overall, the model with balance-sheet and market variables explains 26.41% of the variation of banks CDS spreads. When we decompose the share of the explained variance of the regression into contributions (last four rows of Table 3.4), we find that the explanatory power of the balance-sheet variable groups is dominated in their impact on CDS spreads by the market variable groups (explaining 20.95% of the variance).

In model (III) we include the rating variables. The results largely confirm our baseline findings. Additionally, we observe a significant impact of the banks specific credit risk rating. As expected, banks with lower credit risk rating is likely to have higher CDS spreads. The explanatory power of the balance-sheet and rating variable groups is broadly equivalent (10.86% and 9,82%, respectively) but both are dominated in their impact on CDS spreads by the market variable groups (explaining 29.59% of the variance). Finally, models (IV) and (V) include the dummy variables for US and European crisis, respectively. The results confirm the previous findings. Undercapitalised, leverage, credit quality and size show a significant impact on the CDS spreads of banks. The results also confirm the significance of market volatility, risk free interest rate and slope of the yield curve. Banks specific credit risk rating continues to have a significant impact on banks CDS spreads. Nevertheless, when we account for the crises, the coefficient on country risk credit rating is statistically significant. Banks CDS spreads widen as a county's sovereign credit rating deteriorates, probably reflecting the sovereign-bank public debt linkages. Not surprisingly, the onset of the US financial crisis and sovereign debt crisis are associated with a widening of CDS spreads. The highly statistically significance of the coefficient on European crisis highlights the spillover effect of the sovereign crisis to the banking system. The increase on the systematic risk of some European countries was transmitted to the banks. The contagion effect is due to the strong link between financial and sovereign institutions. Spillover among financial and sovereign institutions takes place through many channels with large potential for amplification. Financial institutions are exposed to sovereigns through government bond holdings, which can weigh on both the value of their assets and on their funding cost level. The decomposition of the share of the explained variance of the regression into contributions continues to show that the explanatory power of the balance-sheet variable groups is dominated in their impact on CDS spreads by the market variable groups and the onset of the US (European) crisis (explaining 39.27% (37.72%) and 44.78%(39.94%) of the variance, respectively). These findings support the claim that adding the common systematic components helps to address the *credit-spread puzzle* in bank CDS spreads.

3.4.1 Results divided by geographical areas

To determine whether the relationship between banks CDS spreads and the variables in our model changes with varying zones, further regressions were performed. We estimate our baseline equation separately for banks by different groups of European countries: Euro-Peripheral (Greece, Ireland, Italy, Portugal, Spain), Euro-Core (Austria, Belgium, France, Germany, Netherlands), Non-Euro (Denmark, Sweden, Switzerland, United Kingdom), and USA. Table 3.5 reports the results from these estimates. Breaking down the sample according to zones reveals that there are important differences across (groups of) countries. These differences are also reflected in the decomposition of the variance into the balance sheet, market, rating and crisis dummies determinants. Our baseline results underline that the capital adequacy does not work properly as a cushion against the fluctuations of earnings in European banks. Given its quantitative importance, a careful assessment of the implementation of new rules on capital buffers proposed by Basel III is crucial for banking stability system. The Basel Committee partially confirms the problems of this ratio. The crisis demonstrated that credit losses and write downs come out of retained earnings, which is part of banks' tangible common equity base. It also revealed the inconsistency in the definition of capital across jurisdictions and the lack of disclosure that would have enabled the market to fully assess and compare the quality of capital between institutions

Results overall										
$CDS_{t+1week}$	(I)		(II)		(III)		(IV)		(V)	
Capital Adequacy	-0.0268		0.0159		0.0109		0.0155		0.0040	
	(0.073)		(0.073)		(0.070)		(0.071)		(0.071)	
Undercapitalised	-0.1843	***	-0.1788	***	-0.0987	*	-0.0991	*	-0.0986	*
	(0.060)		(0.062)		(0.056)		(0.056)		(0.056)	
Leverage	0.1676	*	0.1683	*	0.1796	*	0.1718	*	0.1808	*
	(0.090)		(0.095)		(0.104)		(0.103)		(0.107)	
Loan quality	0.1424		0.1359		0.1800		0.1734		0.1690	
	(0.095)		(0.089)		(0.150)		(0.148)		(0.151)	
Credit quality	0.1397	*	0.1844	**	0.1292	*	0.1586	**	0.1359	*
	(0.084)		(0.087)		(0.073)		(0.073)		(0.076)	
Size	-1.3404	***	-1.2647	**	-1.0594	*	-0.9818	*	-1.0391	*
	(0.489)		(0.574)		(0.554)		(0.551)		(0.557)	
Funding	-0.0130		-0.0119		-0.0092		-0.0095		-0.0073	
	(0.011)		(0.011)		(0.009)		(0.009)		(0.009)	
MIR			-0.6819	*	-0.6082		-0.3653		-0.5732	
			(0.406)		(0.413)		(0.439)		(0.418)	
Mrk volatility			0.0368	***	0.0415	**	0.0404	**	0.0281	*
			(0.014)		(0.016)		(0.016)		(0.016)	
r_5			0.4452	**	0.4003	**	0.3730	**	0.3546	**
			(0.203)		(0.171)		(0.170)		(0.176)	
Term structure			-1.2803	***	-1.2878	***	-1.2356	***	-1.1570	***
			(0.228)		(0.226)		(0.221)		(0.215)	
Bank rating					-0.1299	*	-0.1437	**	-0.1394	**
					(0.067)		(0.068)		(0.067)	
Country rating					0.1829		-0.1932	*	-0.1785	*
					(0.150)		(0.099)		(0.098)	
US crisis dummy							0.6230	**		
							(0.275)			
EU crisis dummy									0.6830	***
									(0.239)	
Constant	12.8423		16.0792		6.6224		3.8807		6.4883	
	(11.174)		(10.396)		(10.001)		(9.599)		(10.073)	
N	734		734		734		734		734	
Year/bank FE	Y		Y		Y		Y		Y	
R^2	0.2138		0.2641		0.2735		0.2248		0.2399	
F-fisher	5.23	***	5.00	***	4.78	***	4.86	***	5.77	***
VIF	1.36		1.85		2.16		2.32		1.98	
Wooldridge test	0.427		0.214		0.949		0.513		0.583	
Marginal contributions										
Balance-sheet			6.87%		10.86%		14.12%		16.39%	
Market			20.95%		29.59%		39.27%		37.72%	
Rating					9.82%		1.83%		5.96%	
US/EU crisis							44.78%		39.94%	

Table 3.4: *Table reports the coefficients estimated by running Panel regressions over the period Q1 2007- Q1 2016. Robust standard errors are in parenthesis below the coefficient estimates. (I) reports the estimates of balance-sheet variables. (II) and (III) include market and rating variables, (IV) and (V) consider the US crisis and the European crisis, respectively. The Wooldridge test reports the p-values for the null hypothesis of no serial correlation. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively.*

(BCBS (2010)). These shortcomings might be a proof of the inefficiency of the capital adequacy in safeguarding banks against insolvency. The reforms of Basel Committee raise both the quality and quantity of the regulatory capital base and enhance the risk coverage of the capital framework.

The CDS spreads of Euro-Peripheral banks appear to be higher for more leveraged banks, and for banks with higher non-performing loans; and it is lower for larger banks. Among the market variables, the coefficient on market volatility and term structure of interest rates are highly statistically significant. The credit risk of Euro-Peripheral banks shows a direct link to the bank risk credit ratings. More specifically, credit risk appears to be higher for banks with lower credit ratings (a 1% point increase in credit ratings spreads by 402 (374) basis points). The CDS spreads widen as a country's sovereign credit rating deteriorates, probably reflecting the sovereign-bank public debt linkages that was very strong in these countries during the sovereign crisis. As expected, the onset of both crises is associated with a significant widening of CDS spreads. This implies that, in periods of high financial market volatility, the price of credit risk is larger than in normal periods. Not surprisingly, the CDS spreads of Euro-Peripheral banks have recorded an higher increase during the sovereign crisis than the financial crisis. In the decomposition of the variance into the balance-sheet, market, rating and crisis dummies determinants, balance-sheet variable group is dominated in their impact on CDS spreads by the market and rating determinants and the onset of the US/ EU crisis.

The most important determinants of Euro-Core banks are market and rating variables. Their explanatory power is broadly equivalent (23.55%(24.12%) 20.48% (21.67%), respectively) but both are dominated in their impact on CDS spreads by the onset of the US financial crisis and European sovereign debt crisis (explaining 51.48% and 45.25% of the variance). Funding structure, stock market index returns, prospective business conditions and bank specific credit risk rating appear to dominate spreads in core euro country banks. In this area, an increase in funding structure is associated with a narrowing of spreads, signaling that retail deposits are considered as a more stable source of funding. Furthermore, the future interest rate levels forecast an economic environment with a rising inflation rate and a tightening of monetary policy. On the contrary of the Euro-Peripheral banks, the country sovereign credit risk rating appears to play no direct role in the determination of CDS spreads in Euro-Core banks, which may be indicative of a direct link between banks and countries credit risk only in case of riskier countries[8]. A downgrade in riskier countries may have greater repercussions on the banks' asset portfolio and then on their probability to default.

Leverage, loan quality, stock market index returns, risk free interest rate and prospective business condition are key drivers of spreads of banks in non-euro adopting European countries. The capitalisation has a significant impact on the perceived credit risk of undercapitalised banks whereas we do not observe a significant effect for banks with a Tier 1 higher than 8.5%. This non-linear relationship between perceived credit risk and capitalisation variable may be indicative of the misleading nature of capital adequacy ratios, signaling that they work cushion against the fluctuations of earnings only for banks that hold a Tier 1 ratio below the minimum required. Additionally, bank CDS spreads narrow in response to improvements in the stock market index returns, an upward sloping yield curve, and widen as risk free interest rate increases, signaling higher cost of funds. Finally, credit rating variable group appears to play no direct role in the determination of spreads. The spreads of banks in non-euro adopting European countries widen in response to the European sovereign crisis but not in response to US financial crisis, signaling a great exposition of these banks to the European sovereign debt. The marginal contributions show that balance sheet variables dominate market variables and the crisis dummies in influencing the CDS spreads of Non-Euro banks.

Capital-asset ratio, leverage, credit quality, funding structure are the balance-sheet variables that affect the CDS spreads in US banks. An increase in capital adequacy (both well capitalized and undercapitalised banks) and funding structure is associated with a narrowing of spreads, whereas an increase in loan loss provisions is associated with a widening of spreads, as would be expected. For US banks all the market variables are statistically significant and of the anticipated signs. Additionally, the spreads decrease as bank specific credit risk rating increase. Not surprisingly, the onset of the US and European crisis is also associated with a widening of CDS spreads. Nevertheless, the effect

[8] 90% of the Euro-Core countries are rated as *investment-grade countries.*

of the US crisis is more pronounced than that of European sovereign debt crisis. The onset of US financial crisis has caused an increase of around 1433 bps whereas the impact of European sovereign debt crisis has been around 583 bps. Although in European banks the decomposition of share of the explained variance has shown that the market variable group dominates the others, in US banks it reveals an inverse trend. In fact, the explanatory power of the rating and crisis variable group is broadly equivalent but both are dominated in their impact on CDS spreads by the balance-sheet variables (explaining 42.60% (44.42%) of the variance).

3.4.2 Further analysis: the impact of financial and sovereign crisis

Our results underline a strong impact of financial and sovereign crisis on the CDS spreads. To better understand the impact of both crises on the determinants of banks CDS spreads, we run an additional analysis by incorporating the interaction between the balance-sheet variables and US or sovereign debt crisis (Hasan et al. (2015)). In line with Hasan et al. (2015) we study the possible additional effects of the balance-sheet variables on the CDS spreads during the financial crisis by adding to Eq. 3.1 the interaction terms. Additionally to Hasan et al. (2015), we run this exercise by considering the sovereign crisis. Therefore, we can observe if there are differences in pricing the banks credit risk during a financial or an economic shock. We use the methodology in Hasan et al. (2015)[9]. The results are presented in Table 3.6 model (I) and (II). The coefficient on US and European crisis variable is positive and significant, confirming that the CDS spreads widen during the US financial crisis and European sovereign debt crisis. The results with the interaction variables confirm the previous findings. The key factors of CDS spreads in European and US banks are, among the balance-sheet variables, leverage, credit quality and size; market volatility, risk free interest rate, term structure of interest rates, bank and country credit rating contribute to explain the CDS spreads of banks. Nevertheless, the effects of some variables on the CDS spreads was exacerbated by the US financial crisis and European sovereign debt crisis and some others was recorded only during the turmoil periods. More

[9] To avoid multicollinearity problems, we subtract the mean from the value before constructing the interaction terms.

Results divided by areas								
$CDS_{t+1week}$	*Euro-Peripheral*		*Euro-Core*		*Non-Euro*		*USA*	
Capital Adequacy	-0.071	-0.122	-0.084	-0.085	0.035	0.034	-0.180***	-0.164***
	(0.180)	(0.171)	(0.078)	(0.082)	(0.022)	(0.022)	(0.049)	(0.058)
Undercapitalised	-0.113	-0.090	0.019	0.022	-0.041**	-0.050***	-0.195**	-0.180**
	(0.086)	(0.083)	(0.085)	(0.085)	(0.019)	(0.017)	(0.089)	(0.090)
Leverage	0.417**	0.411**	-0.237	-0.240	-0.072	-0.070	0.050	0.085
	(0.188)	(0.195)	(0.334)	(0.345)	(0.069)	(0.064)	(0.097)	(0.128)
Loan quality	0.206*	0.217*	-0.027	-0.040	0.196*	0.196*	0.604	0.421
	(0.116)	(0.115)	(0.156)	(0.160)	(0.118)	(0.109)	(0.425)	(0.357)
Credit quality	-0.223	-0.186	0.603	0.548	0.142	0.102	0.026*	0.046**
	(0.167)	(0.140)	(0.485)	(0.454)	(0.108)	(0.097)	(0.014)	(0.023)
Size	-1.221**	-1.525***	-0.550	-0.494	0.200	0.206	-0.333	-0.583
	(0.614)	(0.512)	(0.678)	(0.731)	(0.261)	(0.282)	(0.659)	(0.729)
Funding	-0.021	0.010	-0.083***	-0.089***	0.002	0.002	-0.034*	-0.034**
	(0.015)	(0.020)	(0.017)	(0.015)	(0.005)	(0.004)	(0.019)	(0.017)
MIR	0.682	-0.399	-1.799**	-2.167**	-1.018***	-1.274***	-1.898**	-1.769**
	(1.158)	(0.935)	(0.702)	(0.990)	(0.214)	(0.275)	(0.755)	(0.704)
Mrk volatility	0.167***	0.105***	0.000	-0.018	0.022	-0.004	0.011*	0.017**
	(0.060)	(0.030)	(0.014)	(0.014)	(0.014)	(0.011)	(0.006)	(0.008)
r_5	-0.670	-0.958	0.881*	0.862	0.368***	0.335***	0.663*	0.900**
	(0.413)	(0.664)	(0.524)	(0.611)	(0.111)	(0.073)	(0.351)	(0.360)
Term structure	-1.327***	-1.587***	-1.158***	-1.089**	-0.709***	-0.581***	-1.266***	-1.263***
	(0.330)	(0.386)	(0.396)	(0.490)	(0.119)	(0.092)	(0.365)	(0.375)
Bank rating	-0.402***	-0.374***	-0.494***	-0.353**	0.019	0.024	-0.785***	-0.682***
	(0.131)	(0.129)	(0.145)	(0.137)	(0.103)	(0.102)	(0.129)	(0.124)
Country rating	-0.804**	-0.833**	0.314	0.244	0.062	0.025		
	(0.392)	(0.345)	(0.249)	(0.259)	(0.226)	(0.232)		
US crisis dummy	0.948**		0.451*		0.108		1.433***	
	(0.474)		(0.256)		(0.207)		(0.367)	
EU crisis dummy		2.986***		0.465**		0.528***		0.583**
		(0.993)		(0.222)		(0.122)		(0.249)
Constant	13.629	35.993	39.087	42.698	5.935	8.508	8.652	16.424***
	(37.032)	(36.912)	(30.301)	(31.360)	(6.360)	(6.146)	(8.376)	(6.073)
N	193	193	159	159	198	198	184	184
N of Banks	19	19	21	21	14	14	9	9
Year/bank FE	Y	Y	Y	Y	Y	Y	Y	Y
R^2	0.497	0.549	0.278	0.290	0.592	0.598	0.440	0.408
F-fisher	14.02***	16.98***	3.16***	3.24***	10.26***	11.34***	10.01***	9.04***
VIF	2.68	2.99	2.77	2.59	2.45	2.63	2.73	2.97
Wooldridge test	0.106	0.653	0.352	0.179	0.130	0.203	0.269	0.214
Marginal contributions								
Balance-sheet	14.88%	17.04%	4.49%	8.96%	25.77%	26.70%	42.60%	44.42%
Market	28.38%	28.22%	23.55%	24.12%	44.02%	45.08%	8.66%	5.24%
Rating	25.08%	25.48%	20.48%	21.67%	7.13%	7.93%	28.18%	27.77%
US/EU crisis	31.66%	29.25%	51.48%	45.25%	23.08%	20.29%	20.57%	22.56%

Table 3.5: *Table reports the coefficients estimates by running Panel regressions divided by zones. Robust standard errors in parenthesis below the coefficient estimates. The Wooldridge test reports the p-values for the null hypothesis of no serial correlation. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively.*

specifically, during both turmoil periods, the capital adequacy ratio (for both well capitalized and undercapitalised banks) has a significant and negative effect on the CDS spreads. It implies that there was a non-linear effect between Tier 1 ratio and credit risk during the crises. Furthermore, the impact of leverage and credit quality plays a substantially more important role with the onset of the recent US financial crisis and sovereign debt crisis. The response of the CDS spreads to an increase on leverage or loan loss provisions is more than double during a period of financial or economic turmoil. The interaction between crisis and funding structure points out that banks with high portion of retail deposits during financial crisis has less likely to fail. Probably, during periods of turmoil, retail deposits are considered as a more stable source of funding (Shleifer and Vishny (2010)) and thus they reduce the perceived probability to fail. Nevertheless, this effect disappears after the US financial crisis. Not surprisingly, the effect of funding structure is not observed during the sovereign debt crisis, probably it may be due to the fact that the retail deposits are typically insured by the government.

The decomposition of the share of the explained variance continues to show that the explanatory power of the balance sheet and rating variable groups is broadly equivalent but both are dominated in their impact on CDS spreads by the market variable groups and the onset of the financial and economic crisis.

3.5 Robustness tests

In this section, to test our hypothesis that the availability of balance-sheet information affects the CDS spreads, a number of further regressions were carried out. We run model in Eq. 3.1 by using as dependent variable bank CDS spreads at time t and time *t+2 weeks* and balance-sheet variables at time t. The first group of regressions, using the CDS spreads at time t, tests the hypothesis that the information transmission does not affect the pricing of CDS spreads in European and US banks. Instead, the regressions that consider the bank CDS spreads at time *t+2 weeks* as dependent variable test the hypothesis that the CDS spreads in banking industry can be affected by the information released by the banks to the market with a delay of two weeks. Both regressions were conducted on the overall

Further analysis				
$CDS_{t+1week}$	(I)		(II)	
Capital adequacy	-0.1323		-0.0806	
	(0.104)		(0.058)	
*Capital adequacy*crisis*	-0.4283	**	-0.6421	***
	(0.184)		(0.121)	
Undercapitalised	-0.0585		-0.0819	
	(0.064)		(0.050)	
*Undercapitalised*crisis*	-0.2592	***	-0.3643	***
	(0.081)		(0.125)	
Leverage	0.2413	***	0.2079	**
	(0.092)		(0.103)	
*Leverage*crisis*	-0.1966	**	-0.2178	**
	(0.091)		(0.093)	
Loan quality	0.0472		-0.0380	
	(0.106)		(0.066)	
*Loan quality*crisis*	0.2991		0.1382	
	(0.286)		(0.155)	
Credit quality	0.1494	**	0.1301	**
	(0.066)		(0.061)	
*Credit quality*crisis*	1.2652	***	1.3927	**
	(0.192)		(0.637)	
Size	-0.9428	*	-0.9108	**
	(0.524)		(0.363)	
*Size*crisis*	-0.0814		-0.2917	
	(0.199)		(0.230)	
Funding	0.0017		-0.0073	
	(0.009)		(0.010)	
*Funding*crisis*	-0.0418	***	-0.0419	
	(0.011)		(0.125)	
MIR	-0.4711		-0.4718	
	(0.296)		(0.384)	
Mrk volatility	0.0195	*	0.0293	*
	(0.012)		(0.017)	
r_5	0.5219	***	0.4179	***
	(0.178)		(0.138)	
Term structure	-1.3490	***	-0.6426	***
	(0.230)		(0.178)	
Bank rating	-0.1063	*	-0.1101	**
	(0.057)		(0.049)	
Country rating	-0.2422	*	-0.1206	*
	(0.125)		(0.067)	
US crisis dummy	6.9551	***		
	(0.298)			
EU crisis dummy			3.8951	***
			(0.038)	
Constant	1.9186		7.3648	
	(10.587)		(9.843)	
N	734		734	
R^2	0.3101		0.5101	
F-fisher	5.20	***	11.91	***
Year/bank FE	Y		Y	
Wooldridge test	0.143		0.348	
Marginal contributions				
Balance-sheet	13.48%		20.26%	
Market	34.13%		29.03%	
Rating	15.52%		21.13%	
US/EU crisis	36.87%		29.58%	

Table 3.6: *Table reports the results of further analysis. Robust standard errors in parenthesis below the coefficient estimates. The Wooldridge test reports the p-values for the null hypothesis of no serial correlation. ***, **, and * indicate statistical significance at the levels of 1%, 5%, and 10%, respectively*

sample. Our results confirm the findings of Chiaramonte and Casu (2013) that test the hypothesis of a possible reaction of the CDS spreads to the publication of balance-sheet results by using as dependent variables the CDS spreads at the preceding quarter and following quarter.

The results in Table 3.7 demonstrate that the CDS spreads in European and US banks do not precede the balance-sheet data and the publication of balance-sheet results by banks marginally affect the determinants of the CDS spreads. In both cases the results largely confirm our baseline findings: i) leverage and credit quality affects positively the CDS spreads; ii) large banks are considered as too big to fail; iii) bank CDS spreads widen as stock market volatility increases, signaling an increase in uncertainty about economic prospects; iv) term structure of interest rates impacts negatively on the CDS spreads; v) banks with high credit rating are less likely to fail; vi) an increase on the country sovereign credit rating is associated with an increase on CDS spreads; vii) CDS spreads widen in periods of financial and economic stress; vi) market determinants and the onset of financial and economic crisis dominate balance-sheet determinants for all banks.

Comparing of the results of Panel regression in Table 3.7 with those of the Panel regressions of Table 3.4 reveals that the choice of the time in which we measure the CDS spreads impacts marginally on the determinants of CDS spreads. In fact, measuring the credit risk with the CDS spreads at time t implies some information loss on the importance of the undercapitalization, market volatility, risk free interest rate and sovereign credit risk. The CDS market do not react in advance to the balance-sheet information but it is capable of reacting to information as it is made public.

3.6 Conclusion

This chapter investigates the determinants of banks CDS spreads during Q1 2007-Q1 2016, a period dominated by financial and European crisis. Based on a sample of European and US banks with senior CDS spreads at 5 years, we run a Panel model with fixed effect and robust standard errors in which we include banks balance-sheet, market and rating variables. Consistent with the previous literature, the findings show that banks-specific

Robustness Tests								
	CDS_t				$CDS_{t+2weeks}$			
Capital Adequacy	-0.0893		-0.1027		-0.0765		-0.0966	
	(0.100)		(0.099)		(0.094)		(0.092)	
Undercapilised	-0.1078		-0.1042		-0.1307	**	-0.1261	**
	(0.505)		(0.499)		(0.059)		(0.060)	
Leverage	0.1755	*	0.1820	*	0.1686	**	0.1783	**
	(0.094)		(0.097)		(0.071)		(0.071)	
Loan quality	0.0088		0.0046		0.0610		0.0567	
	(0.120)		(0.125)		(0.106)		(0.112)	
Credit quality	0.1638	**	0.1439	*	0.1937	**	0.1304	*
	(0.075)		(0.074)		(0.075)		(0.071)	
Size	-0.9547	*	-1.0058	**	-0.9778	*	-1.0862	**
	(0.498)		(0.511)		(0.525)		(0.540)	
Funding	-0.0070		-0.0052		-0.0101		-0.0075	
	(0.009)		(0.010)		(0.011)		(0.011)	
MIR	-0.2899		-0.4295		-0.1011		-0.3480	
	(0.371)		(0.327)		(0.456)		(0.437)	
Mrk volatility	0.0217		0.0108		0.0485	***	0.0337	*
	(0.014)		(0.014)		(0.018)		(0.017)	
r_5	0.2170		0.2490		0.3491	**	0.3226	*
	(0.155)		(0.160)		(0.163)		(0.171)	
Term structure	-0.7959	***	-0.7179	***	-1.0972	***	-0.9979	***
	(0.167)		(0.172)		(0.199)		(0.205)	
Bank rating	-0.1417	**	-0.1370	**	-0.1510	**	-0.1509	**
	(0.065)		(0.065)		(0.062)		(0.060)	
Country rating	-0.0261		-0.0401		-0.2657	**	-0.2557	**
	(0.138)		(0.137)		(0.120)		(0.118)	
US crisis dummy	0.5438	**			0.7326	**		
	(0.272)				(0.297)			
EU crisis dummy			0.5936	**			0.8339	***
			(0.256)				(0.229)	
Constant	25.8506	***	28.6309	***	18.0746	*	22.6147	**
	(9.198)		(9.202)		(9.395)		(9.453)	
N	734		734		734		734	
R^2	0.3339		0.3415		0.2626		0.2846	
F-fisher	8.57	***	9.78	***	9.27	***	9.93	***
Year/bank FE	Y		Y		Y		Y	
Wooldridge test	0.249		0.552		0.191		0.125	
Marginal contributions								
Balance-sheet	15.42%		16.02%		16.69%		17.86%	
Market	29.28%		29.11%		25.76%		26.02%	
Rating	7.18%		8.24%		29.14%		29.04%	
US/EU crisis	48.12%		46.62%		28.41%		27.08%	

Table 3.7: *Table reports the results of robustness tests, all banks. Robust standard errors in parenthesis below the coefficient estimates. The Wooldridge test reports the p-values for the null hypothesis of no serial correlation. ***, **, and * indicate statistical significance at the levels of 1%, 5%, and 10%, respectively*

variables affect the CDS spreads. We find empirical evidence of the importance of market variables in explaining the CDS spreads of European and US banks. Our results would appear to confirm the applicability of Merton (1974) models extended to include market variables to the understanding and explaining of bank credit risk. Therefore, they support the claim that adding the common systematic components helps to address the *credit-spread puzzle* in bank CDS spreads. The credit risk is driven by undercapitalization, financial leverage, credit quality, banks size, market volatility, risk free interest rate, term structure of interest rates, banks credit rating and country credit rating. More specifically, our key results suggest that less capital, greater leverage, poor credit quality, a weak current and prospective business environment, and a low bank-specific credit rating are all associated with a widening of bank CDS spreads. In addition, bank size and sovereign risk rating also appear to be important determinants of CDS spreads. In the former case, this might reflect economies of scope and/or creditors perception that large banks are too big to fail; in the latter case, it likely reflects sovereign-bank public debt linkages. The financial and sovereign crisis have determined a widening of the banks CDS spreads. Finally, we find that the release of information by the banks partially affects the CDS spreads. The results largely confirm our baseline findings, though there is some information loss on the importance of capitalization variable, the market volatility, risk free interest rate and sovereign risk rating when the CDS spreads at the end of the quarter is the dependent variable.

Important differences in the determinants of spreads emerge from estimating our baseline equation separately for banks by different groups of European countriescore euro countries, euro periphery countries, non-euro adoption EU countries, and the US. The determinants of CDS spreads vary across zones. As consequence, our results might have a numbers of policy implications for regulators to adopt and formulate the capital adequacy system. More specifically, the Euro-peripheral and Euro-core banks do not show a significant relationship between CDS spreads and capital adequacy ratio whereas it appear to be significant in Non-Euro (only for undercapitalised banks) and US banks. This result reveals the inconsistency in the definition of capital across jurisdictions and the lack of disclosure that would have enabled the market to fully assess and compare the quality of capital between institutions (BCBS (2010)). Additionally, it appears that certain parameters, such as capital adequacy, contain elements of national discretion to reflect jurisdiction-specific conditions. In these cases, in the regulations of each jurisdiction, a clear and transparent definitions of the parameters could provide clarity both within the jurisdiction and internationally. By generating doubts about the efficacy of Tier 1 ratio as cushion and safeguard against the risk of future defaults of European and US banking system, this result corroborates the efforts made by policy makers in making new rules in order to reinforce the capability of a bank to absorb the losses deriving by the financial and economic shocks, in particular of undercapitalised ones. A careful design of capital adequacy schemes should be useful to improve the financial stability.

Additional shortcomings on capital adequacy ratios are found by evaluating the effects of financial and European sovereign crisis. In period of financial or economic shocks, the capital adequacy ratios seem to be of significance. The credit risk of both well capitalized and undercapitalised banks narrows in response to an increase on capital adequacy ratios. This is the proof that the capital adequacy ratios have a significant effect only in periods of high volatility but they do not work properly in normal periods. This result supports the prudential regulatory initiatives via Basel III, aimed at reviewing the core capital levels of institutions, in particular of undercapitalised ones. The effect of leverage and credit quality on credit risk is even more evident during the turmoil periods. The bank funding structure also seems to be of significance during period of financial distress, with those banks relying on a large deposit base suffering less than those more dependent on market funding. However, this effect disappears after the crisis and it is not observed during economic distress. This may be indicative of the fact that the retail deposits are typically insured by the government that, during the sovereign debt crisis, are in the spotlight.

Given the transmissions speed of financial and economic tensions, the regulators should pay joint attention to the banking and sovereign CDS market to avoid that an economic crisis may involve the financial markets and vice versa. For this purpose, the regulatory has to take into account not only the internal shocks but also the external shocks and the effect of the possibility to ease the movement of capital across borders on the borrowing cost of different countries. Furthermore, the study underlines the strong link between the domestic preconditions, instabilities of economy, and banks credit risk. The attention on this issue is confirmed in Europe by the recent guidelines of European Banking Authority (EBA) about SREP (EBA (2014)) where, in order to assess the soundness of internal capital adequacy assessment process, authorities have to review and evaluate the capital and liquidity resources on a forward-looking basis (including in assumed stress scenarios) in connection with the overall strategy or significant transactions. In addition, to address this issue, the Basel Committee (Basel III) includes the countercyclical buffer with the aim to ensure that banking sector capital requirements take account of the macro-financial environment in which banks operate. Our findings suggest to intensify supervisory inference significantly. Therefore, this study could help policymakers around the world develop early warning systems and associated supervisory norms for financial institutions, in order to prevent future crises having the scope and the speed of the recent crisis. Therefore, our results call for supervisors to enhance their knowledge of the impact of financial and economic shocks on banks credit risk.

Chapter 4

The impact of credit rating announcement on the CDS market

Abstract

This chapter analyses the impact and the spillover effect of a rating announcement on the US CDS market. By applying the event study technique, the chapter demonstrates that downgrades and upgrades considerably affect financial markets. The analysis shows that the impact is due to the information discovery effect and to the certification effect. Conversely, the CDS market does not seem to react significantly to rating warning announcements. Furthermore, we find evidence of a spillover effect after a downgrade and upgrade announcement. Our results show that the size of the spillover effect is influenced by the difference between firms' ratings, financial crisis, liquidity of the CDS contract, financial leverage and option-implied volatility. Furthermore, we find a significant contamination effect around a downgrade announcement.

4.1 Introduction

Credit rating agencies (CRAs) play an important role in financial markets since they are sources of financial information and they mitigate the asymmetry information among the market participants. The CRAs assess the creditworthiness of corporate and sovereign entity by evaluating a range of quantitative and qualitative indicators. This implies that the process to make changes in credit ratings is quite stringent and long, and CRAs seem to react to new corporate developments slowly compared to the market (Hull et al. (2004), Norden and Weber (2004)). However, in financial market there is an open question related to the information content of credit ratings because they are still required to be instrumental even if they are not up to date (Galil and Soffer (2011)). With financial crisis and the sub-prime debate, a greater attention has been given to the market response to announcements by credit rating agencies. The skepticism surrounding the information relevance of credit ratings that we highlighted in chapter 2 and 3, has led us to test the market response to announcements by CRAs. Therefore, we measure the impact of corporate rating announcement on US companies observing the reaction of the credit default swaps market to a credit rating announcement.

Three main services motivate issuers and investors to employ credit ratings: information, monitoring and certification service. These services explain how the CRAs affect the financial markets (Kiff et al. (2012)). The credit rating produces and disseminates relevant information to market for pricing process and it is useful to reduce the aversion to uncertainty of market participants. Monitoring theory, as underlined by Boot et al. (2006), is related to the service that adds the main value to the financial markets because the CRAs have access to private information during the credit watch procedure that are not available in financial markets. Finally, the certification role is relevant in financial regulation because it relies heavily on credit ratings to identify both the suitability and riskiness of investment, and credit ratings play a role in regulatory capital adequacy requirements. In fact, the standardized approach to calculate bank capital requirements, known as Basel II, has formalized the importance of certification role. Moreover, Kiff (2010) underlines the effect of rating downgrades from investment- to speculative-grade on spread between the yield on the rated instrument and the risk-free rate, the so-called *cliff effect* in spreads and prices triggered by credit rating changes. Therefore, the study of the impact of credit ratings announcement on the financial markets is important from different perspectives. First of all, from a market perspective, it is important for financial stability since the opinions of CRAs can significantly affect the market. From a corporate perspective, the access to the funding market and the spread applied to the firms strongly depend on the credit ratings. From a banking perspective, the credit ratings are used to evaluate the risk weighting of rated corporate and thus, to calculate the capital buffer and to classify the firms as investment or non-investment grade.

The aim of this chapter is to contribute to the literature about the impact of the credit rating announcements on the CDS markets in several ways. First, it extends the analysis that earlier studies did in periods of low volatility to periods characterized by high volatility. On the contrary of the previous literature such as Hull et al. (2004) and Norden and Weber (2004), we are able to consider both upgrades and downgrades because we have sufficient number of observations for both rating events. Second, as our dataset is composed by a sample of 312 US companies over the period 2007-2015, this is the first study about the US corporate market that considers crisis and post-crisis period and analyses the impact of a credit rating announcement in both periods. Therefore, to the best of our knowledge, this is the first paper that examines the effect of the dramatic financial crisis on the response of the CDS market to credit rating announcement. Third, we investigate the relative impact of three types of credit signals: rating changes, outlook signals and watch events by considering the different roles of a CRA on the CDS market. Although the outlook and watch signals have been found to be at least as important as rating changes in their market impact on the sovereign credit ratings (Kiff et al. (2012), Drago and Gallo (2016)), most prior research on the impact of CRAs actions on the corporate CDS market has focused on rating changes. Finally, as in Wengner et al. (2015), we assess the spillover effect among US corporate market by considering not only the information issued by CRAs but also the firm-specific and market variables. We contribute to the previous studies by evaluating a contamination effect between simultaneous credit rating events.

To study the response of the CDS market to a credit rating change, we employ an event study. The main results are as follows. The analysis shows that negative corporate credit signals quickly and significantly are incorporated into the CDS spreads of US firms, in the expected direction. Additionally, we find a significant and negative response of the CDS market to a positive credit signal. However, the CDS market appears to be more affected by a negative announcement after financial turmoil. The results show that negative changes to outlook and watch are important as well as actual downgrades but the effects are less immediate than the downgrades. In fact, we find a significant effect around an outlook and watch announced by Moody's whereas we do not find a significant effect around the time of negative outlooks and watch announced by S&P and Fitch. Conversely, we have empirical evidence of a certification service in case of S&P and Fitch agency. The regression analysis that assess the spillover and contamination effects shows that both positive and negative credit signals have a significant spillover effect on the corporate CDS spreads. The univariate analysis shows that negative corporate credit signals by all three agencies are incorporated quickly and significantly into the CDS spreads, in the expected direction. The spillover effect is less immediate around a positive corporate credit signals, but still significant. The regression analysis controls for event company, firm-specific variable. We find that negative credit signals by S&P and Moody's have a stronger significant and positive spillover effect on the CDS spreads, whereas the spillover from Fitch news is weaker. On the contrary, we find that positive credit signals by S&P and Moody's have a significant and negative spillover effect on the CDS spreads of non-event companies, whereas the spillover from Fitch news is insignificant. Furthermore, the empirical analysis supports the view of a contamination effect among CRAs when they announce a simultaneous negative event.

The remaining of the chapter is organized as following. Section 4.2 discusses the relevant literature. In Section 4.3, we present our hypotheses. Section 4.4.3 and 4.4 shows and describes the data and the applied methodology. In section 4.5.1 and 4.4.2, we present the empirical results of the event study and the spillover effect. Finally, in the last section, we conclude.

4.2 Literature review

Several studies examine the impact of rating event on financial markets, such as stock and bond market. Nevertheless, seminal papers extended the literature by applying the event study to the CDS market given the growing of the CDS market and the strong link between credit rating and CDS market. Therefore, we can divide studies about the impact of credit ratings on three groups focused on stock price, bond price and, finally, CDS spread.

The impact of credit rating announcement on stock market

The papers about the relationship between the stock market and the rating announcement underline the capability of the credit rating announcements to affect the stock market. Empirical results are relatively mixed. Pinches and Singleton (1978) consider the abnormal stock returns of 207 firms on the period 1959-1972. They find that the upgrade and the downgrade are fully anticipated from the stock market. More specifically, the stock prices react to the credit rating changes the previous 15-18 months. A more recent study, Kenjegaliev et al. (2016), confirms these results by investigating the behaviour of the German stock market. By analysing the daily abnormal stock return, they show that the German market adjusts the prices before the change of credit rating. This effect can be observed in both downgrade and upgrade announcement, however it is stronger in case of downgrade than in case of upgrade. On the contrary of Pinches and Singleton (1978) and Kenjegaliev et al. (2016), Goh and Ederington (1993) find evidence of the capability of stock market to anticipate downgrade announcements but not upgrade announcements. Furthermore, they show that the negative stock market reaction to downgrades is due to earnings deterioration. In the opposite direction is the paper of Dichev and Piotroski (2001). It shows that the stock market is a lagged indicator of credit rating announcements. The abnormal stock returns are negative and significant after the credit rating announcements and, in particular, during the first month. In case of an upgrade, the stock market does not show empirical evidence of a significant reaction. Vassalou and Xing (2003), using an alternative-to-bond-ratings measure of default risk, show that the abnormal negative returns in short horizons disappear. In particular, they demonstrate that the theoretical relationship between risk and return is verified in stock market when the Merton model is used to compute the default risk since they find that stocks with large increases in their default risk earn significantly higher subsequent returns than stocks with large decreases in their default risk.

The impact of credit rating announcement on bond market

The papers of Wansley et al. (1992) and Hite and Warga (1997) about the reactions of the bond prices to a credit rating announcement find an asymmetric reaction of the bond price to positive and negative credit rating announcements. On the contrary, Katz (1974) shows that the bond market does not have an unusual behaviour before the rating announcement. He notes that the adjustment of bond's yield is lagged of 6-10 months. Some studies, such as Grier and Katz (1976) and Hettenhouse and Sartoris (1976), focus on some industrial sectors. More specifically, Grier and Katz (1976) focus on Industrials and Utilities sector and find that the capability of the bond market to anticipate the downgrade announcement of the credit rating is given only in the industrials sector. While Grier and Katz (1976) do not find empirical evidence of a response of the Utilities sector to a credit rating announcement, the study of Hettenhouse and Sartoris (1976), focused only on Utilities sector, shows the capability of the CDS market to anticipate the credit rating change. The results of Weinstein (1977) contradict the findings of the previous two papers. In fact, Weinstein (1977), by examining 412 bonds from Industrials and Utilities, finds that the abnormal bond returns are a good anticipator of the credit rating change. In particular, the bond price changes during the period from 18 to 7 months before the rating change is announced. The price continues to react to the change during the month of change or for 6 months after the change. Therefore, he shows a double effect of the credit rating change into the bond's price.

In addition to the previous two strand of the literature, there is a third and small strand of studies that is the sum of the previous two. More specifically, these papers study the reaction of stock price and bond price to a credit rating announcements. For example, Hand et al. (1992), by examining 1100 credit rating changes, find a different results for upgrade and downgrade announcements. In particular, they underline the significantly abnormal stock and bond returns after a downgrade but there is not effect for upgrades. The study of Steiner and Heinke (2001) focuses on the relevance of credit ratings in international markets especially in Euro market. They find that the announcement of rating changes has a significant effect on the abnormal return the day and the following trading day. They underline the asymmetric reaction of the bond market to an upgrade and downgrade and, in addition, they show that also the effect of the watchlistings changes. Indeed, the positive watchlistings do not affect the abnormal return of the bond market. On the contrary, the negative watchlistings cause market overreaction. Moreover, Steiner and Heinke (2001) analyse the factors that affect the abnormal return and they find that the price reaction is larger the higher the default free yield level. In particular, lowest price reactions are observed on bank bonds, while government bonds show stronger price reaction and corporate bonds the strongest price reaction. They do not find a significant impact of the preceding rating event.

The impact of credit rating announcement on CDS market

A more recent strand of the literature focuses on the reaction of the CDS market to credit rating announcements on corporate and sovereign CDS spread. The ongoing of the European sovereign debt crisis has shifted the attention of the researchers on the sovereign CDS spreads rather than corporate CDS spreads[1]. As shown in the previous studies, the reaction of the CDS market is mixed in empirical studies. Some authors underline that the CDS market anticipates the rating announcements in both upgrade and downgrade credit rating announcements. Some others highlight the capability of the CDS market to anticipate the negative credit rating announcements but not the positive credit rating announcements.

Hull et al. (2004) analyse the relationship between CDS and announcement by credit rating agencies. They find that the response of the CDS market to a downgrade announcement is more significant than an upgrade announcement. In Norden and Weber (2004), the focus is on the response of stock and CDS market to credit rating announcements. They find that both markets are able to anticipate the rating downgrades and, in particular, the reviews for downgrade by S&P's and Moody's are more significant than the reviews for downgrade issued by Fitch. In studying the impact of the credit rating announcements, Wengner et al. (2015) focus on the different industries. Overall, the findings about the reaction of the CDS market are in line with the previous papers. However, they highlight that the downgrade announcements are more anticipated than the upgrade

[1] Given the object of this chapter, we will focus only on the literature related to the corporate market.

announcements. Furthermore, they show that the market reaction differs from industry by industry and it has been more pronounced since the US financial crisis. Micu et al. (2004) extend the literature on the informational value of credit ratings by controlling for various preceding rating events. They find that two credit rating events might be more informative than one. Additionally, they show that the impact is more pronounced when the corporate rating changes from investment to speculative grade. It means that the reaction of the CDS spreads is stronger when the investment grade status is at risk. In line with the previous papers but, in addition to the credit rating announcements, Galil and Soffer (2011) study the response of the CDS market to private and public information. They underline the asymmetric reaction of the CDS market to the good and bad news. The CDS market reacts stronger to downgrade or bad news than upgrade and good news.

4.3 Development of hypotheses

The credit rating agencies have different roles and impacts on the financial markets. They can influence issuer survival by affecting the access to funding markets and their funding costs (Kiff et al. (2012)). The traditional and, perhaps, the most important role of the CRAs is the information discovery effect. Indeed, they mitigate the problems of asymmetric information between market participants by disseminating information on the risk of fixed income securities. As described in the previous section, there are various papers that focus on the reaction of the financial market to a credit rating announcement. Nevertheless, the results are contradictory. Hull et al. (2004), Norden and Weber (2004) and Galil and Soffer (2011) underline the reaction of the CDS market to a credit rating announcement only in case of downgrade, while they do not find a significant reaction of the CDS market to a positive event (upgrade), probably due to the few positive announcements. Instead, Micu et al. (2004) show that the CDS market is affected by both types of credit rating announcements. Based on this reasoning, the first hypothesis is:

Hypothesis 1. *Positive and negative rating announcements affect the CDS spreads.*

In addition to the information theory, Boot et al. (2006) underline the monitoring effect theory. According to this theory, the CRAs are able to affect the perceived credit risk when they announce a *rating warnings* (outlooks and reviews) because they provide signals to investors about a possible future downgrade or upgrade. We should observe a greater downgrade impact when the downgrade is preceded by a rating warning. The monitoring theory has not been applied to the corporate CDS spreads and, in case of sovereign CDS spreads, there is not empirical evidence of monitoring service (Kiff et al. (2012), Drago and Gallo (2016)). Our second hypothesis is:

Hypothesis 2. *The reaction of CDS market to a downgrade announcement preceded by outlooks and reviews is more pronounced than an unanticipated downgrade.*

The third role of the CRAs is given by the certification effect that is relied to the financial regulation because the credit ratings are involved in the calculation of minimum capital requirements for banks that adopt the Standardised Approach (Basel II and Basel III). Furthermore, credit ratings are used to classify securities as either investment or non-investment grade. This classification could force investor's decisions and his portfolio choices. The attention on the certification service increased after the financial crisis (Kiff et al. (2012)). Basel Committee provides new rules with the aim of reducing mechanistic reliance on external ratings. In this regard, the Committee proposes an approach that removes references to external ratings and assigns risk weights based on two risk drivers: capital adequacy (CET 1) and asset quality (Non performing assets (NPA) ratio) for risk-weighting exposures to banks; and revenue and leverage for risk weighting exposures to corporate (BIS (2016a)). Therefore, the shift from one rating category to another could have a great impact on the CDS market for regulatory constraints. In the previous literature about the sovereign CDS spreads, we have empirical evidence about the impact of changes from investment to speculative grade and vice versa (Kiff et al. (2012), Finnerty et al. (2013)). This leads to the following hypothesis:

Hypothesis 3. *The reaction of CDS market to a credit rating announcement is greater if the issuer shifts rating category.*

Ismailescu and Kazemi (2010) find empirical evidence that a credit rating announcement affects not only the event country but also a non-event country. Wengner et al. (2015) investigate the spillover effect applied to the corporate market. They show a spillover effect and, in particular, they find that the spillover effect is more pronounced since the beginning of the financial crisis. Therefore, the new information should also affect a non-event firm. In particular, a non-event firm could profit or suffer from credit rating events. In addition to the spillover effect, Galil and Soffer (2011) study the contamination effect between CRAs. They find that the abnormal behaviour of market surrounding a rating announcement is affected by similar announcements by other rating agencies or by public or private information. In view of the previous results, we want to investigate if a non-event firm can be affected by an upgrade or a downgrade and if the response of CDS market changes when the credit rating event is announced by more than one CRA. Therefore, our fourth hypothesis is formulated as following:

Hypothesis 4. *A positive or a negative rating event generates a significant spillover effect on the US corporate CDS market. The size of the spillover effect depends on the contamination effect.*

4.4 Methodology and Data

4.4.1 Event study methodology

To study the impact of credit rating announcements on the CDS market we use the event study methodology (MacKinlay (1997)). We define as *event* a rating announcement. We include both rating changes and rating warnings (review and outlook). We divided the rating announcements into two groups: negative events that include downgrade and negative review/outlook, and positive events that include upgrades and positive review/outlook. Following Norden and Weber (2004), we choose 7 event windows around the day of announcement (event day t_0) that we denote as $[t_1, t_2]$. We choose to consider the 60 days before and after the event day t_0 because we want to investigate if the financial markets are able to anticipate or lagged the announcement. The event windows considered are: [-60,-31], [-30,-16], [-15,-2], [-1,1], [2,15], [16,30], [31,60]. We do not consider the event window [-90,-60], as in Norden and Weber (2004), to prevent contamination by other events that could affect the CDS spreads.

We start to identify the event day t_0 for each firm in our sampling period and to calculate the CDS spreads index that is the equally weighted cross-sectional mean of all CDS for a certain rating class in our sample. After estimating the CDS spreads index for each event window, we calculate the abnormal CDS spreads changes. We adjust abnormal CDS spreads changes (ASC) by CDS spreads index changes. The abnormal CDS spread change (ASC_{it}) for firm i on day t is given by

$$ASC_{it} = \begin{cases} (CDS_{it} - CDS_{it-1}) - (Index_{ot} - Index_{ot-1}) \text{ if } t < 0 \\ (CDS_{it} - CDS_{it-1}) - (Index_{nt} - Index_{nt-1}) \text{ if } t \geq 0 \end{cases} \tag{4.1}$$

where $Index_{ot}$ indicates the CDS spreads index for old rating class on day t and $Index_{nt}$ indicates the CDS spreads index for new rating class on day t. The first factor of equation 4.1 represents changes in CDS quotes. The second factor of equation 4.1 checks for the average default risk in a certain rating class in US market. Both of them are expressed in basis points.

Information effect

To test the information effect of the credit rating announcement on the CDS market, we should observe that the abnormal CDS spreads changes are statistically different from zero in the event windows following the credit rating announcement. Conversely, if the CDS market is able to anticipate the changes in creditworthiness, we should observe that the abnormal CDS spreads are significantly different from zero in the event windows ($[t_1, t_2]$) that precede the event day (t_0). We use three different statistical tests to assess abnormal CDS spreads changes significance. First, we assume that the abnormal returns are distributed as Student's t with *n-1* degrees of freedom (Hull et al. (2004), Norden and Weber (2004), Galil and Soffer (2011)). We test the null hypothesis that mean ASC in $[t_1, t_2]$ is significantly equal to zero against the alternative hypothesis that the abnormal CDS spreads changes are statistical different from zero. In particular, we test two different alternative hypotheses. If the firm experienced a negative event, we test the alternative hypothesis that the ASC are greater than zero whereas, the alternative hypothesis is that the ASC are less than zero in case of a positive event. Formally, the testing framework is the following:

$$\begin{aligned} &H_0 : \textit{mean ASC=0} \\ &H_1 : \textit{mean ASC>0 for negative event} \\ &H_1 : \textit{mean ASC<0 for positive event} \end{aligned} \tag{4.2}$$

Nevertheless, the *t-test* is a parametric test based on the assumption of a normal and symmetric distribution of abnormal CDS spreads. Therefore, the results could be biased. Consequently, as in Norden and Weber (2004), we use two non-parametric tests that do not rely on any such assumptions. The first is the Wilcoxon sign test under the null hypothesis that the median of the differences is zero ($H_0 : median - ASC = 0$). The second is the Wilcoxon sign rank test under the null hypothesis that the median of the differences is smaller than zero ($H_0 : median - ASC \leq 0$). We use these three tests to assess the statistical significance of the mean abnormal CDS spreads overall, in crisis period and post-crisis period. As in chapter 2, we define *crisis period* the period between March 2007- March 2009 and *post-crisis period* the period between April 2009- July 2015.

Monitoring effect

The *monitoring role* of CRAs is emphasised by Boot et al. (2006). The CRAs give signal about the potential future credit rating change to the markets by announcing *credit review* or *outlook*. This signal, especially in case of *negative warnings*, might encourage the issuer or the manager of firm to take decisions and actions to avoid a future downgrade. Hence, the negative warnings could be translated in an improvement or a stability of own creditworthiness. Therefore, an anticipated downgrade might have a greater impact on the corporate CDS spreads than an unanticipated rating change. We can divided the rating changes in anticipated by a rating warnings and unanticipated rating changes.

Given the importance of *negative warnings*, we decide to analyse the CDS market reaction around a downgrade announcement. We assume that the presence of a monitoring effect in the US corporate market would imply that anticipated downgrades have a significant greater impact than unanticipated downgrades on the CDS market. To verify our *Hypothesis 2*, we use two different tests of hypothesis: *t-test* and *Kolmorogov-Smirnov test*. Our null hypothesis is that the means of the two distributions are not statistically different against the alternative hypothesis that the mean ASC observed around an anticipated downgrade announcement is statistically greater than the mean ASC observed around an unanticipated downgrade announcement.

Certification effect

The certification effect theory underlines the impact of credit ratings on the calculation of bank's minimum capital requirement (Basel II and III). According to IMF (2010), to assess the *certification effect*, the analysis should be based on the market response of CDS market to rating announcements that shift the issuer from investment grade to speculative grade or vice versa. However, we cannot apply this methodology because we do not have sufficient number of observations in our sample. Thus, we assess the certification effect by using the role of credit ratings in financial regulation. The banks that use the Standardised Approach (SA) to calculate the minimum capital requirements have to use the risk weights established by Basel II and III[2]. According to the Standard Approach, the risk weights range from 20% to 150% in relation to the credit ratings (BIS (2016a)).

We define the crossover downgrade as a downgrade that produces a shift in risk weights. Conversely, a non-crossover downgrade is a downgrade that does not generate a change in capital requirement of banks. To verify the *certification effect*, we must show that the impact of a crossover downgrade is greater than the impact of a non-crossover downgrade. Also in this case, we test our *Hypothesis 3* by using *t-test* and *Kolmorogov-Smirnov test* under the null hypothesis that the two distributions are not statistically different and the alternative hypothesis that the mean abnormal returns observed around a crossover downgrade announcement is statistically greater than the ASCs observed around a non-crossover downgrade announcement.

4.4.2 Regression model

In this section, we extend the previous analysis, verifying the presence of the spillover effect of a rating announcement on the US corporate CDS market. First of all, we

[2]Basel III supervisory guidance (BCBS (2010)) mitigates the reliance on external ratings in Basel II (BCBS (2006)).

define *event firm (E)* that firm for which a credit rating agency announced a downgrade (upgrade). Conversely, when the CRA does not announce neither downgrades nor upgrades for a firm, this firm is defined as *non-event firm (NE)*. We verify the existence of a spillover effect estimating a regression model. We run the regression model by separating the positive and negative events. To run this analysis, we use the methodology applied by Ismailescu and Kazemi (2010) to the sovereign CDS market. Therefore, our dependent variable is the CDS spread change of a non-event firm observed in [-1,1] after a downgrade (upgrade) of an event firm. We do not use the ASC since the equally-weighted CDS index created in the sample can bias the results because CDS index could be also affected by the spillover effects. We estimate the following regression model:

$$\begin{aligned} &\log(CDS_{NE,\kappa}) = \beta_0 + \beta_1(Events_{E,\kappa}) + \beta_2(Difference_{NE,\kappa}) + \\ &\omega(Interactions_{E,\kappa}) + \alpha(\text{US Crisis}) + \gamma(Z_{NE,\kappa}) + \lambda(X_{NE,\kappa}) + \varepsilon_{NE,\kappa} \end{aligned} \tag{4.3}$$

In Eq. 4.3, κ is the event window that we use in our estimates. As in Wengner et al. (2015), the variable *events* identifies the change (non-zero) in the credit rating of event firms on the event date. If we observe on the same day more than one rating change, we sum the values of observed credit rating changes. We consider the absolute value of the changes because we test the spillover effect of a negative and a positive rating change separately. The coefficient on this variable allows us to test the presence of spillover effects. The CDS market reaction should depend on the size of the changes. Higher (lower) CDS market reaction should be observed when CRAs issue a downgrades (upgrades) of more notches or more events on the same day. Therefore, when CRAs announce a downgrade, a positive sign is expected. Vice versa, a negative sign is expected if the credit rating agencies announce an upgrade. This variable allow us to test the first part of *Hypothesis 4*. If the coefficient on this variable is statistically significant, we have empirical evidence on the spillover effect on the US corporate CDS market.

Difference is defined as difference in absolute value between ratings of *NE* and *E* firm. This variable test if the presence of the spillover effect depends on the distance between the two firms' ratings.

In the previous literature, Galil and Soffer (2011), by using an event study, test the hypothesis that rating announcements are normally contaminated. Hence, the abnormal behaviour of the markets surrounding a rating announcement cannot be exclusively connected to the rating announcement of a credit rating agency. Based on this reasoning, we insert in our model three interaction terms between the announcements of different rating agencies for the same event-firm in the studied event window. We consider only rating changes having negative sign for downgrades and positive sign for upgrades. These variables permit to control for possible *contamination effect* that can affect the spillover effect size. These interaction variables allow us to test the second part of *Hypothesis 4*. If the coefficient on *Events* and on these variables are statistically significant, we accept *Hypothesis 4* and thus, the size of the spillover effect depends on the contamination effect.

Similar to Ferreira and Gama (2007) and Wengner et al. (2015), we include a variable that takes into account the financial crisis. *Crisis* is a dummy variable that takes value 1 when the rating change is announced in the period March 2007- March 2009 and 0 otherwise. This variable allows us to understand if there is a change in the behaviour of market participants after increasing the market volatility.

We also control for $Z_{NE,\kappa}$ that is a vector of variables that includes the key determinants of the CDS spreads (see chapter 2): leverage ($leverage_{NE,\kappa}$), put option implied volatility ($put_{NE,\kappa}$) and slope of the yield curve ($slope_{\kappa}$). In addition, we test the hypothesis that the spillover effect is affected by the liquidity of the CDS market. As in Pires et al. (2015), we proxy the *liquidity* by using the absolute difference between bid and ask CDS premium expressed in bps. Given the construction of this variable, a high bid-ask spread should indicate a contract less liquid that is perceived as riskier by the market participants and thus, it should be associated with a higher CDS spreads. Hence, the relationship between CDS spreads and liquidity should be positive. Finally, we include a dummy variable set, $X_{i,\kappa}$ to control for sector fixed effects.

4.4.3 Data

Our data set is composed by daily CDS spread quotes provided by Bloomberg over the period January, 2007 to July, 2015 and it contains the CDS quotes of US companies making up the S&P 500. For each company, we need to collect any rating changes that transpired during the period of analysis. We manually extracted all rating changes for the analysed period from Bloomberg. We choose to use the Long Term credit Rating of Standard&Poor, Fitch and Moody's. We download the credit rating announcements for each CRA and, manually, we create the time-series of the credit rating for each firm.

Table 4.1 presents rating change announcements by each CRA and rating typologies. We present the rating changes for all sample and broken down by crisis and post-crisis period [3]. The total number of upgrades and downgrades in our sample is more or less the same for each credit rating's agency. Nevertheless, Standard&Poor is the CRA that records, in the period of analysis, the largest number of upgrades while Fitch records the highest number of downgrades. On the contrary, Moody's focuses more on the stability of its ratings. In fact, we can observe that the number of both upgrade and downgrade announcements are less than in the other two agencies. Panel B of Table 4.1 shows the number of rating announcements during the financial crisis. During this period, upgrade and downgrade announcements are very limited and most of them are preceded by a rating warning. In particular, we observe that all of the upgrade actions are preceded by a positive review/watch while half of downgrade actions are preceded by negative review/watch. It is not surprising that upgrade and downgrade announcements are more likely after the financial crisis (Panel C of Table 4.1). We observe that, after the financial crisis, credit rating agencies announce more positive than negative warnings. In post-crisis period, upgrades are more likely in our sample and more than 70% of them are preceded by a positive review/watch. We can observe the same trend in case of downgrade announcements.

4.5 Results

This section discusses the results on CDS spreads reactions to S&P, Moody's and Fitch credit rating signals, which are presented in sections 4.5.1, 4.5.1 and 4.5.1. Furthermore, we present the results of the regression analysis in section 4.5.2.

[3] We defined crisis period and post-crisis period as in Chapter 2.

Actions	*Standard&Poor*	*Fitch*	*Moody's*
Panel A:All sample (2007-2015)			
Upgrade	*141*	*122*	*107*
Downgrade	*100*	*109*	*76*
Positive warnings	*105*	*92*	*78*
Negative warnings	*62*	*89*	*63*
Panel B: Crisis period (2007-2009)			
Upgrade	*27*	*26*	*22*
Downgrade	*33*	*40*	*23*
Positive warnings	*25*	*11*	*27*
Negative warnings	*19*	*22*	*17*
Panel C: Post-crisis period (2009-2015)			
Upgrade	*114*	*96*	*85*
Downgrade	*67*	*69*	*53*
Positive warnings	*80*	*81*	*51*
Negative warnings	*43*	*67*	*46*

Table 4.1: *Frequency of rating events across type and rating agencies over the period January 2007- July 2015, March 2007-March 2009 (crisis period) and April 2009- July 2015 (post-crisis period).*

4.5.1 Results of the event study analysis

Information effect

The response of CDS market around a downgrade announcement is reported in Table 4.2. We report the results for each CRA (Standard&Poor, Fitch and Moody's) for all sample (2007-2015). The results show a significant increase of abnormal CDS spreads in the event window [-1,1]. The high statistical significance, in this event window, confirms that an announcement of a downgrade by each CRA increases the CDS spreads. The market participants adjust the CDS spreads of around 1.60 bps. In particular, the adjustment is greater when the downgrade is announced by Moody's agency. In this case, the CDS spreads increase of around 1.71 bps. As in Norden and Weber (2004), our empirical analysis shows that the market response to rating events by Fitch is weaker than in the case of other two agencies. Our results do not support the thesis that the CDS market anticipates the rating changes. However, we find that negative credit rating announcements by Moodys are anticipated by the CDS market in the 15 days before the credit rating announcement. Therefore, we can conclude that the CDS market is able to incorporate rapidly new information and, the effects are anticipated and more pronounced for Moody's. The CDS market exhibits no significant abnormal performance within most of the post-event windows. This result is in line with Norden and Weber (2004).

We carried out a similar test to that in Table 4.2 for positive events. We provide the results in Table 4.3. We have mixed evidence about the reaction of the CDS market to an upgrade. The effect of a credit rating announcement is highly statistically significant around the positive credit rating signals by Moodys. The effect is still negative for Fitch in comparison, but it is insignificant. As well as for downgrade announcements also for upgrade announcements, we observe the most significant effect around the event date, with a decrease in the daily mean abnormal returns of 2.40 (2.15) bps.

These results confirm the findings of the previous literature as regards the impact of downgrade announcements on the CDS market. Furthermore, our empirical analysis shows the capability of the CDS market to incorporate also positive credit rating announcements. We have statistical evidence of a change in credit risk perception the day before and after a rating announcement. These results confirm our *Hypothesis 1* as regards the impact of negative and positive rating changes. Investors seems to do not anticipate the rating announcements but they seem to perceived a change in credit risk simultaneously to the rating agencies.

Information effect across different times and industries

In order to better understand the behaviour of the CDS market to a change in credit risk, we investigate the response of CDS market to an announcement of a downgrade across two periods: crisis period and post-crisis period. This allows us to understand if the response to an announcement of a downgrade in financial crisis is statistically different to the response of an announcement in period of lower volatility. Therefore, we verify if the systemic risk of the financial markets can impact on the capability of the CDS market to anticipate the changes in credit ratings[4]. To test if there is a significant difference between the two distributions, we use t-test and Kolmogorov-Smirnov test under the null hypothesis that the two distributions are not statistically different and the alternative hypothesis that the

[4]We do not run this analysis for upgrade announcements because in crisis period we do not have sufficient number of observations.

Information effect around a downgrade announcement								
Panel A: All sample (2007-2015)								
Rating agency		**[-60,-31]**	**[-30,-16]**	**[-15,-2]**	**[-1,1]**	**[2,15]**	**[16,30]**	**[31,60]**
	ASC (bps)	0.288	-0.221	0.315	1.616	0.566	0.408	0.948
S&P	t-test[1]	0.447	0.7623	0.205	0.060	0.928	0.067	0.662
	Sign test[2]	0.441	0.419	0.143	0.071	0.8481	0.114	0.568
	Sign rank[3]	0.902	0.580	0.296	0.020	0.3327	0.386	0.794
	ASC (bps)	-0.537	0.520	0.461	1.572	-0.601	-1.298	0.290
Fitch	t-test[1]	0.792	0.287	0.751	0.095	0.765	0.575	0.180
	Sign test[2]	0.893	0.092	0.188	0.096	0.804	0.500	0.300
	Sign rank[3]	0.388	0.317	0.588	0.019	0.291	0.531	0.523
	ASC (bps)	-0.366	0.766	0.863	1.705	0.959	-0.265	0.122
Moody's	t-test[1]	0.981	0.0001	0.060	0.007	0.284	0.688	0.126
	Sign test[2]	0.806	0.638	0.008	0.011	0.130	0.287	0.987
	Sign rank[3]	0.292	0.659	0.002	0.011	0.156	0.093	0.253

Table 4.2: *Table shows the CDS market reaction around a downgrade announcement for all sample. It provides the mean adjusted CDS spread changes (ASC) and the corresponding p-value of t-test, Wilcoxon sign test and sign rank tests.*

[1] H_0: *mean(ASC)=0;* [2] H_0: *median(ASC)=0;* [3] H_0: *median(ASC)$\geq$0.*

ASCs in period of crisis is statistically greater than the ASCs in post-crisis period.

Panels A of Table 4.4 report the results of the response of CDS market around a downgrade in crisis period. The empirical analysis shows that the response of the CDS market vary across agencies. During the crisis period, mean abnormal returns observed around a downgrade are statistically different from zero in event window [-1,1]. In the previous event windows, we register an increase in perceived credit risk but this trend is not statistically confirmed. The market response to rating events announced by S&P agency is stronger than in case of Fitch. The ASC is equal to 2.29 bps and 1.471 bps for downgrade announced by S&P and Fitch, respectively. In case of Moody's announcements, the response of the CDS market in the event window [-1,1] is not confirmed by the two non-parametric tests. When this agency announces a downgrade in crisis period, we observe a postponed effect. In fact, our results underline an adjustment of the CDS spreads in event window [2,15] in which the ASCs will increase of 1.17 bps.

Panels B of Table 4.4 report the results of the response of CDS market around a downgrade in post-crisis period. We observe that market participants pay much more

Information effect around an upgrade announcement								
Panel A: All sample (2007-2015)								
Rating agency		**[-60,-31]**	**[-30,-16]**	**[-15,-2]**	**[-1,1]**	**[2,15]**	**[16,30]**	**[31,60]**
	ASC (bps)	1.117	0.763	-0.679	-2.402	-1.241	-0.328	-1.728
S&P	t-test[1]	0.202	0.058	0.859	0.053	0.625	0.782	0.717
	Sign test[2]	0.592	0.107	0.067	0.004	0.768	0.784	0.121
	Sign rank[3]	0.682	0.219	0.967	0.010	0.472	0.183	0.551
	ASC (bps)	1.273	0.608	-1.155	-0.704	-0.663	-0.463	0.032
Fitch	t-test[1]	0.391	0.466	0.048	0.743	0.853	0.538	0.497
	Sign test[2]	0.854	0.740	0.204	0.919	0.300	0.564	0.260
	Sign rank[3]	0.439	0.558	0.2445	0.779	0.651	0.954	0.689
	ASC (bps)	-1.035	-0.678	-1.949	-2.153	-1.027	0.438	0.301
Moody's	t-test[1]	0.993	0.261	0.148	0.002	0.121	0.992	0.925
	Sign test[2]	0.999	0.179	0.099	0.002	0.631	0.395	0.397
	Sign rank[3]	0.358	0.078	0.162	0.006	0.642	0.251	0.573

Table 4.3: *Table shows the CDS market reaction around an upgrade for all sample. It provides the mean adjusted CDS spread changes (ASC) and the corresponding p-value of t-test, Wilcoxon sign test and sign rank tests.*

[1] *H_0: mean(ASC)=0;* [2] *H_0: median(ASC)=0;* [3] *H_0: median(ASC)$\leq$0.*

attention to credit risk changes after the financial crisis. In this period, the CDS market anticipates the credit rating announcement of all rating agencies. The market participants adjust the CDS spreads one month before a S&P and Moody's announcement and 15 days before a Fitch's announcement. After the announcement of a downgrade, the market participants continue to perceive an increase in credit risk but this trend is statistically verified in [2,15] interval only in case of Moody's announcement.

The response of CDS market is greater in crisis period than in post-crisis period but the test of hypothesis indicates that the difference between the means of ASCs is not statistically significant. Only in case of Moody's agency, we can conclude that the reaction of the CDS market in crisis period is statistically greater than the reaction of CDS market in post-crisis period. During the crisis period, the response of CDS market to an announcement of Moody's downgrade is two times the response of CDS market in the period after the financial turmoil.

Overall, these results underline that, after the financial crisis, the response of CDS market to a change in credit risk is not statistically lower or higher than the response of CDS market in crisis period. However, we have empirical evidence that, after a period of financial stress, the CDS market is generally most affected by a negative rating announcement. Also, we emphasize the greater capability of the CDS market to anticipate the change in perceived credit risk after a period of financial stress. This result highlights that the investor and the market participants, after a period of financial stress, are more careful to changes in credit risk and they perceive and thus, incorporate these changes before the CRAs.

In the second analysis, we verify whether the results about the impact of rating announcements vary across industries (Daniels and Shin Jensen (2005), Wengner et al. (2015)). Also in this analysis, we test if the differences of ASCs are statistically different across the industries by using the Kruskal-Wallis test[5]. Since, in section 4.5.1, we demonstrated that rating changes have a significant impact on the CDS market around the announcement day, we run the analysis divided by industries only in case of event window [-1,1]. Panel A of Table 4.5 provides the abnormal CDS spreads around a downgrade announcement. The results show that, in the considered event window, a downgrade announcement has a significant impact on Financial and Consumer industry. The response of the CDS market to the announcement depends on the rating agency that issues the rating changes. When the announcement is issued by S&P for a financial firm, the adjustment of the CDS spreads is around 2.87 bps. The ASCs are equal to, respectively, 1.50 for downgrades issued by Fitch and 0.95 bps for downgrades issued by Moody's. In case of Consumer sector, the ASCs also differ across CRAs. Panel B of Table 4.5 presents the results of the analysis for upgrade announcements. We find that the impact of an upgrade announcement is negative and significant in Consumer indutry but we do not have empirical evidence about the other industry sectors.

Kruskal-Wallis test compares the means of each industry under the null hypothesis that the means of all distributions are not statistically different. In our analysis around a downgrade annoucement, we can reject the null hypothesis and then we can conclude that the response of the CDS market around a downgrade is statistical different across industries. These results are consistent with those of Daniels and Shin Jensen (2005) and Wengner

[5]Kruskal-Wallis test is a non-parametric test that allows to compare different sub-samples. It is a generalization of the two-sample Wilcoxon rank sum test.

Information effect across different times								
Rating agency		**[-60,-31]**	**[-30,-16]**	**[-15,-2]**	**[-1,1]**	**[2,15]**	**[16,30]**	**[31,60]**
	Panel A: Crisis period (2007-2009)							
	ASC (bps)	-0.583	-0.363	0.783	2.290	0.606	0.145	0.218
	t-test[1]	0.904	0.842	0.431	0.041	0.894	0.480	0.785
	Sign test[2]	0.930	0.634	0.205	0.012	0.884	0.146	0.518
	Sign rank[3]	0.089	0.320	0.541	0.016	0.245	0.759	0.564
S&P	***Panel B: Post-crisis period (2009-2015)***							
	ASC (bps)	0.257	1.575	0.997	1.471	0.456	0.132	0.216
	t-test[1]	0.207	0.040	0.080	0.548	0.788	0.014	0.288
	Sign test[2]	0.152	0.018	0.026	0.840	0.523	0.294	0.612
	Sign rank[3]	0.187	0.059	0.030	0.959	0.965	0.262	0.649
Test of hypothesis[4]								
	t-test	0.074	0.771	0.854	0.877	0.568	0.981	0.807
	Kolmorogov-Smirnov test	0.137	0.401	0.261	0.410	0.499	0.727	0.593
	Panel A: Crisis period (2007-2009)							
	ASC (bps)	-0.387	0.991	0.459	1.867	-0.160	-1.365	0.481
	t-test[1]	0.690	0.172	0.267	0.094	0.508	0.000	0.107
	Sign test[2]	0.726	0.027	0.083	0.096	0.902	0.002	0.343
	Sign rank[3]	0.854	0.088	0.146	0.026	0.127	0.003	0.389
Fitch	***Panel B: Post-crisis period (2009-2015)***							
	ASC (bps)	-0.962	-0.832	0.276	0.573	0.226	1.496	0.204
	t-test[1]	0.781	0.668	0.097	0.069	0.842	0.066	0.648
	Sign test[2]	0.927	0.756	0.097	0.073	0.332	0.000	0.378
	Sign rank[3]	0.161	0.352	0.021	0.047	0.642	0.002	0.879
Test of hypothesis[4]								
	t-test	0.351	0.194	0.016	0.714	0.118	0.479	0.166
	Kolmorogov-Smirnov test	0.331	0.119	0.013	0.892	0.488	0.959	0.560
	Panel A: Crisis period (2007-2009)							
	ASC (bps)	-0.217	0.369	1.239	2.835	1.170	0.899	0.257
	t-test[1]	0.698	0.393	0.424	0.090	0.016	0.690	0.653
	Sign test[2]	0.866	0.996	0.185	0.705	0.006	0.972	0.131
	Sign rank[3]	0.231	0.140	0.148	0.506	0.003	0.010	0.935
Moody's	***Panel B: Post-crisis period (2009-2015)***							
	ASC (bps)	-0.453	0.240	0.388	1.243	0.611	0.036	0.576
	t-test[1]	1.000	0.001	0.040	0.004	0.000	0.480	0.148
	Sign test[2]	0.597	0.056	0.098	0.0424	0.002	0.688	0.999
	Sign rank[3]	0.712	0.007	0.014	0.003	0.002	0.835	0.204
Test of hypothesis[4]								
	t-test	0.741	0.001	0.078	0.085	0.000	0.223	0.962
	Kolmorogov-Smirnov test	0.000	0.031	0.005	0.022	0.000	0.097	0.692

Table 4.4: *Table shows the CDS market reaction around a downgrade in crisis and post-crisis period. It provides the mean adjusted CDS spread changes (ASC) and the corresponding p-value of t-test, Wilcoxon sign test, Wilcoxon sign rank tests and Kolmorogov-Smirnov test.*

[1] H_0: *mean(ASC)=0;* [2] H_0: *median(ASC)=0;* [3] H_0: *median(ASC)≤0;* [4] H_0: *mean(ASC_{crisis})=mean($ASC_{Post-crisis}$).*

et al. (2015). However, in case of upgrade announcements, the p-value of Kruskal-Wallis test does not allow us to reject the null hypothesis. Hence we conclude that the means of the distributions are not statistically different across industries when an upgrade is announced by the CRAs.

Monitoring effect

The CRAs, by providing outlooks and reviews, might affect the impact of a subsequent rating change announced in the following. In this section, we test the hypothesis that the anticipated downgrades have a significantly greater impact on the CDS market than an unanticipated downgrades (*Hypothesis 2*). Table 4.6 reports the mean of daily abnormal returns around an anticipated and unanticipated downgrade announcement. We report the t-test and the Kolmorogov-Smirnov test to verify if the impact of an anticipated downgrade is statistically greater than the impact of an unanticipated downgrade.

Panels A of Table 4.6 report the results of an anticipated downgrade. We observe that the outlooks and reviews for downgrade issued by S&P and Fitch agency do not statistically affect the CDS spreads. In both case, we register an increase in the perceived credit risk around the event date but the statistical tests do not confirm this trend. On the contrary, when the Moody's agency announces an outlook or a review, we can observe the capability of the CDS market to anticipate these events. In fact, in the month preceding an anticipated downgrade announcement, the ASCs is approximately 0.55. The response of the CDS market is more pronounced during the 15 days before the announcement. In [-15,-2] interval, we observe an adjustment of around 2.73 bps.

Panels B of Table 4.6 report the results of an unanticipated downgrade. For this event, in [-1,1] interval we observe a significant impact for each rating agency even if it varies across credit rating agencies. It is more than 2 bps in case of S&P and Fitch's agency whereas, the effect is weaker and around 1.56 bps in case of Moody's agency.

Although we observe the effect only for Moody's agency, we have empirical evidence about the monitoring effect. Threfore, in contrast to Hill and Faff (2007) and Kiff et al. (2012), who do not find evidence of the monitoring services in sovereign ratings, these results do not leave doubts about a monitoring service in corporate ratings in case of

Information effect across different industries									
Rating agency		**Bm**[a]	**Comm**[b]	**Cons**[c]	**Energy**	**Fin**[d]	**Ind**[e]	**Techno**[f]	**Utility**
Panel A: CDS market reaction around downgrade									
S&P	*ASC*	0.673	0.554	1.492	0.638	2.874	0.476	0.436	1.077
	t-test[1]	0.516	0.490	0.025	0.321	0.073	0.412	0.454	0.540
	Sign test[2]	0.313	0.834	0.028	0.500	0.041	0.419	0.856	0.965
	Sign rank[3]	0.715	0.586	0.061	0.753	0.094	0.511	0.889	0.575
Test of hypothesis									
Kruskal-Wallis test	*0.0574*								
Fitch	*ASC*	1.332	0.413	2.671	1.823	1.500	0.607	1.408	0.522
	t-test[1]	0.815	0.110	0.024	0.128	0.001	0.283	0.528	0.170
	Sign test[2]	0.656	0.500	0.010	0.105	0.011	0.271	0.887	0.500
	Sign rank[3]	0.753	0.285	0.006	0.179	0.009	0.491	0.722	0.374
Test of hypothesis									
Kruskal-Wallis test	*0.0734*								
Moody's	*ASC*	1.937	1.742	1.912	2.289	0.953	0.425	0.632	0.522
	t-test[1]	0.695	0.098	0.086	0.100	0.024	0.034	0.588	0.014
	Sign test[2]	0.971	0.623	0.045	0.726	0.043	0.500	0.813	0.020
	Sign rank[3]	0.397	0.333	0.031	0.374	0.091	0.173	0.500	0.015
Test of hypothesis									
Kruskal-Wallis test	*0.0245*								
Panel B: CDS market reaction around upgrade									
S&P	*ASC*	-0.090	-0.213	-0.886	-0.230	-0.525	-0.325	-1.449	-1.505
	t-test[1]	0.504	0.920	0.096	0.977	0.994	1.000	0.901	0.988
	Sign test[2]	0.984	0.407	0.060	0.974	1.000	0.989	0.254	0.997
	Sign rank[3]	0.345	0.673	0.029	0.032	0.005	0.002	0.859	0.008
Test of hypothesis									
Kruskal-Wallis test	*0.4518*								
Fitch	*ASC*	-0.598	-0.421	-1.442	-0.279	-0.327	-1.034	-0.348	-1.342
	t-test[1]	0.490	0.639	0.099	0.426	0.981	0.843	0.957	0.366
	Sign test[2]	0.656	0.500	0.080	0.416	0.928	0.856	0.965	0.773
	Sign rank[3]	0.655	0.795	0.064	0.553	0.025	0.263	0.044	0.866
Test of hypothesis									
Kruskal-Wallis test	*0.4113*								
Moody's	*ASC*	-0.761	-0.335	-0.305	-0.239	-1.591	-0.270	-1.462	-0.456
	t-test[1]	0.778	0.295	0.092	0.501	1.000	0.999	0.962	0.996
	Sign test[2]	0.605	0.887	0.043	0.407	0.996	0.998	1.000	0.979
	Sign rank[3]	0.875	0.944	0.003	0.779	0.003	0.011	0.018	0.019
Test of hypothesis									
Kruskal-Wallis test	*0.4292*								

Table 4.5: *Table shows the CDS market reaction around a downgrade (Panel A) and an upgrade (Panel B) announcement divided by sectors in the event window [-1,1]. It provides the mean adjusted CDS spread changes (ASC) and the corresponding p-value of t-test, Wilcoxon sign test, sign rank tests and Kruskal-Wallis test.* [a] *Basic Material;* [b] *Communication;* [c] *Consumer;* [d] *Financial;* [e] *Technology.*

[1] H_0*: mean(ASC)=0;* [2] H_0*: median(ASC)=0;* [3] H_0*: median(ASC)$\geq$0.*

Moody's agency. An anticipate downgrade has a greater impact on the CDS market than an unanticipated downgrade. T-test and Kolmorogov-Smirnov test confirm this finding. This implies that, in case of Moody's agency, a downgrade preceded by an outlook or a review have an impact statistically greater on the US corporate CDS market than an unanticipated downgrade. In the other two agencies, we do not have this empirical evidence. Hence, we can only partially reject *Hypothesis 2*.

Certification effect

In this section, we investigate the certification effect of CRAs on the CDS market. We consider crossover and non-crossover downgrade announcement. Table 4.7 reports the results divided by crossover and non-crossover downgrade announcements for each CRA. Panels A of Table 4.7 report the results for downgrade that determines a change of rating category. On the contrary, Panels B show the results of the daily mean abnormal CDS spreads changes for those downgrades that do not generate a shift of rating category. Crossover and non-crossover downgrades results vary across credit rating agencies. In case of S&P agency, in the event window [-1,1], we observe a significant impact of rating announcement on the CDS market, equals to 0.827 bps for crossover downgrades and to 0.503 for non-crossover downgrades. Therefore, the impact of a crossover downgrade is greater than the impact of a non-crossover downgrade. As confirmed by t-test and Kolmorogov-Smirnov test, this difference is statistically significant. We can conclude that S&P agency provides a certification service. Hence, a downgrade that determines a shift of credit rating category implies a more intense reaction from investors due to regulatory constraints. In case of Fitch agency, we have the same trend of S&P agency. We observe that a crossover downgrade has a significant impact on the CDS market in the event window [-1,1] in which the ASCs are equal to 2.73 bps. We register an increase in perceived risk also for non-crossover downgrade, although this result is not statistically confirmed by the Wilcoxon test. Also in this case, the first impact is greater than the latter. Finally, crossover downgrades of Moody's agency are anticipated by the CDS market in the event window [-15,-2]. In this event window, we observe a significant impact of rating announcement on the CDS market equals to 1.33 bps for crossover downgrades. On the contrary, non-crossover downgrades show a significant

		Monitoring effect						
Rating agency		**[-60,-31]**	**[-30,-16]**	**[-15,-2]**	**[-1,1]**	**[2,15]**	**[16,30]**	**[31,60]**
	Panel A: Anticipated downgrade							
	ASC(bps)	-1.169	-1.175	-1.059	0.794	0.416	0.273	0.633
	t-test[1]	0.776	0.715	0.843	0.305	0.961	0.447	0.022
	Sign test[2]	0.584	0.423	0.581	0.428	0.939	0.798	0.416
	Sign rank[3]	0.808	0.829	0.518	0.373	0.102	0.952	0.117
S&P	***Panel B: Unanticipated downgrade***							
	ASC (bps)	0.074	-0.281	0.368	2.381	0.519	0.382	0.159
	t-test[1]	0.378	0.802	0.183	0.044	0.861	0.121	0.715
	Sign test[2]	0.429	0.439	0.191	0.022	0.678	0.100	0.525
	Sign rank[3]	0.915	0.619	0.295	0.060	0.615	0.456	0.676
Test of hypothesis[4]								
	t-test	0.295	0.337	0.281	0.891	0.101	0.481	0.990
	Kolmorogov-Smirnov test	0.950	0.873	0.573	0.323	0.127	0.682	0.353
	Panel A: Anticipated downgrade							
	ASC(bps)	-0.516	1.423	0.808	2.052	-0.714	-1.030	0.456
	t-test[1]	0.677	0.452	0.671	0.067	0.660	0.679	0.403
	Sign test[2]	0.788	0.760	0.593	0.389	0.262	0.132	0.910
	Sign rank[3]	0.510	0.952	0.648	0.153	0.783	0.737	0.433
Fitch	***Panel B: Unanticipated downgrade***							
	ASC(bps)	-0.5293	0.569	0.456	2.103	-0.593	-1.199	0.338
	t-test[1]	0.782	0.275	0.743	0.052	0.756	0.568	0.162
	Sign test[2]	0.888	0.098	0.184	0.054	0.808	0.543	0.177
	Sign rank[3]	0.404	0.339	0.515	0.057	0.298	0.533	0.355
Test of hypothesis[4]								
	t-test	0.501	0.477	0.470	0.926	0.492	0.438	0.509
	Kolmorogov-Smirnov test	0.570	0.571	0.881	0.153	0.590	0.669	0.718
	Panel A: Anticipated downgrade							
	ASC(bps)	-1.135	0.556	2.731	1.464	1.132	-0.942	0.799
	t-test[1]	0.804	0.084	0.061	0.207	0.464	0.794	0.177
	Sign test[2]	0.982	0.021	0.011	0.105	0.059	0.304	0.856
	Sign rank[3]	0.156	0.061	0.015	0.121	0.042	0.445	0.828
Moody's	***Panel B: Unanticipated downgrade***							
	ASC (bps)	-1.978	0.672	1.356	1.562	1.065	-0.097	0.948
	t-test[1]	0.864	0.001	0.063	0.027	0.729	0.506	0.129
	Sign test[2]	0.988	0.810	0.002	0.230	0.053	0.102	0.936
	Sign rank[3]	0.040	0.467	0.000	0.056	0.081	0.123	0.880
Test of hypothesis[4]								
	t-test	0.327	0.999	0.086	0.482	0.575	0.424	0.492
	Kolmorogov-Smirnov test	0.140	0.981	0.000	0.285	0.936	0.803	0.278

Table 4.6: *Table shows the CDS market reaction around an anticipated or unanticipated downgrade. It provides the mean adjusted CDS spread changes (ASC) and the corresponding p-value of t-test, Wilcoxon sign test, Wilcoxon sign rank tests, t-test and Kolmogorov-Smirnov test.*

[1] H_0: *mean(ASC)=0;* [2] H_0: *median(ASC)=0;* [3] H_0: *median(ASC)$\geq$0;* [4] H_0: *mean($ASC_{anticipated}$)=mean($ASC_{unanticipated}$).*

but weak impact on the CDS market in event window [-1,1]. The abnormal CDS spreads are equal to 0.26 bps.

In line with the findings on the sovereign CDS market (Finnerty et al. (2013), Kiff et al. (2012) and Drago and Gallo (2016)), these results provide empirical evidence of a certification service to the corporate CDS market. Therefore, the transition from one rating category to another implies a more intense reaction of the CDS market due to the regulatory constraints imposed by Basel II and III. This empirical evidence confirms our *Hypothesis 3* about the certification effect of the CRAs.

4.5.2 Regression results

Table 4.8 and Table 4.9 show the results obtained from the estimation of Eq. 4.3 for downgrade and upgrade announcements issued by each credit rating agency, respectively. First, we run Eq. 4.3 by including only the variables that consider the information provided by the CRAs. In a second step, we control for firm-specific and market variables that we found be able to affect the CDS premium (see chapter 2). In addition, to account for the amount of information asymmetry in the market, we consider the liquidity of the CDS contract.

The results for downgrade announcements (Table 4.8) confirm the presence of a significant spillover effect. If a rating agency announces a downgrade of a one notch rating the CDS spreads of a non-event firm increase of around 0.2 bps. The positive and significant coefficient on *Events* indicates that a wider rating change amplifies the spillover effect of a downgrade announcement. Surprisingly, the CDS market reaction to a downgrade does not depend on the difference between the two firms' rating. We observe a contamination effect measured by the interaction terms. In particular, we find that the CDS spreads increase if Moody's and S&P agencies simultaneously announce a downgrade for the same firm. It implies that the credit rating announcements are not completely independent but there is an influence among CRAs. The market participants perceive a greater increase on credit risk if the announcement is given by two CRAs in the same days. As shown in the previous section, the statistical significance of the coefficient on *Crisis* highlights that announcements in period of crisis has a greater information effect on the CDS market.

		Certification effect						
Rating agency		**[-60,-31]**	**[-30,-16]**	**[-15,-2]**	**[-1,1]**	**[2,15]**	**[16,30]**	**[31,60]**
	Panel A: Crossover downgrade							
	ASC (bps)	-3.689	-0.824	-0.368	0.827	0.343	0.746	0.332
	t-test[1]	0.881	0.553	0.241	0.070	0.856	0.160	0.119
	Sign test[2]	0.891	0.875	0.403	0.025	0.688	0.250	0.313
	Sign rank[3]	0.249	0.593	0.397	0.018	0.465	0.180	0.144
S&P	***Panel B: Non-Crossover downgrade***							
	ASC (bps)	0.232	1.832	0.530	0.503	0.312	0.907	0.418
	t-test[1]	0.257	0.322	0.132	0.085	0.270	0.576	0.876
	Sign test[2]	0.168	0.382	0.586	0.025	0.244	0.125	0.870
	Sign rank[3]	0.984	0.687	0.846	0.094	0.386	0.696	0.205
Test of hypothesis[4]								
	t-test	0.162	0.415	0.921	0.090	0.219	0.872	0.766
	Kolmorogov-Smirnov test	0.408	0.976	0.523	0.096	0.572	0.164	0.262
	Panel A: Crossover downgrade							
	ASC (bps)	1.358	1.749	1.493	2.736	3.670	2.351	0.281
	t-test[1]	0.045	0.961	0.762	0.099	0.616	0.245	0.321
	Sign test[2]	0.537	0.813	0.123	0.061	0.721	0.923	0.604
	Sign rank[3]	0.910	0.174	0.441	0.084	0.901	0.269	0.849
Fitch	***Panel B: Non-Crossover downgrade***							
	ASC (bps)	-0.536	1.431	1.880	1.864	2.703	0.763	0.303
	t-test[1]	0.505	0.016	0.373	0.094	0.712	0.090	0.534
	Sign test[2]	0.976	0.045	0.166	0.092	0.248	0.326	0.336
	Sign rank[3]	0.299	0.083	0.470	0.153	0.842	0.232	0.898
Test of hypothesis[4]								
	t-test	0.952	0.006	0.142	0.036	0.465	0.914	0.681
	Kolmorogov-Smirnov test	0.420	0.033	0.540	0.033	0.316	0.182	0.331
	Panel A: Crossover downgrade							
	ASC (bps)	1.673	-0.732	1.333	0.2630	0.674	1.386	0.483
	t-test[1]	0.071	0.891	0.062	0.454	0.141	0.577	0.343
	Sign test[2]	0.048	0.974	0.058	0.828	0.132	0.933	0.133
	Sign rank[3]	0.161	0.091	0.055	0.733	0.218	0.338	0.221
Moody's	***Panel B: Non-Crossover downgrade***							
	ASC (bps)	-0.454	0.263	-0.377	0.2627	0.459	0.839	1.277
	t-test[1]	0.999	0.110	0.952	0.003	0.984	0.872	0.954
	Sign test[2]	0.500	0.900	0.463	0.004	0.452	0.102	0.999
	Sign rank[3]	0.873	0.236	0.236	0.002	0.652	0.308	0.540
Test of hypothesis[4]								
	t-test	0.954	0.132	0.051	0.129	0.572	0.560	0.460
	Kolmorogov-Smirnov test	0.190	0.033	0.022	0.726	0.143	0.311	0.369

Table 4.7: *Table shows the CDS market reaction around a crossover or a non-crossover downgrade. It provides the mean adjusted CDS spread changes (ASC) and the corresponding p-value of t-test, Wilcoxon sign test, Wilcoxon sign rank tests and Kolmorogov-Smirnov test.*

[1] H_0: *mean(ASC)=0;* [2] H_0: *median(ASC)=0;* [3] H_0: *median(ASC)$\geq$0;* [4] H_0: $mean(ASC_{crossover})=mean(ASC_{non-crossover})$.

Hence, the investors have assigned a higher default probability to US corporate market by incorporating the uncertainty of the financial markets. When we add the firm-specific and market variables, the results are confirmed. We find that the firm-specific variables are highly statistically significant whereas the coefficient on *Slope* is not able to affect the CDS spread changes in the event window [-1,1]. The changes on CDS spreads strongly depend on the liquidity of the contract. It implies that there is an illiquidity cost measured by absolute bid-ask spread. The results show that the coefficient on *Liquidity* is positive and statistically significant at the 1% level. This implies that CDS spreads are higher for more illiquid contracts. In other words, it is the protection seller who is compensated for the illiquidity of the CDS. This makes sense since this party is the one exposed to the credit risk of the underlying. If it seems that the position may be hard and costly to unwind in case new unfavorable information becomes available in the future, the protection seller will require a higher compensation to begin with (Pires et al. (2015)).

Table 4.9 reports the results obtained from the estimation of Eq. 4.3 for upgrade announcements issued by each credit rating agency. The results obtained estimating our Eq. 4.3 show that there is a significant spillover effect also around an upgrade. We observe a negative and significant coefficient on *Events*. It implies that a positive rating change affects the non-event firm. If there is an upgrade of one rating notch issued by S&P or Moody's agency, the CDS spreads on average decrease of around 0.05 bps and 0.10 bps, respectively. On the contrary of the previous results, when S&P or Fitch agency announces an upgrade, the coefficient on *difference* becomes negative and significant. Hence, in case of upgrade announcements, the spillover effect depends on the distance between the two firms' rating. The higher the difference between the two firms' rating, the higher is the CDS spread changes. We do not observe a contamination effect when a credit rating agency announces an upgrade. The simultaneous announcement of upgrades do not have a significant impact on the CDS spread changes. The positive and significant coefficient on *Crisis* implies that the information content could be weighed in different ways among different periods. The information content, in fact, during periods of financial turmoil could be affected by the negative perspectives of the market participants (Wengner et al. (2015)). When we control for firm-specific and market variables, the previous results are confirmed. The coefficient on

Liquidity, Leverage and *Option implied volatility* are highly significant and positive. Also in case of upgrade announcements, we observe a liquidity effect on the CDS spread changes. The market variable, *Term Structure*, does not show a significant impact on the CDS spread changes.

We can, therefore, conclude that the CDS spreads of a non-event firm increase (decrease) if the CRA announces a downgrade (upgrade) of other firms. This result confirms our *Hypothesis 4*. It should be noted that there is a symmetric impact on the CDS spread changes of US corporate market between positive and negative rating changes. In fact, similar to downgrades, the results show that also upgrades cause a significant spillover effect. However, we observe that the spillover effect on the CDS market of a downgrade is greater than the spillover effect of an upgrade. Nevertheless, both events could be considered indicative of the US financial health.

4.6 Conclusion

In this study we examine the CDS market response to credit rating announcements during the period 2007-2015. We question whether rating announcements by all three credit rating agencies (Standard&Poor, Moody's and Fitch) add new information to the markets or not. First, we find that the CDS market has a significant reaction to positive and negative rating events in the event window [-1,1]. The results are confirmed by all three agencies. We can observe a significant abnormal performance in the expected direction around both negative and positive events because, given the financial crisis, we have a sufficient number of observations for downgrades and upgrades. Therefore, the results provide empirical evidence on the existence of the information service issued by the credit rating agencies in announcing a rating event. The new information released by the CRAs are able to affect the investors' riskiness perception. The information service appears to be more clear after a period of financial stress in which the negative expectations of the market participants are incorporated on the investors' decisions. In fact, after a period of financial stress, investors and market participants are more careful to changes in credit rating. As consequence, it seems that the information content is affected by the negative expectations of the market

Spillover effect of a downgrade												
	S&P				**Fitch**				**Moody's**			
Events	0.201	***	0.104	***	0.208	***	0.307	***	0.290	***	0.189	***
	(0.030)		(0.030)		(0.031)		(0.023)		(0.037)		(0.031)	
Difference	0.0078		0.0016		0.0118		0.0176		-0.0016		-0.0116	
	(0.007)		(0.007)		(0.007)		(0.015)		(0.007)		(0.010)	
*S&P*Moody's*	0.4830	***	0.2017	**					0.3468	***	0.4033	***
	(0.129)		(0.102)						(0.134)		(0.108)	
*S&P*Fitch*	0.1372		-0.1857		0.5416		0.3293					
	(0.297)		(0.133)		(0.355)		(0.269)					
*Fitch*Moody's*					0.7655	*	0.4413	*	0.1663		0.0092	
					(0.393)		(0.251)		(0.399)		(0.217)	
US Crisis	0.1358	***	0.6759	***	0.0992	***	0.7462	***	0.1627	***	0.6533	***
	(0.037)		(0.046)		(0.036)		(0.027)		(0.052)		(0.083)	
Liquidity			0.0969	***			0.0013	***			0.1051	**
			(0.014)				(0.000)				(0.045)	
Leverage			0.0272	**			0.0160	***			0.0812	
			(0.014)				(0.004)				(0.061)	
σ^2			0.0236	***			0.0243	***			0.0232	***
			(0.001)				(0.000)				(0.003)	
Term Structure			0.0236				0.0030				-0.0080	
			(0.023)				(0.015)				(0.010)	
Constant	4.6061	***	3.6159	***	5.4294	***	3.8841	***	4.2902	***	3.5333	***
	(0.072)		(0.097)		(0.119)		(0.069)		(0.088)		(0.075)	
N	2297		2297		5050		5050		2995		2995	
Sector dummies	Yes		Yes		Yes		Yes		Yes		Yes	
F-test	7.66	***	43.09	***	18.28	***	54.49	***	17.38	***	66.85	***
R^2	0.0458		0.1988		0.0558		0.1637		0.0608		0.1423	

Table 4.8: *Table reports the results of the spillover effect around a downgrade divided by CRAs. Robust standard errors are in parenthesis below the estimated coefficients. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively.*

Spillover effect of an upgrade												
	S&P				***Fitch***				***Moody's***			
Events	-0.054	***	-0.066	***	0.019		0.011		-0.100	***	-0.120	***
	(0.018)		(0.014)		(0.025)		(0.024)		(0.024)		(0.019)	
Difference	0.0242	***	0.0149	***	0.0333	***	0.0291	***	-0.0004		-0.0063	
	(0.006)		(0.005)		(0.008)		(0.008)		(0.005)		(0.004)	
*S&P*Moody's*	0.5116		0.2058						-0.0470		-0.1093	
	(0.402)		(0.264)						(0.393)		(0.238)	
*S&P*Fitch*	0.3257		0.3380		0.1839		0.2046					
	(0.359)		(0.222)		(0.308)		(0.316)					
*Fitch*Moody's*					0.1903		0.2221		0.0460		0.0245	
					(0.315)		(0.317)		(0.202)		(0.139)	
US Crisis	0.4076	***	0.8519	***	0.5592	***	0.5829	***	0.7104	***	0.8535	***
	(0.039)		(0.031)		(0.039)		(0.038)		(0.063)		(0.050)	
Liquidity			0.0015	***			0.0016	***			0.0014	***
			(0.000)				(0.000)				(0.000)	
Leverage			0.0497	***			0.0648	*			0.0698	***
			(0.005)				(0.037)				(0.006)	
σ^2			0.0302	***			0.0288	***			0.0344	***
			(0.002)				(0.010)				(0.001)	
Term Structure			0.0034				-0.0141				0.0020	
			(0.012)				(0.014)				(0.013)	
Constant	5.0989	***	3.9268	***	5.1926	***	4.6235	***	4.7889	***	3.8411	***
	(0.100)		(0.094)		(0.143)		(0.118)		(0.044)		(0.050)	
N	6709		6709		3719		3719		4163		4163	
Sector dummies	Yes		Yes		Yes		Yes		Yes		Yes	
F-test	83.65	***	26.46	***	33.48	***	36.2	***	32.21	***	66.85	***
R^2	0.0738		0.0921		0.1109		0.1799		0.0628		0.1306	

Table 4.9: *Table reports the results of the spillover effect around an upgrade divided by CRAs. Robust standard errors are in parenthesis below the estimated coefficients. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively.*

participants in the CDS market. After a period of financial stress, we observe the capability of the CDS market to anticipate the changes in credit ratings. In the 15 days preceding the negative announcement, the ASC are statistically greater than zero. It implies that after the financial crisis the CRAs just reflect information available to the market and thus, their action are not relevant. Furthermore, our findings provide evidence of asymmetric market reaction around upgrades and downgrades at the industry level. Second, we investigate whether the CRAs are able to provide a monitoring service. By studying the impact of an outlook or a review on the CDS market, we find that they are relevant for investors only when a rating warning is announced by Moody's agency whereas, in the case of the other two agencies, we do not have statistical evidence of a more pronounced reaction of CDS market to a downgrade announcement preceded by outlooks and reviews. To the extent that credit ratings play a significant role in regulations, we focus on the certification service provide by CRAs. This service is particularly relevant in the use of external ratings by banks that apply Standard Approach. We observe a significant impact on the CDS market when a negative rating event produces a shift of rating category. The obtained results about the certification service could open a discussion on the use of external ratings and could validate the doubts raised by the Basel Committee. An important issue is related to the excessive reliance on the external ratings when the banks use a Standard Approach. The primary objective of the FSB Principles is to discourage banks from relying mechanistically on external ratings for the assessment of an asset's creditworthiness. As long as banks continue to have Standard Approach capital requirements based on external ratings, banks should also put in place processes to ensure that they have an appropriate understanding of the uses and limitations of external ratings (BIS (2016a)).

In the second part of this chapter, we study and find evidence of a significant and positive spillover and contamination effect of a downgrade announcement. The size of the effect is affected by the US financial crisis, liquidity of the contract, financial leverage and option-implied volatility. The contamination effect is significant and increases the size of the spillover effect when the announcement is issued simultaneously by Fitch and Moody's agency. Furthermore, we find a significant negative spillover effect also for upgrade announcements. The size of the effect is influenced by the difference between firms' ratings, financial crisis, liquidity of the contract, financial leverage and option-implied volatility. In case of a positive rating event we do not observe a contamination effect between CRAs. The results about the spillover effect suggest that non-event firms suffer from credit downgrades and profit from credit upgrades. These findings confirm the integration process of the financial markets but they also permit to reflect about the possibility that the default of a firm could lead to other defaults by generating instability on the whole financial system.

The recent heavy downgrade activity should imply a serious reflection about the most appropriate methodology to determine the creditworthiness. As discussed in chapter 1, the regulation context has reduced mechanistic reliance on credit rating agency (CRA). The US regulators, with the Dodd Frank Act approval, increased the transparency of the markets by creating the Office of Credit Ratings. The aim of this Office is to oversee the work of the major rating agencies (the Nationally Recognized statistical rating organizations or NRSROs). The European regulators, with Basel III, removed references to external ratings and assigned risk weights based on different risk drivers. Our analysis seems to corroborate the efforts of both regulators. This context suggests that credit ratings should embed the notion that credit risk is linked to the macroeconomic conditions by focusing on a *point in time* basis rather than on a *through the cycle* basis. While the first approach takes into account the macroeconomic scenario that, especially in period of financial stress, could change the creditworthiness of an issuer and its probability to default, the second is supposed to balance the need for accurate default estimates and the desire to achieve rating stability.

Chapter 5

Main conclusions and future research

One of the major challenge for risk managers and market regulators is credit risk. Banks, regulators and central banks do not agree on how to measure credit risk and, more particularly, on how to compute the optimal capital that is necessary for protecting the different partners that share this risk. Asking banks to keep too much capital in reserve to cover credit risk can be a source of credit crunch (Acharya (2005)). After the financial turmoil, the financial landscape has gone through radical structural change. This change has lead to the introduction of new instruments to manage the credit risk that has been and still remains the essential and core risk in commercial bank activities.

Our findings provide useful tools both to supervisors and to credit risk managers. Supervisors could use those to evaluate the quality of credit assessments both under the standardised and the Internal Ratings-Based (IRB) approach approach, as the method of combining assessments provides them with a way to create benchmark ratings based on multiple sources of information. Credit risk managers can also profit from the methods that combine multiple sources of credit risk assessment because a timely credit risk indicator could change their investment decisions. Most importantly perhaps, the findings could contribute to increasing awareness of the need to carefully scrutinise and skilfully use credit risk information. Finally, and although much work is yet to be done in the area of combining credit assessments and obtained results do not allow us to say if it is better to measure the credit risk by using credit ratings or market measures, the thesis puts forward the idea of using the market indicators to compute optimal credit risk assessments in order to refine a credit rating. The credit ratings should be composed by a core, based on firm-specific factors and a market contribution, consisting of market and country information. In fact, the CDS spreads provide a useful information on potential liquidity difficulties that can be used as early warning signals to a worst situation, such as the default. This function is selected in a way that reduces the stability of credit ratings and uses all the available information.

5.1 Policy implications and recommendations

The market participants in pricing of CDS spreads have moved from a corporate perspective to a market perspective. In fact, the monetary policy and the Quantitative Easing of the Central Banks have determined relevant changes in the perception of creditworthiness. Investors and market participants, after the financial turmoil, started to incorporate their expectations about the future economic conditions on the capability of a firm to pay back its own debts. We believe that the massive injection of liquidity, issued by Central Bank to mitigate defaults and the collapse of the financial system, could also have had an impact on the transmission mechanism of monetary policy. This finding could be important to reflect about the development of a more risk-sensitive prudential framework with the goal to develop macro-prudential tools for financial stability surveillance.

The exploration of the bank CDS spreads, in both its micro and macro aspects, calls for a blending of different intellectual strands. It could usefully draw on the claim that common systematic components help to address the *credit-spread puzzle* in banking context. The strong link between CDS spreads and market variables produce the need to embed these factors into a general model of pricing to better understand the perceived credit risk. This result may offer a potential tool for fundamental-based monitoring of European and US banks. The CDS spreads contain information about the probability of default and, hence, the determinants of CDS spreads in banking sector could provide information about the extent of their vulnerability. Since banks have demonstrated to be transmitters of financial stress, with dangerous effects on the financial stability, regulators should pay more specific attention to the CDS market in banking systems, also to mitigate the pro-cyclical effect frightened by critics of the Basel Accords. The identified fundamental determinants of CDS pricing can be used as an early warning tool that can be applied also for banks that do not have a CDS spread. CDS spread determinants would produce forward looking credit default risk assessment of their financial vulnerability in cross-section and time dimension. The big exposure of banks to sovereign debt has been the connecting link between banks credit risk and sovereign credit risk that has arguably become more relevant after 2009. Under some circumstances, the strong link between banking and country risk may therefore also contribute to amplify business fluctuations more than in the past. A careful consideration of the interlinkage between these two entities could be of important interest because the cointegration between banking and country risk may increase the speed of crisis transmission, with dangerous effects on the financial and banking stability and on investors and consumer confidence. Financial and economic shocks are of fundamental importance in pricing the banks credit risk. They produce a huge increase of the perceived credit risk. Therefore, a number of policy implications could be taken by these findings. First of all, the regulators should be more careful on the definition of capital ratio because they result inadequate especially in some European countries. More specifically, the results seem to indicate that regulators and market participants are aligned when considering the importance of capitalisation in determining the banks' risk. Our findings corroborate the efforts made by policy makers in searching new strategies to face the *too big to fail* paradigm. Second of all, the funding structure of bank may play an important role in case of shocks. A more stable funding structure implies more retail deposits that are a more stable source of funding than wholesale markets since they are typically insured by the government.

The interaction between CDS market and credit rating agencies has been changed by the financial crisis. Although ratings supply an evaluation of a company's credit riskiness, after a period of financial stress, they lag with respect to the CDS market. Credit rating agencies explain this lag with the reliance on accounting and financial statements, with the impossibility of continuous monitoring. This implies that the CRAs just reflect information available to the market, their actions are not relevant from a financial stability perspective. Our findings corroborate the efforts made by policy makers in increasing the requirements and transparency of credit rating agencies. The spillover and contamination effect of a credit rating announcement shows that CDS spreads depend not only on traditional variables, such as accounting and market variables, but also on qualitative information obtained from CRAs. Our finding suggests that CDS market could serve as a timely risk indicator to market participants and regulators, especially after a period of financial stress. Nevertheless, this result does not provide sufficient proofs to formulate the assumption that the risk assessments expressed by the market are more accurate than those of credit rating agencies but, it should imply a serious reflection about a revision on the policy of CRAs. The calculation of credit quality by credit rating agencies should introduce a greater attention on the market conditions to accurately evaluate and immediately capture the changes in creditworthiness of an issuer. The empirical analysis suggests that credit ratings should embed the notion that risk is a forward looking dimension conditional on macroeconomic scenario (Kiff et al. (2012)). We consider two possible regulatory implications with respect to the credit rating industry. From one hand, we would recommend to policy makers to tighten the regulation of the rating agencies. On the other hand, we would encourage to reduce the required centrality of the rating agencies and thereby open up the bond information process. The removal of excessive reliance of regulations on ratings is warranted by the evidence of the impact of CRA's certification services. This result is in line with the new rules introduced by Basel Committee in Basel III supervisory guidance (BCBS (2010)) in which the Committee has introduced some new measures to perform bank's internal assessments that adopts a Standard Approach to calculate the minimum capital requirements. Among these measures, the Committee includes market related monitoring tools, such as CDS spreads which provide a source of instantaneous data on potential liquidity difficulties.

5.2 Directions for future research

The specificity and circumstances of credit risk management models is important to the choose of the right credit risk management model of the commercial banks and to the strategies of investment. Since the current situation in financial sector and in other sectors bears series of questions for discussions on evaluation of credit risk and its management, it is relevant a deeper study of some aspects of credit risk that could be related to banks or companies. In this section, we summarize the main suggestions related to extension of the present study. The attention may be focused on the following points:

1. *Focus of analysis.* Similar comprehensive studies should be carried out for European companies. The comparison between European and US banks has underlined as the country risk affects the credit risk in banking sector. Hence, a focus on European company would allow to compare different economies and to study if and how the systematic risk and the different regulatory frameworks affect the key factors of CDS spreads.

2. *Sovereign and bank interdependencies.* The link between banks and sovereign credit risk is mainly due to the big exposure of European banks to government bond. As underlined by Yu (2017), the comovement between bank and sovereign CDS spreads at the country level has been exacerbated by subprime crisis. The interdependence between banks and sovereigns could be source of financial and economic instability because investors also incorporate the increasing sovereign risk when pricing bank bonds, resulting in a looping effect between banks and sovereigns. Therefore, future researches could investigate deeper the dynamic linkage between these two entities by evaluating how a change in sovereign credit risk affects the banks credit risk and then the financial stability. An interesting focus could be on the effects of country's downgrade on banking lending.

3. *Credit risk and bank capital ratios.* International regulation of banks' credit risk was put in place in 1988 and since that time there has been no consensus on how to improve regulatory framework. The weighting factors for credit risk set by Basel II are fixed according to the credit rating. As a result, when the CDS market captures a change in credit risk in advance with respect to the credit ratings, problems and distortions may arise on bank's capital adequacy. Jacobs Jr et al. (2016) have demonstrated that there is divergence between credit risk measured by CDS spreads and credit rating agencies. Hence, it could be of interest to quantify the effects of this divergences on

capital requirements and on banking lending.

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