Fredrik Gromsrud
Morten van den Burgt

BI Norwegian Business School

Thesis

On the Relationship between Sovereign CDS and Equity Markets. Evidence from the European Debt Crisis

Date of submission:
03.09.2012

Campus:
BI Oslo

Examination code and name:
GRA 1903 Final Thesis

Supervisor:
Kjell Jørgensen

Program:
Master of Science in Business and Economics

Abstract

This paper examines the price equilibrium and dynamic relationship between credit default swap (CDS) and equity markets for European sovereign issuers in a time period which encompasses the ongoing European debt crisis. In line with previous research, our results suggest that the markets are inversely related, wherein the strength of the association is related to the underlying obligors' credit quality. Further, we reject the presence of a price equilibrium relationship in the time period under study, indicating that capital structure arbitrage strategies may be difficult to implement. Based on vector autoregressive (VAR) models and Granger causality, our overall results suggest that the CDS market has the leading role in all countries associated with high CDS spreads. Moreover, the stock market seems to contribute the most to price revelation in countries further away from default. This corroborates the view of informed players trading in the credit derivatives market.

Acknowledgements

It is with great pride and delight that we hand in our master thesis, thereby completing our Master of Science Degree in Business and Economics at BI Norwegian Business School.

Starting with the global credit crunch, rapidly followed by the European debt crisis, financial turmoil has pursued us from our first year at BI. Hence, our thesis obviously also had to involve a financial crisis. We can only pray that our professional careers not will be dominated by the same crisis pattern.

We would like to thank our supervisor Kjell Jørgensen for encouraging feedback and helpful conversations. Sometimes a confirmation that you are on the right track is all you need. Nevertheless, we remain responsible for any errors or omissions.

Oslo, August 31, 2012

Fredrik Gromsrud

Morten van den Burgt

Table of Contents

ABSTRACT .... **I**

ACKNOWLEDGEMENTS .... **II**

TABLE OF CONTENTS .... **III**

1 INTRODUCTION **1**

2 THE CREDIT DEFAULT SWAP **3**

2.1 CDS MECHANISMS 3
2.2 THE CDS MARKET 6

3 THEORETICAL RELATIONSHIP: CDS VS. EQUITY **9**

3.1 THE CDS-BOND BASIS 10
3.2 MERTON'S MODEL 11
3.3 EXTENSION OF MERTON'S MODEL TO SOVEREIGNS 12
3.4 MODEL IMPLIED CREDIT SPREADS AND CAPITAL STRUCTURE ARBITRAGE 13

4 LITERATURE REVIEW **15**

5 RESEARCH QUESTIONS AND HYPOTHESES **19**

6 DATA **21**

6.1 SAMPLE SELECTION 21
6.2 FINAL SAMPLE – IN LIGHT OF THE EUROPEAN DEBT CRISIS 24

7 METHODOLOGY **32**

7.1 CORRELATION ANALYSIS 32
7.2 PRICE EQUILIBRIUM 34
7.3 LEAD-LAG RELATIONSHIP 37

8 RESULTS **41**

8.1 CORRELATION ANALYSIS 41
8.2 PRICE EQUILIBRIUM 43
8.3 LEAD-LAG RELATIONSHIP 47

9 DISCUSSION **55**

10 CONCLUSION AND FURTHER RESEARCH **60**

REFERENCES **61**

APPENDICES **67**

PRELIMINARY THESIS REPORT **76**

1 Introduction

The borrower's overall ability to meet contract specified obligations determine the credit risk in an investment situation, and investors have always been exposed to the risk that their counterparties are unable to fulfill their liabilities[1]. Credit risk is reflected in the values of different assets, and should, thus, be visible in different markets. Merton's theory (1974) formalizes the relationship between equity and bond values, and may further be used to identify the close link between equity and credit spreads. From a theoretical point of view, new information should be incorporated simultaneously in all relevant markets. However, the incorporation of news may take place faster in some of the markets due to structural differences and informational advantages. Such pricing inefficiencies can be exploited by market participants by investigating the market that reacts first.

The demand for ways to hedge and diversify credit risk initiated the development of products that has partially liberated financial institutions from the undesirable exposure. Credit derivatives' entry into the world of finance has made it possible to transfer the underlying risk to institutions that have the capacity to bear it, and these instruments have since its birth in the 1990s seen a rapid evolution. Offering protection against counterparty default, credit default swaps (CDSs) currently dominate the credit derivatives market. Being directly linked to the reference entity's default probability, CDSs offer a useful benchmark for measuring credit risk. Hence, market prices on CDSs provide a useful platform to measure market views on default risk. This market price, typically referred to as the CDS spread, may further be used to see how the risk situation affects equity values.

Earlier research has verified the inverse relationship between CDS spreads and stock prices deduced from theory. However, prevailing views on a dominant market in terms of price discovery have not been established. Although the stock market generally is found to contribute the most to price revelation, there is also evidence that the CDS market seems to incorporate credit risk faster in close-to-default situations. Considering the limited evidence on the sovereign CDS-equity relationship, and in light of the ongoing credit troubles in European countries, we

[1] Even though credit risk specifically relates to firms and sovereign risk is used in the case for countries, we use the terms alternately in this paper.

are inspired to examine the link between sovereign CDS spreads and stock markets on the European continent. Our motivation is further amplified by the fact that none of the existing literature has covered a time frame explicitly dominated by financial turmoil on the country-level.

Through an objective country-selection process we end up with a sample of risky and less risky European countries. The split-up is particularly adequate since it allows us to discern potential differences related to the credit quality of the sovereign. Our methodological approach is closely linked to Chan-Lau and Kim (2004), who extend Merton's theory to sovereign obligors and further investigate the CDS-equity relationship in emerging markets. In the study, we rely on correlation analyses, the detection of long-term equilibrium relationships, and the investigation of lead-lag dynamics. In accordance with Merton's theory and the prevailing literature, we find a negative relationship between sovereign CDS spreads and stock prices. Moreover, the magnitude of the correlation is found to be stronger for countries closer to default. The cointegration analysis reveal that a price equilibrium relationship is absent in all countries under study. In addition to technical problems, we believe that practical issues regarding the exploitation of capital structure arbitrage strategies lead to this result. Since cointegration is absent, we rely on the estimation of vector autoregressive (VAR) models and the study of Granger causality in the credit risk discovery analysis. Overall, our results assert a leading role of the CDS market in all risky nations, while the stock market appears to be most important in terms of price discovery in the least risky nations. Following earlier research, this supports the presence of informed players in the credit derivative markets. However, observing a less dominant lead-lag relationship from 2011, we hypothesize that the credit risk has become increasingly important for all financial players, thereby improving the incorporation of credit news in exterior markets.

Our study contributes to the relatively limited research on the relationship involving sovereign CDS and equity markets. To our knowledge we are pioneers in investigating the lead-lag relationship between European sovereign CDS and stock markets in a time period dominated by a financial crisis. Hence, we have contributed to the establishment of a conjecture on the lead-lag relationship in periods of financial distress at the country-level. This should be of interest to investors and regulators involved in these markets, as the results gives indications on what market that reacts first to new information and also suggest that informed players are trading in the credit derivatives market. Moreover, our support for Chan-Lau and Kim's (2004) extension of Merton's model also indicate that the stock index may be a good candidate in assessing sovereign risk. Finally, the failure to detect a price equilibrium relationship should be of interest to arbitrageurs. However, it is important to acknowledge that the conclusions are made on a theoretical basis, and that further studies should investigate the results in a more practical manner.

The remainder of this paper is structured as follows: Section 2 presents the mechanisms of CDSs and gives a brief overview of the CDS market. Section 3 takes a closer look on the theoretical relationship between equity values and CDS spreads. Section 4 reviews previous literature on the topic, while Section 5 specifies our research questions and hypotheses. Section 6 and 7 take a closer look on the data and methodology used in our analyses. Section 8 presents our results. Section 9 discusses our findings, with a particular focus on the relation to earlier research on the topic. Section 10 leaves our concluding remarks.

2 The Credit Default Swap

2.1 CDS mechanisms

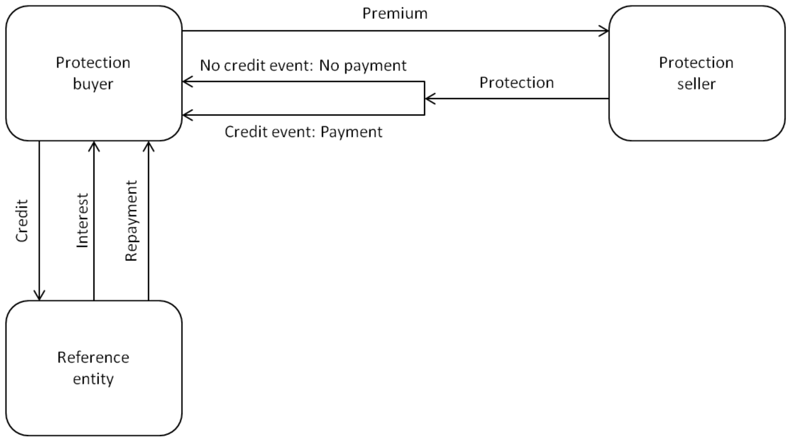
The CDS is the most used credit derivative, and its popularity has grown significantly since institutions began to focus on hedging credit risk in the 1990s. CDSs are financial derivatives that offer insurance against credit or default risk of bonds or loans. Purchasers of such derivatives obtain the right to sell the reference security issued by the reference entity, usually a company or government, for their face value if a credit event occurs. Effectively, credit risk is transferred from the protection buyer to an insurer, represented by the CDS seller, through periodic payments in exchange for protection against default or other adverse credit events. The "insured" credit events are specified in the CDS contract and usually include failure to pay, restructuring of debt, or bankruptcy, but may also refer to events such as obligation acceleration, obligation default, and repudiation/moratorium. Without an ability to file for bankruptcy, typical sovereign credit events include debt restructuring and repudiation/moratorium, in which repudiation/moratorium involves sovereign incapacity or unwillingness to fulfill its obligations (ISDA 2011). Being applicable to both sovereign and corporate reference entities, the CDS contract terminates if it is triggered and the insurer then has the obligation to cover the protection buyer's incurred loss.

Settling the CDS involves either physical delivery or cash payment. In case of physical settlement, the protection seller receives the underlying reference security in exchange for compensating the CDS buyer with the face value. With cash settlement, the protection buyer receives the difference between the recovery value, i.e., the value of the reference security at the time of settlement, and the face value. Due to the difficulty of predicting post-default recovery values, physical delivery was the most commonly used form of settlement for a long time. However, as auction settlement procedures have been incorporated in standard CDS contracts, cash payment is now becoming more widespread (Weistroffer 2009).

The periodic payments made by the purchaser of the CDS, in exchange for default protection, are derived from what is known as the CDS spread or premium. The CDS spread is basically the payments expressed as a percentage of the notional principal[2]. Even though contracts with semiannual and annual transfers exist, protection payments are normally made every quarter. The quotation of the CDS spread, however, is done in basis points (bp) per annum. For example, a CDS spread of 200 bp for default protection on a notional amount of $10 million costs $200,000 per year. Following the market norm, the protection buyer pays the seller $50,000 every quarter until the maturity of the CDS or until an insured credit event occurs. The mechanisms of a CDS agreement are represented in Figure 1.

[2] The notional principal refers to the total face value covered by the CDS contract.

Figure 1. CDS mechanisms



On the trading day, the two parties involved in a CDS deal agree upon the spread required for default protection, and this market price reflects the risk of the underlying credit. Logically, if everything else is equal between two CDSs, the one with the highest premium is associated with the reference credit perceived as most risky. In other words, a purchaser of a CDS pays a relatively higher spread to protect an investment in a company or sovereign that by the market is considered to have the largest likelihood of default. Contrary, a decline in the premium signals an improvement in the perception of the credit quality. In principle, the CDS spread should reflect the expected loss of the reference entity, which again is a function of the probability of default (pd) and the recovery rate (rr). A simplified version of the CDS premium can, thus, be expressed as follows (Weistroffer 2009):

$$CDS\ spread = pd * (1 - rr) \quad (1)$$

If the recovery rate is assumed to be zero, a protection buyer insuring credit, issued to a reference entity with a 2% default probability, would have to pay a spread of 200 basis points on the notional amount. Naturally, the CDS spread is a rising and declining function of the default probability and recovery rate, respectively.

The simplified formula in (1) proves much of CDSs’ qualities as a credit risk measure. Being directly linked to default probabilities, the CDS spread should reflect the “pure” credit risk in an investment situation. If a CDS quote is observed in the market, reverse engineering can be used to determine the implied default probability. In this connection, the cumulative probability of default (CPD) is a measure often referred to in the financial world. Calculated from observable CDS spreads in the market, the CPD reflects the probability of a reference entity being unable to service its debt over a given time period. One example on the application of CPD can be extracted from the sovereign risk reports published by Credit Market Analysis Limited (CMA)[3]. On the basis of CPD, each publishing ranks sovereign credits from most to least risky. Since the CPD measure used in the reports incorporates the probability of a debt restructuring, it is particularly convenient when analyzing sovereigns. However, being determined in the market, the CDS spread may in practice be affected by non-default factors such as speculation, excessive market fears, and liquidity, and therefore provide biased estimates on default probabilities. Still, CDSs are commonly thought and proved to be less influenced by irrelevant components when compared to other credit risk measures (e.g. Ericsson, Reneby, and Wang 2005). In an analysis of the sovereign default of Argentina in January 2002, Chan-Lau (2003) argues that default probabilities derived from CDSs works efficiently in constructing early warning signs of debt default, indicating the usefulness of CDS-implied default probabilities.

2.2 The CDS market

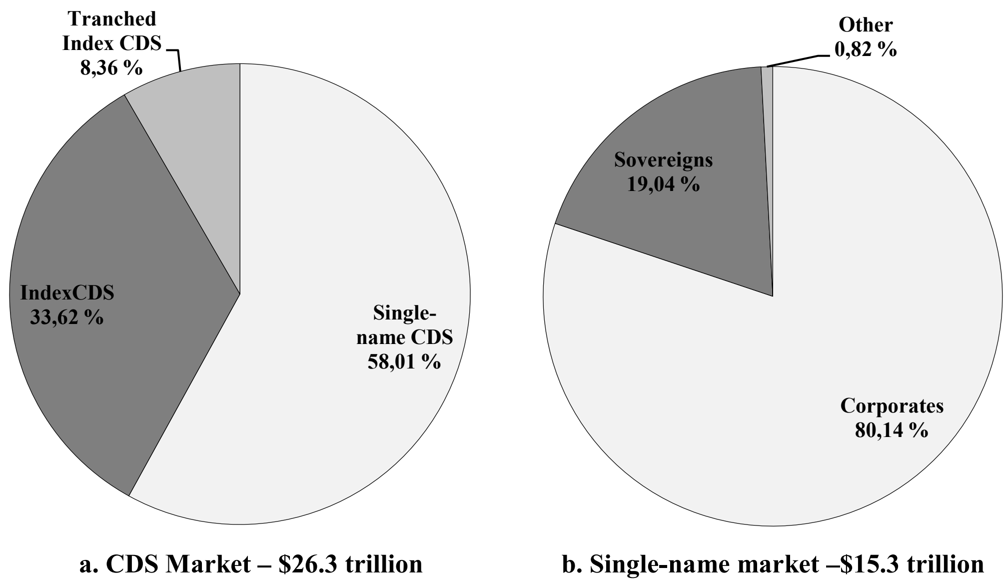
Broadly speaking, CDS products are used for hedging, speculation, and arbitrage. While hedging purposes dominated in the early years, other trading objectives soon became equally important (Weistroffer 2009). Since CDSs are traded privately in the over-the-counter (OTC) market, they allow counterparties to tailor the contracts in accordance with their specific needs. Despite the possibility to customize the contracts, most traded CDSs are standardized according to a framework provided by the International Swaps and Derivatives Association (ISDA). Along with the increased attention on credit risk hedging and speculation, the introduction of standard contracts in 1998 fuelled the growth of the CDS market (Hull 2012: 550). The notional amount outstanding of CDSs grew from $918.9 billion in 2001 to a peak of $62.2 trillion in 2007 (ISDA 2010). During the financial crisis, the lack of transparency and the market’s vulnerability to systemic

[3] CMA is a leading source of independent data in the OTC markets and their services are utilized by numerous financial institutions around the world. For more information on CMA visit: www.cmavision.com

risk started to concern regulators, and the development of clearing houses for CDS trades was one answer to the prevailing concerns (Hull 2012: 550). Moreover, efforts were focused on trade compression, a process that reduces the overall notional size and number of outstanding contracts in credit derivative portfolios without changing the net risk position of a financial institution.

Due to a fall in CDS trading activity and effective portfolio compression during and after the financial crisis, the outstanding gross notional declined to $26.3 trillion in 2010 (ISDA 2010). According to the Depository Trust & Clearing Corporation (DTCC), the market size has remained rather steady the last few years, still amounting to $26.3 trillion in May 2012. The market size is spread across roughly 2.4 million contracts, which leaves the average CDS deal notional around $11 million (DTCC 2012a). CDSs come in different forms that exist to satisfy heterogeneous investor preferences, and can in general terms be split into two categories; single-name and multi-name CDSs. Single-name CDSs represent the traditional form, in which the derivative contract is referenced on individual corporate or sovereign borrowers, while the multi-name CDSs are written on various entities. Noteworthy, the increased use of proxy hedges has fuelled growth in the multi-name segment the recent years (Weistroffer 2009). Figure 2 breaks down the CDS market by product categories.

Figure 2. The CDS market divided by (a) instruments and (b) reference entities in terms of gross notional values



Source: DTCC, 2012ab

The pie in 2a represents the CDS market as a whole and is divided between single-name CDSs and two multi-name segments. As of May 2012, single-name CDSs accounts for $15.3 trillion in gross notional values or 58 % of the market, while the multi-name products, represented by Index CDSs and Tranched Index CDSs, amounts to 34 % and 8 %, respectively. The right chart further decomposes the most common instrument group by reference entity type. With its 80 % market share, corporate single-names are by far the largest product category of the CDS market. Amounting to $2.9 trillion, the Sovereign CDS market is a clear number two (DTCC 2012b). However, it should be noted that sovereigns hold the first eight places when reference entities are ranked by the gross notional size of contracts issued on them (DTCC 2012c).

The credit derivative market is concentrated around a few major participants and around large institutional banks in particular. This is confirmed by the most recent update from the Office of the Comptroller of the Currency (OCC 2012) on insured U.S. commercial banks. Being the top four banks ranked on notional amounts outstanding, JPMorgan Chase, Citibank, Bank of America and Goldman Sachs account for 94.8 % of U.S. banks' positions in credit derivatives[4]. A similar structure is found in the CDS market. According to the European Central Bank (2009) and Fitch (2009), the five largest dealers in the CDS market are JPMorgan Chase, Goldman Sachs, Deutsche Bank, Barclays and Morgan Stanly. Fitch further suggests that this quintuplet accounts for 88 % of the market in terms of total notional amount bought and sold. Seeing that the average deal amounts to $11 million in gross notional, it seems logical that market is not easily accessible. Weistroffer (2009) also notes that the market has become even more concentrated after the financial crisis, as some of the main participants have exited the market.

Referring to their importance as a credit risk management tool, Hull (2012: 555) concludes that the future of the CDS market looks bright. Even though it came under a great deal of regulatory scrutiny during and after the financial crisis, the market survival and further development is a signal of strength. The high CDS activity related to the ongoing European debt crisis is another healthy sign. However, market practitioners, regulators, and academics remain worried about

[4] Each quarter OCC reports banks' derivative activities, based on call reports filed by all insured U.S. commercial banks.

the CDS market structure. The high market concentration leads to high counterparty risk within the market, a problem that has been partially solved by introducing clearing houses and collateral requirements. More importantly, there seem to be a potential asymmetric information problem in the CDS market, also related to the major players in the market. While other OTC derivatives depend on observable variables, such as interest rates, exchange rates, and commodity prices, CDSs depend on default probabilities of *specific* reference entities during a *specific* time frame. In contrast to the other derivatives, where the information is public, sophisticated financial institutions, that usually work closely with a particular company or sovereign, arguably have more information regarding its likelihood of default (Hull: 556). Thus, these institutions have a clear advantage in the trading of default protection contracts on the same reference entity. Acharya and Johnson (2007) quantify the problem and provide evidence of insider trading in the CDS market. Such issues are most likely present in other markets as well, but the concentrated structure leaves the CDS market particularly vulnerable. Effectively, all major market players are insiders with the possibility of exploiting their informational advantage. Despite the findings of insider trading, Acharya and Johnson (2007) find no adverse effects on prices or liquidity. The asymmetric information problem and its effects in particular, are highly relevant for the topic under investigation, and, thus, further discussed later in this paper.

3 Theoretical relationship: CDS vs. Equity

Given their adequate characteristics and the sizeable market growth, CDS spreads have gained wide acceptance as a platform to gauge credit risk. Literature shows that CDS quotes more or less outperform the more traditional bond spread, with the sovereignty closely linked to their association with “pure” default risk. In this section we take a closer look on the interrelation between CDS and bond spreads, presents some of the evidence of the outperformance, before we use their linkages to formalize a relationship between CDS spreads and equities values. The relationship is further extended to sovereign application. Finally, the mechanism believed to foster integration between the CDS and stock markets is outlined.

3.1 The CDS-Bond basis

In this context, the bond spread may be defined as the excess of the bond yield over the risk-free rate. Being directly related to default probabilities, both the bond spread and the CDS spread provide useful information on the riskiness of various reference entities. In contrast to credit ratings, these measures offer market views on credit risk on a continuous basis. Even though the CDS and bond spread stem from different assets and markets, arbitrage mechanisms keep them closely related. Specifically, the CDS-bond basis, defined as the difference between the CDS spread and the bond spread, should be close to zero for no arbitrage opportunities to exist. Essentially, this is because the purchase of a CDS turns a bond "approximately risk-free". If the bond spread, i.e., the excess of the bond yield over the risk-free rate, is significantly larger than the CDS spread for a specific reference entity, an investor can earn more than the risk-free rate by taking a long position in the bond and buying default protection. Equivalently, if the CDS spread is markedly above the bond's risk premium, investors can borrow at less than the risk-free rate by shorting the bond and selling a CDS. The theoretical relationship is empirically confirmed by a number of researchers[5].

In theory, integrated behavior between the markets makes sense, but several factors complicate the relationship in practice and may cause the spreads to diverge. In addition to credit risk, bond yields are considerably affected by interest rate risk and liquidity, while the CDS spread depends heavily on elements such as recovery rates and counterparty risk (Weistroffer 2009). Prior to the credit crunch in 2007, the CDS-bond basis was on average slightly positive. However, due to a relatively high risk premium in the bond market, the basis turned negative and drifted far away from its theoretical equilibrium during the financial crisis (Hull 2012: 551). Empirical studies conclude that CDS spreads in general lead the bond market, and thus serves as a better market indicator of distress[6].The reasons for this are attributed to some favorable characteristics of the CDS premium. First, the CDS spread separates credit risk from the interest rate risk incorporated in bond

---

[5] See, for example, Hull, Predescu, and White (2004), Blanco, Brennan, and Marsh (2005), Zhu (2006), Norden and Weber (2009) for cointegration on the corporate level, and Chan-Lau and Kim (2004) and Ammer and Cai (2011), Palladini and Portes (2011) for integration on sovereigns.
[6] See, among others, Longstaff, Mithal, and Neis (2003), Zhu (2006), Norden and Weber (2009), Ammer and Cai (2011), and Palladini and Portes (2011).

yields, effectively removing one source of pricing uncertainty. Second, CDSs are generally more liquid than their underlying bonds for risky credits (Kiff, Elliot, Kazarian, Scarlata, and Spackman 2009). Third, while the liquidity in bond markets shrinks, CDS trading seem to continue in periods of distress (Becker 2009). The relatively high risk premium in the bond market during the financial crisis provides evidence of the latter attribute.

3.2 Merton's model

A model proposed by Robert C. Merton (1974) formalizes the relationship between bond and equity prices, and can also be used to draw a link between CDS and equity markets. Recognizing that equity represents a residual claim, Merton defines the equity of a company, partly financed by debt, as a call option on the company's assets. If the value of a company's assets (V) is less than the debt repayment (D), it is rational for equity holders to default on the debt since the equity (E) is worthless, i.e., E = V – D < 0. However, if the assets exceed the debt value, the company should repay the debt and obtain an equity value of E = V – D > 0. Using option-pricing theory, the company's equity is:

$$E = \max(V - D, 0) \tag{2}$$

Phrased differently, the equity value is a call option on the value of the assets with an exercise price corresponding to the face value of the debt. Then, if the assets are worth more than the debt, the call option is "in-the-money". Contrary, the option is "out-of-the-money" and a default occurs if debt repayment goes beyond the asset values.

A company's liabilities constitute a barrier level for the value of its asset. The higher the debt level is relative to assets, the higher is the default risk. In this connection, Merton notes that bond and equity prices exhibit positive correlation, in which the degree of correlation will be stronger when debt-to-asset values are high and default is a substantial threat. If the current asset values in a company are close to what is owned to the creditors, the slightest negative move can send the call option out-of-the-money and provoke a default situation. In other words, if the firm's value is just enough to cover the company's debt, then relatively small changes in firm value may cause it to default. Adverse movements will lead to a decline in equity prices, since the residual claim is in danger of becoming worthless, and bond prices will plunge as a result of increased default risk. Rising default risk reduces the expected payoff for bond holders, and since this is incorporated into a higher risk premium, equity prices and bond spreads will move in opposite directions. Given the close relationship between bond spreads and the CDS premium, as described in the section above, the negative association should also hold between equity prices and CDS spreads.

3.3 Extension of Merton's model to sovereigns

Chan-Lau and Kim (2004) justify how Merton's framework can be extended to sovereigns. The main difference between corporate and sovereign issuers is that a country may choose to default on its debt even when it is able to pay, i.e., the asset values of the country exceed the debt repayment but still the country refuses to fulfill its obligations. This may be due to conflict of interest, where liquidity and political factors come into play. Following the theory on CDSs, this may lead to a repudiation/moratorium credit event. Since a "willingness-to-pay factor" enters the system, the asset values in which a country may choose default are higher than in the case with firms. Being the only substantial difference, this implies that the default risk for a sovereign is higher for every asset value. However, the relationship between CDS spreads and equity values should remain unaltered.

Intuitively, higher default or sovereign risk is related to deteriorating economic fundamentals and a negative outlook for the national economy, elements that also have adverse impact on the stock market. Due to an increase in the risk premium required by investors, equity values will depreciate. At the same time, increased sovereign risk will be incorporated in CDS prices and also push up the total demand for insurance against default. Since protection sellers typically neutralize their exposure by shorting bonds or equity, a further downward pressure will hit the stock market (Chan et al. 2009). Therefore, a country's sovereign risk, captured by CDS spreads, should be inversely related to its stock prices, the equity proxy. Additionally, increased sovereign debt, followed by increased borrowing cost leads countries into a viscous circle. Locking up more money to be able to pay external debt holders has adverse effects on the countries' economic outlook, as this may lead to lower spending and reduced investments. In total, this may possibly drive the economy into recession. Consequently, similar to the corporate market, the degree of correlation is predicted to be higher if sovereign risk is a major concern.

3.4 Model implied credit spreads and capital structure arbitrage

Financial institutions and banks rely on continuous evaluation of credit risk, and they devote vast resources to carry out this task. While the ongoing financial turmoil again confirms the importance of careful credit risk assessment, the adjustment of the Basel Accords have specifically put more pressures on financial institutions. CDSs offer a continuous measure that can be used to evaluate credit risk. However, market participants often employ additional tools to assess the amount of default risk present in an investment situation. By applying a structural Merton-type model, market participants or regulators are able to predict default probabilities and, hence, theoretical CDS spreads – so-called model implied credit spreads. The derivation of model implied credit spreads and the use of these can be found in among others Leland and Toft (1996) and Hull, Nelken, and White (2004). Based on stock and CDS data Forte (2011) further modifies Leland and Toft's (1996) structural model. The modified version results in stock market implied credit spreads, which is found to fit the time series of market CDS spreads. At the sovereign level, Gray, Merton, and Bodie (2007) propose a framework to measure, analyze, and manage sovereign risk that can be used to estimate credit spreads. Recent papers from Jeanneret (2012) and Mayer (2012) also employ structural models particularly concerned with the determination of sovereign credit spreads. In a nutshell, all approaches seek to obtain implied credit spreads based on asset values and volatility obtained from equity values. If Merton's theory applies, the credit spread obtained from the models can also be used to assess credit risk. In this connection, Chan et al. (2009) explicitly suggest that the negative correlation found between Asian stock markets and sovereign CDS spreads indicate that "in assessing the country-specific factor for sovereign risk, the stock index is a good candidate". Additionally, the theoretical spread may be compared to market spreads and thereby determine if pricing inefficiencies exist.

The latter implication is particularly important for arbitrageurs. As mentioned, CDSs are primarily used for hedging, speculation, and arbitrage purposes. In practice, arbitrage plays an important role in maintaining the integration between the CDS and equity markets. More precisely, a popular hedge fund strategy referred to as *capital structure arbitrage* utilizes the negative association predicted by Merton's theory, and aims to exploit pricing inefficiencies in the capital structure of a firm. Basing the strategy on convergence between equities and CDS spreads, the objective is to profit from pricing disparities that exists in the market. Specifically, a capital structure arbitrage strategy starts off by comparing the theoretical price, obtained from the model, to the prevailing CDS spread in the market. If inconsistencies are detected, this may indicate that arbitrage opportunities exist. This is basically because the CDS and equity markets should price default risk equally for price efficiency to be present. If the premium obtained in the market is significantly larger than the model implied CDS spread, the arbitrageur may sell credit protection if it is believed that the equity market reflects the correct price. Essentially, the arbitrageur then believes that the CDS market has incorporated a default risk that is too high. To hedge the position, equity should be shorted. Due to the belief of integration between the markets, it is now expected that the CDS premium converges towards the predicted spread, making profit for the arbitrageur. If it, on the other hand, turns out that the default risk was higher than predicted by the stock market, the idea is that the loss on the credit protection can be offset by the gain on the short equity position. In the latter case, the stock market has priced in too little credit risk, and a drop in equity values is thus predicted to uphold the relationship between CDS spread and equity values.

In the paper "How Profitable Is Capital Structure Arbitrage?" from 2006, Fan Yu proves the efficiency of the CDS-equity arbitrage strategies in a study on corporate obligors. Even though he notes that losses can occur on an individual basis, the findings suggest that an equally weighted portfolio of all trades produced industry benchmark Sharpe ratios. The strategy is less explored at the sovereign level, and, to our knowledge, there are no practical studies on arbitrage opportunities between sovereign CDS spreads and national stock indices. However, Chan-Lau and Kim (2004) and Chan et al. (2009) indicate that capital structure arbitrage strategies can be exploited if these series are cointegrated. Essentially, it is believed that the CDS and equity markets should be integrated, i.e., their market prices should converge, as capital structure arbitrage eliminates mispricing. However, they also note that the equilibrium relationship may be absent due to country-specific elements and market frictions.

4 Literature review

Due to CDSs' relatively short history, prior research on the field is limited. The rapid development and increased use of credit derivatives have, however, boosted the interest for CDSs and extended the literature base on the topic the recent years. The existing literature investigating the association between credit risk and equity values, and in particular involving the link between CDS and stock markets, primarily investigates the relationships at the corporate level.

Longstaff et al. (2003) are the first to incorporate the price relationship between stock and CDS markets in the credit risk discovery analysis. Using a VAR model the authors study the lead-lag relationship between weekly CDS spreads, bond yields and stock returns for a sample of U.S. firms from 2001 to 2002. The findings suggest that both CDS spreads and stock returns lead the bond market. However, the evidence is mixed regarding the leadership between CDS spreads and stock returns[7]. Fung, Sierra, Yau, and Zhang (2008) examine the market-wide relation between the U.S. stock and corporate CDS market in period from 2001 to 2007. Since the authors expect that the information flow between stocks and CDSs is stronger in close to default situations, two CDS indices are created by separating investment-grade and high-yield obligors. Their results support the separation, indicating that the lead-lag relationship is affected by the credit quality of the underlying obligor. Results from VAR estimations indicate that the stock market appears to lead both of the CDS indices. However, while they note that the stock market is more important in terms of pricing, the CDS market plays a more significant role in volatility spill over. Overall, they find that the relationship between high-yield CDSs and the stock market is stronger than in the case of investment-grade CDSs. They also find evidence which is consistent with the notion about feedback effects being present between stocks and CDS when credit conditions are worsening. When they test for a long-run equilibrium relationship, they do not detect cointegration between CDS spreads and stock prices when the

[7] Unfortunately, the authors do not report characteristics of the firms where CDS spreads lead stock returns.

whole period is accounted for. However, when the same framework is applied in the time period July 2007-December 2007, the test results provide evidence of statistically significant cointegration. According to the authors, this support the hypothesis that the CDS market and stock market has become more closely related. Interestingly, cointegration is found in a period when the markets started to grew nervous about sub-prime mortgages.

A more dominant importance of one market over the other is found by Byström (2005) and Norden and Weber (2009). The former analyzes a sample covering the time period June 2004-April 2005 to investigate the relationship between the European sector iTraxx CDS indices and the stock market. First, the theoretical inverse relationship between stock prices and CDS spreads is confirmed in a correlation study. Further, his results suggest that information is embedded into stock prices before CDS spreads, implying that the stock market leads the CDS market in transferring firm-specific information. While confirming the inverse relationship, Norden and Weber (2009) also report the correlation to be stronger for firms with lower credit quality. With a methodology closely linked to the one employed in this paper, they study the lead-lag relationship between CDS spreads, bond spreads and stock prices for a sample of 58 U.S and non-U.S. entities over the period 2000-2002. The estimated VAR model implies that the stock market leads both the CDS market and bond market. This results is further supported by the Granger causality test, which suggest that stock returns Granger-cause CDS changes for a higher number of firms than vice versa.

As discussed earlier, the CDS market is thought to be suffering under an asymmetric information problem. Using a sample spanning the period from 2001 to 2004, Acharya and Johnson (2007) try to quantify the problem by investigating where the information revelation occurs. The authors notice that the credit derivative market may be especially vulnerable to asymmetric information and insider trading, as most of the players are insiders. It is also noted that firms typically have a closer relationship with their private financiers, than with their public securities investors. Bearing in mind the position of large institutional banks in the credit derivative market, one could assume that informed traders take advantage of their private information. By using the stock market as a benchmark for public information, the article hypothesizes that the credit market, at least in some cases, reacts before the equity market. Measuring the information flow between the markets by employing predictive regression coefficients and examining the cross-correlation, the article offers several interesting findings. First, on days with negative credit news and for firms with a higher default probability, the information revelation seems to occur in the CDS market. Also, the result is stronger for firms with increased number of bank relationships. These findings are consistent with active insiders trading on personal information. However, as already noted, the authors do not find the existence of insider trading to adversely affect prices or liquidity.

Different from the traditional approach of using CDS spreads and equity values, Forte and Peña (2009) uses a structural model to calibrate stock market implied credit spreads when they study the credit risk discovery process between equity, CDS, and bond markets. The result of the Johansen cointegration test suggest that the implied credit spread and CDS spread are cointegrated for four of 14 different firms investigated. Based on their results on cointegration, they estimate a VECM or VAR model in their price discovery analysis. Their overall results show that the stock market leads both the CDS market and the bond market, and confirms the leading role of the CDS market with respect to the bond market. Hasbrouck information share and Gonzalo-Granger measures further indicate that the stock market contributes the most to the price discovery. However, their results are clearly varying, leading to preliminary evidence of a time-varying price discovery relationship between the markets. This implies that the contribution to price discovery from the two markets is dependent on economic fundamentals, suggesting that lead-lag relationship findings should be evaluated by the time period analyzed.

In order to discover which of the markets that leads in times of financial crisis, Forte and Lovreta (2012) analyze a data set containing European companies in the period 2002-2008. Again, the authors rely on stock market implied credit spreads and CDS spreads when investigating the dynamic relationship. The sample is divided into a period with crisis and a period without crisis. Identifying the dot-com crisis (2002) and the sub-prime crisis (mid-2007-2008), they are able to observe the dynamic process between the markets. Even though evidence of cointegration is found for 55.4 % of the firms, the authors argues that a VECM is applicable for the whole sample. The VECM results indicate that the stock market leads in time of crisis, while the CDS market's contribution to price discovery picks up in tranquil periods. However, the authors stress that their results do not contradict the theory of insider traders in the credit derivatives market, as they document a positive relationship between *severe* credit crises and the probability of the CDS market leading the credit risk revelation.

While the relationship between stock and CDS markets has been explored by a range of researchers at the corporate level, the existing literature base involving sovereigns is somewhat limited. However, a few articles on the field point out some interesting findings. Similar for all studies at the sovereign level is the use of national stock indices as a proxy for equity value. The first study of the relation at the sovereign level is reported in Chan-Lau and Kim's IMF Working Paper from 2004. After extending Merton's theory to sovereigns, the authors analyze the CDS-equity relationship for a set of emerging markets in a time frame spanning the period 2001-2003. Chan-Lau and Kim (2004) only detects cointegration between the markets in one out of eight countries, and advocates that the lack of arbitrage opportunities, the low debt-to-asset values, and market frictions present may serve as an explanation for the absence of integration between the markets. However, they also speculate that the cointegration results may suggest that the equity indices included do not proxy countries' equity values correctly or that the dynamic relationship is non-linear[8]. On the other hand, they indicate that arbitrage strategies are applicable in countries where the prices converge in a long-run equilibrium relationship. In terms of price discovery, a VECM is employed in the country where cointegration is present, while a basic VAR is the starting point in the remaining nations. The Granger causality tests and the VECM-based robustness measures do not show any clear evidence of a dominant market. The authors attribute the mixed findings to the data, which contains observations on countries that frequently move in and out-of-the-money, and conclude that more research on the topic is needed.

Following the setup in Chan-Lau and Kim (2004), Chan et al. (2009) report that price discovery primarily occurs in one of the markets in their analyses of Asian

8 The cointegration tests are based on linear regression techniques, and will, therefore, not be able to capture a non-linear relation.

emerging markets in the period 2001-2007. Before initiating the price discovery analysis, the authors detect strong negative correlations between the country-specific stock indices and sovereign CDS spreads, and the association seems to be stronger when the credit rating worsens. Furthermore, a long-run equilibrium relationship is found between the CDS market and the stock market in three out of seven countries. Again, depending on the presence of cointegration, a VAR or VECM model is adopted to investigate where the price discovery occurs. The results are robust in suggesting that the CDS market primarily contributes the most to price discovery. However, for Japan, there is no causation in either direction, and is largely seen as sign of their low sovereign risk. It is basically suggested that in-the-money equity values are more affected by other factors than credit risk. In addition, a master thesis by Berg and Tjemsland (2011) investigate the relationship in six European countries using monthly data from the period 2004-2010. First, in a similar vein as Chan et al. (2009), they confirm the negative correlation between the markets. Based on graphics they surprisingly also *conclude* that the stock and CDS market are cointegrated for all European countries investigated[9]. In contrast to Chan et al. (2009), they find that the stock movements lead CDS spreads when they examine the error correction adjustments between the markets.

5 Research questions and hypotheses

Considering earlier research' primary focus on the dynamic relationship between corporate CDSs and equity markets, our master thesis will contribute to field of sovereign CDSs. Influenced by the research conducted by Chan-Lau and Kim (2004) and in light of the ongoing sovereign debt crisis, we want to provide an outline of the sovereign CDS market in Europe and investigate its link to equity markets. In particular, we want to study the dynamic relationship between sovereign CDS spreads and stock indices in selected European countries, focusing on the markets' contribution to price discovery. Based on the outlined theory and existing literature, the following research questions and hypotheses are formulated:

[9] Some aspects of the analyses make us question the validity of Berg and Tjemsland's (2011) conclusions. This is further discussed in section 9.

1. How are the stock and sovereign CDS markets in European countries related?

   H1: The stock and CDS markets are inversely associated.

   H2: The relationship between country-specific stock indices and CDS spreads are stronger in countries closer to default.

   H3: There is a long-term equilibrium relationship between the stock and CDS markets.

2. Which of the markets is more important for price discovery in European countries?

   H4: The CDS market leads the stock market in countries closer to default.

Several implications for the relationship between the sovereign CDS and stock markets can be inferred from the confirmation or rejection of the hypotheses above. Confirming H1 and H2 can be seen as support for Merton's theory and Chan-Lau and Kim's (2004) extension to sovereign obligors. As noticed by Chan et al. (2009), a confirmation of these hypotheses implies that stock index is a good candidate in the assessment of sovereign risk. Corroboration of H3 yields evidence of a cointegrating relationship between the markets, indicating that market forces keep the prices aligned. This supports the idea of CDS-equity arbitrage strategies at the sovereign level. Finally, conclusions on research question number two indicate which market investors should span for information. Even though the existing literature on the lead-lag relationship primarily has found the stock market to lead the CDS market, we hypothesize that the CDS market plays the leading role in a time period dominated by financial distress. As several researchers has observed, the CDS market seem to play a more important role during crisis. However, studies examining the relationship in a time period solely consisting of distress have not yet been conducted. Thus, a confirmation of H4 verifies that the lead-lag relationship varies with credit quality and gives an indication of a time-varying relationship between the markets. Following Acharya and Johnson (2007), a leading role of the CDS market confirms the presence of informed traders in the credit derivatives market.

6 Data

6.1 Sample selection

The raw data used as a basis for our analyses include daily end-of-day observations on sovereign CDS spreads and equity value proxies for a set of European countries, and covers a time period from April 2009 to April 2012. This time frame is of particular interest since it encompasses the ongoing European debt crisis, from its eruption and until recent escalations. European countries have suffered severe credit deterioration during the period; some have (practically) defaulted, while others find themselves in close-to-default scenarios. The continuing crisis provide us with an exclusive data set and a unique opportunity to explore how credit spreads and equity values are interrelated at the sovereign level during a period of financial distress. Merton’s theory offers rationale for a closer relationship between stock values and CDS spreads in case of low credit quality, and previous literature has largely confirmed the conjecture by revealing differences between risky and less risky corporate reference entities. To our knowledge, we are the first to investigate the dynamic link for sovereigns during a period explicitly dominated by financial turmoil on the country-level.

The selection of countries for inclusion in the final sample is based on the underlying theory and carried out with an aim of answering the formulated hypotheses. It is expedient to focus on a set of high-risk countries, but a pair of solid nations is also included to discern potential differences related to the reference entities’ credit quality. The country selection process rests on quarterly sovereign risk reports published by CMA. Relying on CDS spreads, the CMA reports focus on changes in sovereign reference entities’ risk profile and rank sovereign credits from most to least risky. A synopsis of the ranking used in our country selection process, stemming from Q4 2011, is presented in Appendix A. After excluding non-European nations, sovereigns appearing in the most risky category include Greece, Portugal, Ireland, Ukraine, Hungary, Italy, Croatia, and Spain. The European part of the least risky category is dominated by the Nordic countries; Norway, Sweden, and Finland and accompanied by Switzerland, UK, and Germany.

To maximize the efficiency of the CDS spreads and equity proxies included in our analyses, we narrow down the selection by assessing market liquidity. Despite the major growth in the CDS markets, some reference entities still suffer under low trading volumes. Table 1 shows how the remaining countries perform along three variables yielding information about market liquidity. First, the governments are ranked according to the gross notional amount covered by CDS contracts issued on themselves. Second, weekly trading activity is presented for each nation. Lastly, the countries are labeled according to their MSCI Market Classification, a widely used measure for market status in the financial world. Based on economic development, size and liquidity, as well as market accessibility, the MSCI classification arranges international equity markets in three categories: developed, emerging, and frontier. Thus, the categorization serves as an indicator of market efficiency. Naturally, developed economies score highest on these criteria, while emerging and frontier markets represent the middle and bottom category, respectively. Whereas emerging markets experience rapid growth in business activity, typical frontier economies suffer under lower market capitalization and limited liquidity.

Table 1. Market liquidity

Country	Gross Notional Amount	Trades/Week	MSCI Classification
Italy	$ 340 655 975 527	314	Developed
Spain	$ 179 316 658 646	444	Developed
Germany	$ 119 460 642 733	116	Developed
Greece*	$ 78 810 942 968	135	Developed
Hungary	$ 71 193 678 133	88	Emerging
Portugal	$ 69 530 452 541	135	Developed
UK	$ 67 706 520 679	125	Developed
Ireland	$ 47 389 535 314	85	Developed
Ukraine	$ 39 392 696 766	34	Frontier
Sweden	$ 21 252 107 191	24	Developed
Finland**	$ 16 762 549 141	10	Developed
Croatia	$ 10 343 901 834	15	Frontier
Norway	$ 8 416 458 737	7	Developed
Switzerland***	NA	1	Developed

Table 1 reports how the countries extracted from the CMA report perform along three measures used to evaluate market liquidity. Gross Notional Amount is sourced on Apr 20, 2012. Trades/Week is the aggregate of contracts traded per reference entity divided by the number of weeks during Mar 2011 – Aug 2011, excluding transactions which did not result in changing market positions. Notional amounts and the trading data are collected from DTCC's Trade Information Warehouse. The classification stems from Jun 2012 and categorizes international equity markets based on economic development, size, liquidity, and market accessibility. Some inconsistencies should be noted: *Notional in Greece is from May 20, 2011. **Notional in Finland is from Jun 29, 2012, *** Notional amounts for Switzerland are not found, while Trades/Week is from Sept 2011 – Feb 2012.

The table indicates that liquidity in the CDS market is mainly a function of two factors:

1. Size of the economy/bond market.
2. Riskiness of the credit.

These conclusions are based upon the following observations: First, low trading volumes seem to be particularly evident among the smaller economies in the least risky category. In combination, the relatively small bond markets and the low sovereign risk in these countries keep the demand for credit protection at a minimum. Note further that three out of the top-four safe credits (in Europe), with exception of Finland, are not part of the Eurozone. Second, greater liquidity observed in German and British CDSs may be explained by their sizable bond markets. Since market participants have larger positions in these markets, the demand for credit protection is logically driven up, as different players seek to hedge their exposure. Though, one should not undermine the possibility that Germany and UK is also perceived to be more risky due to closer relations with the risky countries in the Eurozone, and, thus, attract more CDS activity. Thirdly, the liquidity results on the risky credits are relatively high on the whole, providing informal support for the application of CDS spreads as a measure of credit risk in periods of distress. This is especially true for the advanced economies in the risky category, represented by Italy, Spain, Greece, Portugal, and Ireland. We notice that the CDSs traded on the two major economies of Italy and Spain are particularly liquid. In fact, when the whole CDS market is accounted for, Italy and Spain still represent the reference entities with the highest aggregate gross notional values (DTCC 2012c). While Italy and Spain are trillion-dollar economies, more minor countries with high CDS spreads also seem to attract market activity. In addition to the developed nations, Hungary, classified as an emerging market, appears high on the list. The risky frontier markets, Ukraine and Croatia, seem to suffer under lower liquidity and are found in the bottom section of the table. Even though Ukraine’s gross notional is not far behind the Irish CDS, there seems to be a clear division when it comes to trading frequency. Additionally, since the frontier stamp signals equity market immaturity, we choose to exclude all countries below Ireland from further investigation.

6.2 Final sample – In light of the European debt crisis

The final sample thus includes the five South-West Eurozone Periphery (SWEAP) countries – Portugal, Italy, Ireland, Greece, and Spain[10], the emerging economy Hungary, as well as the two solid nations Germany and the UK. While all are EU members, Hungary and the UK use their own currency and are consequently not part of the Eurozone. In total, the eight countries represent approximately 35% of the sovereign single-name CDS market. Data on CDS spreads and equity values employed in the analyses of these countries is obtained from Bloomberg. The CDS quotes included refers to daily mid-spreads at closing and derive from the most liquid 5-year contracts. All spreads are denominated in local currency. In line with previous research on the topic, we use local stock indices as a proxy for the equity value of the country. Specifically, each country's equity is proxied by daily closing prices of their benchmark stock index:

- Germany: DAX
- Hungary: BUX
- Italy: FTSE MIB
- Spain: IBEX 35
- Greece: Athex 20
- Ireland: ISEQ Overall
- Portugal: PSI 20
- UK: FTSE 100

In total, the sample is comprised of 12,228 data points, equally divided between daily updated sovereign CDS spreads and stock index values. The data stems from the three-year period between April 24, 2009 and April 25, 2012 for seven out of eight countries under study. The exception is Greece, which has an observation period between April 24, 2009 and September 16, 2011[11]. While there are 626 updates for Greece, the remaining subsamples include 784 observations. Table 2 displays summary statistics for the series, revealing major disparities between the countries in the final sample:

[10] The quintuplet is often referred to by the more pejorative term "PIIGS" in the media.
[11] Bloomberg's data on Greek CDS spreads is not updated after September 16, 2011.

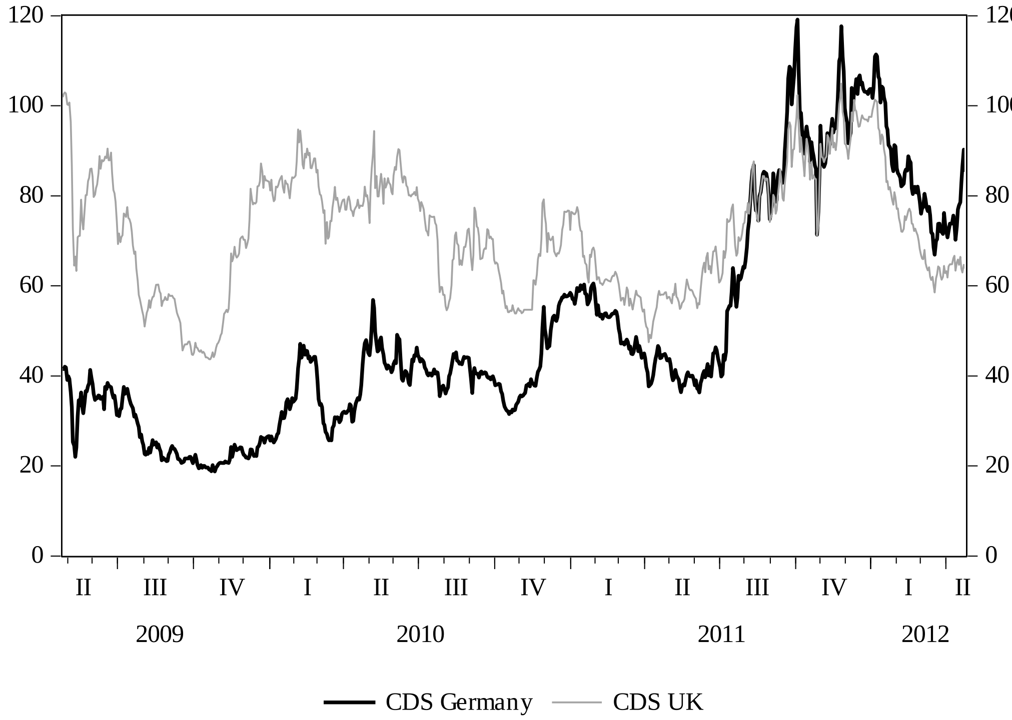
Table 2. Summary statistics

	Germany	Greece	Hungary	Ireland	Italy	Portugal	Spain	UK
				Panel A. CDS Spreads				
Mean	50,53	780,26	345,27	436,30	218,98	504,96	235,51	71,88
Median	42,45	766,34	311,58	469,10	173,57	403,34	234,47	72,02
Max.	119,16	5047,45	738,60	1191,50	591,54	1526,95	511,67	104,92
Min.	18,73	101,43	169,03	110,53	57,60	44,53	53,69	43,69
Std. D	24,53	672,62	126,86	252,42	141,01	408,37	123,62	13,71
Initial value	41,53	166,39	446,20	244,73	115,67	82,79	93,71	101,90
End value	85,34	3535,66	531,88	569,16	441,03	998,13	468,33	63,28
Period Δ	+43,82	+3369,27	+85,67	+324,43	+325,36	+915,34	+374,61	-38,62
				Panel B. Stock Index				
Mean	6183,4	884,6	20411,2	2900,4	19811,3	7186,8	9997,2	5425,4
Median	6083,9	781,2	21232,2	2902,8	20528,8	7418,2	10175,8	5503,5
Max.	7527,6	1559,1	25323,0	3497,2	24426,0	8882,7	12222,5	6091,3
Min.	4572,7	352,3	12365,2	2366,1	13474,1	5104,0	6846,6	4096,4
Std. D	720,8	280,6	2816,3	221,2	2806,7	976,5	1176,5	471,0
Period r	46,4 %	-62,5 %	34,4 %	32,9 %	-21,7 %	-21,8 %	-19,9 %	37,6 %
Obs.	784	626	784	784	784	784	784	784

Table 2 shows descriptive statistics for the CDS spread (Panel A) and stock index (Panel B) for the respective countries included in the sample.

Unsurprisingly, the two safe nations, Germany and the UK, visibly stand out with low average CDS spreads and the largest stock returns over the whole period. Germany's average spread of 50.53 bp is the lowest in the sample, with the UK's 71.88 as a clear second. As revealed by the higher standard deviation, the German spread has, however, been more volatile over the sample period when compared to the UK spread. The two premiums are graphed against each other in Figure 2a. Starting off at 41.53 bips, the German spread has wandered to a high 119.16 and low 18.73, before ending up at 85.34 bp. The British spread initiate close to its maximum and terminates at a level lower than the German CDS, explaining why the UK is better ranked than Germany in CMA's sovereign risk report. Note further that Britain is the only sovereign in the sample experiencing enhanced credit quality. The improved credit in the UK and the deterioration in Germany is partially a signal of differing links to the risky Eurozone countries. Crisis fears, the potential of a Euro break-up, and Germany's burden-sharing role are dragging down the largest economy in the Eurozone. Despite the UK's turbulent economy and highly leveraged financial industry, their CDS spread moved below the German premium in late 2011. In principal this may be attributed to the UK's own currency. Since the pound sterling gives the country a larger degree of monetary independence and flexibility, the market has been easier on the UK's creditworthiness. Noteworthy, the German stock market has gained over the sample period, although the country's credit is perceived to more risky.

Figure 2a. German vs. British CDS spread

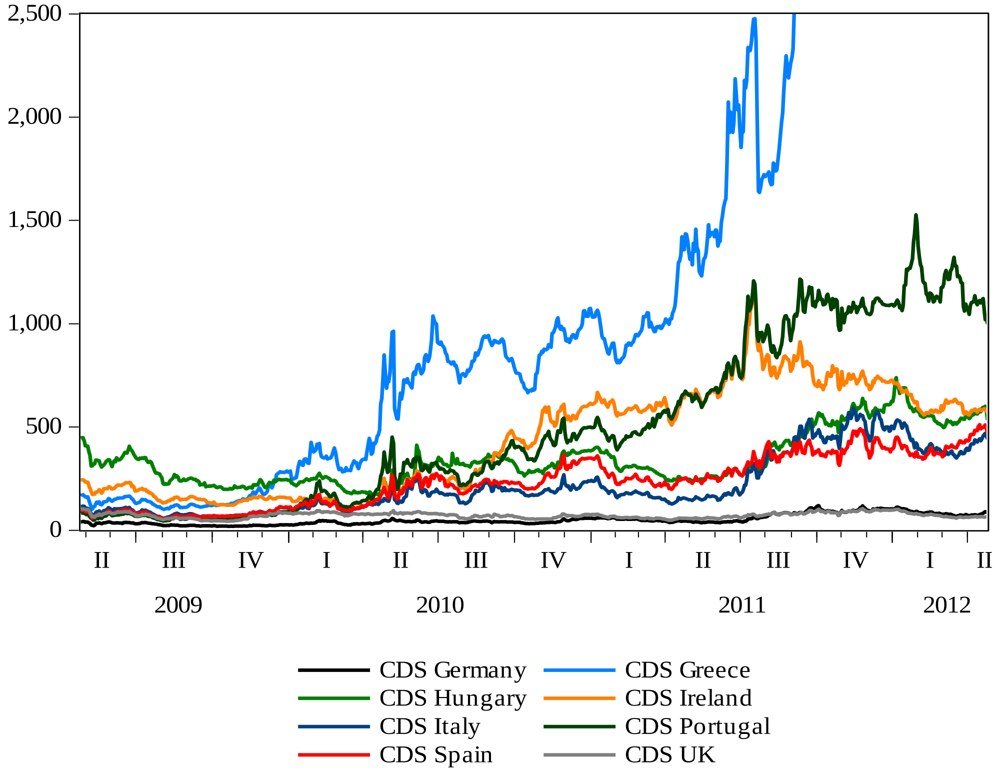


Deteriorating credit is particularly evident in the five SWEAP countries, with Greece severely surpassing the rest. Figure 2b paints a clearer picture of the development. Greece's CDS spread is by far the one with the highest mean and volatility during the investigated time frame[12]. Even though the real origins can be tracked down decades back in time, most commentators trace the initiation of the European debt crisis to the fall of 2009. Earlier in 2009, Greece refused to provide insight on its financial position, and when they, in mid-October 2009, revealed that their budget deficit was at 12.7 % of GDP the problems started to escalate. The deficit, which mainly is attributed to government overspending, was twice the size of earlier estimates and more than four times beyond the "acceptable" limit specified in EMU's Stability and Growth Pact. In 2009, the government debt level represented 127 % of GDP, and when rather vague austerity measures were announced, the markets gradually grew more concerned about the possibility of a

[12] In fact, the upper part of Greece's graph is left out in order to make it possible to visually separate the remaining CDS spreads in the figure.

Greek default[13]. The Athex 20 reached its sample maximum on October 14 and started to drop sharply later the same month. Moreover, Greece suffered credit downgrades from the three major credit rating agencies; Fitch, S&P, and Moody's, in December 2009, and was further slashed into junk territory in April 2010. The reactions in the CDS market are visible from late 2009 and into 2010. A combined credit package from EU and IMF, created in May 2010 and potentially worth over $146 billion, calmed down the markets for a short period, but the effect did not last long and the Greek CDS soon reached new record heights. Over the observation period, the Greek stock market fell over 60 %. The stock market continued to fall into 2012, and by the end of April, the Athex 20 had lost over 80 % from its sample peak. Albeit several measures were taken to improve the situation in Greece, deficit and government debt estimates remained high. Thus, it did not come as a surprise when ISDA in March 2012 declared that the second bailout package, involving a debt restructuring, constituted a credit event that triggered CDS payouts[14]. By the time the country "defaulted", public debt estimates amounted to about 160 % of GDP.

Figure 2b. Evolution of the CDS spreads



[13] All estimates on government debt in this section are extracted from the IMF World Economic Outlook Database, April 2012. If not noted otherwise, the budget deficit announcements are sourced from financial news.

[14] The press releases concerning the Greek default are available at www.isda.org.

Greece was not the only country in trouble, and from late 2009 high government debt levels and budget deficits in the peripheral Eurozone attracted gradually more attention. Ireland became the second country in the monetary union to seek assistance from the IMF and EU. Contrary to Greece, Ireland's troubles originate from the bailout of major financial players in the country, as several Irish banks suffered a double hit during the global credit crunch. The first hit was caused by a price bubble in the national property market which started to deflate in 2007, while the second came from overexposure to subprime derivatives. The economy collapsed in 2008 and Ireland was the first Eurozone country to fall into recession. With the ISEQ Overall Index losing 80% of its value from February 2007 to March 2009, accompanied by rising unemployment levels and suffering public finances, the country lost its triple-A rating during the spring of 2009. In response to the recession and failing financial sector, the government borrowed money from the European Central Bank to bail out private bondholders and for the issue of guarantees to six banks. The government's rescue operations, initiated in September 2008, grew costly and led to a record-high budget deficit of 32% in 2010. Between 2007 and 2011, public debt levels rose fast from 25 % to 104 % of GDP. This had dramatic effects on Ireland's creditworthiness, and a bailout program, including a $113 billion financial aid package, was agreed upon in November 2010.

The summary statistics and graphs in Figure 2b verify that the crisis in Ireland initiated earlier than in the rest of the SWEAP countries. Hungary, the emerging economy, is the only reference entity in the sample with initial CDS values higher than Ireland. However, the bailout program, including several austerity measures and interest rate cuts in 2011, has helped to restore some stability in the Irish economy and the country has gradually moved out of the spotlights. In fact, Ireland is the only country among the SWEAPs with a positive stock return over the observation period. The improvement is also discernible in the credit protection market. From a maximum of 1191.50 bp in July 2011, the Irish CDS spread fell to more sustainable levels during the last part of the sample and is now surpassed by both Greece and Portugal. Interestingly, Ireland returned to the debt market in July 2012 for the first time since the bailout in 2010, paying less than the non-program countries Italy and Spain.

During first half of 2010, the financial turbulence, which until then had been confined to Greece and Ireland, reached Portugal, Spain, and Italy. The contagiousness is visible in the market, with the spreads of the latter countries reacting slower than the former. Being mostly a result of years with federal overspending and poor investments, the Portuguese problems escalated when the government reported the 2009 budget deficit, estimated to 9.3% of GDP, early in 2010. Thereafter, the cost of protecting Portuguese credit increased fast on the basis of a recessing economy as well as high public debt. In April 2011, following a series of credit downgrades, Portugal became the third Eurozone country to ask for a financial bailout from the EU and IMF. At the time, the government debt level had crossed 100 % of GDP. A $116 billion rescue program, set to stabilize the country's public finances, was agreed upon in May. Despite the implementation of various austerity measures, the markets still doubted the country's ability to recover from the recession and handle its debt burden. The high CDS spreads observed at the end of the sample period verifies the market concerns of Portugal following in the footsteps of Greece.

Compared with other advanced economies, Spain's public debt level has been far from an outlier. IMF's 2009 estimate for Spain amounted to 54 % of GDP, while government debt levels in countries such as Germany and the UK represented 74 % and 68 %, respectively. Compared to the rest of the SWEAP nations, Spain is undoubtedly the country with lowest debt-to-GDP ratio. Still, Spanish CDS spreads have climbed almost 400 bp in three years. Over the same period, the IBEX 35 has lost 20 % of its value. As one of the largest economies in the EU, Spain has been put under pressure by the markets due to its ailing banking industry, substantial budget deficits, and weak growth. After several upward adjustments of Spanish deficit forecasts, the country had lost its AAA ratings at the three major rating agencies by October 2010. The same year, Spain's government implemented a number of measures to reduce the deficits and withhold a financial collapse. Even though the deficits were slightly reduced, the economy remains in the danger zone. Several vulnerabilities may be pointed out. First, from its sample peak in January 2010, the IBEX 35 slumped over 40 % before the last observation date in April 2012, and the stock market is still under severe pressure. Second, with ratios surpassing 20 % in 2010, the contracting economy suffers under the highest unemployment rate in the Eurozone[15]. Finally, the estimated 2011 deficit amounting to -8.5 % of GDP, gives Spain the 189th place, just in front of Greece and Ireland, when countries are ranked according to their budget performance[16]. Estimates from 2012 show that the financing of budget deficits have increased Spain's debt-to-GDP ratio to 79 %, effectively putting more pressure on the country's ability to pay off its debt. Rising CDS spreads throughout 2011 and in the first months of 2012 verify the troubles, reflecting concerns in the market about Spain's chances to endure without a bailout. The situation in Spain intensified in the months following our observation period, and in July 2012, the EU granted the country a $125 billion rescue package, particularly designed to shore up Spain's banking sector.

Italy's evolution closely resembles the one of Spain. From an initial value of 116 bp, the CDS spread has climbed 325 bips over the sample period, leaving the end premium just below Spain's. The FTSE MIB fell 21.7 % over the whole period, and 40.2 % from its sample maximum in October 2009. In spite of the similar development, the underlying reasons for the widening CDS spreads differ from the case with Spain. While the budget deficits, estimated to be -3.9 % of GDP in 2011[17], are more than half of what Spain is experiencing, the country suffers under remarkably high government debt. The debt-to-GDP ratio has grown steadily over the past years and reached 120 % of GDP in 2011, giving Italy one of the largest debt burdens in the world. The country is only surpassed by Greece in Europe when the economy size is accounted for. Due to the high debt burden, along with weak economic growth, Italy's borrowing costs started to rise in late 2010. Despite the implementation of several austerity measures, the yield on 10-year government bonds climbed to unsustainable levels during the second half of 2011 and crossed 7 % in early November 2011. Rising default fears are clearly discernible in the CDS market in the last part of 2011, with the Italian spread reaching its peak on November 15. The new technocratic government, installed the same month, has implemented new debt-reduction measures and been able to reduce Italy's borrowing costs to some extent. Correspondingly, the Italian CDS

[15] The unemployment rates are also sourced from the IMF World Economic Outlook Database, April 2012.
[16] Sourced from the CIA World Factbook.
[17] Sourced from the CIA World Factbook.

spread is down from its maximum, but still remains high as our observation period comes to an end.

Hungary is different from the SWEAP countries in that they enter the sample period with a relatively high CDS spread and only experience slight credit deterioration when the whole period is accounted for. However, the CDS spread volatility is at the level of troubling Eurozone countries, reflecting the considerable challenges facing the country. The global financial crisis had harsh effects on the Hungarian economy, and in October 2008, the country was bailed out by the EU and IMF to prevent the country from defaulting on its debt. Amplified by implementation of strict austerity measures, the global downturn forced the Hungarian economy into a severe recession in 2009. The relatively high Hungarian CDS spreads in the beginning of the sample period is a clear sign of the lack of market confidence that was present in the wake of the financial crisis. Moderate economic recovery was achieved in 2010 and 2011, but Hungary's exposure to the Eurozone crisis, along with a troubling currency and political issues, has put the country under pressure from the markets again. Fears about Hungary defaulting on its debt remain high, and is also exacerbated by the troubles facing Eurozone banks. With a ratio fluctuating around 80%, Hungary is the country with the highest debt-to GDP level in Eastern Europe. As large portions of Hungary's credit are provided by Eurozone banks, the economy is heavily exposed to the situation in Western Europe. Seeing that the Hungarian CDS spread largely follows the pattern of the SWEAP countries from late 2010 this is also evident in the CDS market.

In summary, the final sample includes six risky nations, represented by the SWEAPs and Hungary, and two less risky nations in Germany and the UK. The risky countries have on average experienced severe credit deterioration over the investigated time frame, but certain individual characteristics should be noted. The Hungarian credit deterioration is relatively smaller than in the remaining countries since their CDS spreads initiates the sample period at a high level. Largely due to their early recession, Ireland experience high initial CDS spreads, while they, in contrast to the remaining risky nations, see an improved credit quality at the end of the period. Regarding the least risky nations, the UK is the only country that actually experience credit improvement over the sample period.

The German CDS spread is slightly up, possibly reflecting closer connections to the risky Eurozone countries.

7 Methodology

The procedure used to answer our research questions is closely linked to the methodology outlined in Chan-Lau and Kim (2004). In addition to a descriptive part, exclusively focused on correlations, we rely on cointegration analysis and the estimation of VAR-type models to analyze the intertemporal price relationship between the markets. If cointegration is detected, a vector error correction model (VECM) may be used to estimate the cointegrating equation and used as a starting point for price discovery analyses. In case of no cointegration between the market prices, the appropriate strategy is to employ a vector autoregressive (VAR) model, in which Granger causality is used to test price leadership. This section further elaborates on the relevant methodology[18].

7.1 Correlation analysis

Merton's theory predicts that there is an inverse relationship between stock values and CDS spreads, and that this inverse association should be stronger when the entity is closer to default. The existing literature has widely confirmed the relationship at the corporate level, but there is less evidence on Chan-Lau and Kim's (2004) extension to sovereign. It is, though, believed that widening sovereign CDS spreads are associated with a falling local stock market, with the association being stronger in close-to-default situations. In order to investigate the hypothesis of a negative relationship and to discern differences related to credit quality, we calculate the correlation between the stock and CDS market.

Correlation is a measure of co-movement between variables and serves as an adequate starting point for our analyses. The correlation between variables can be measured by the use of different statistic techniques. The statistics in Appendix C, indicate that our data suffers under normality issues[19]. Considering the normality

[18] Various textbooks contain useful information on the econometric techniques used in this paper. For the purpose of our analyses we have employed Alexander (2001), Brooks (2008), and Juselius (2006) in addition to the related articles.

[19] The high number of observations makes us confident that the violation of the normality assumptions is practically inconsequential in the regression analysis.

assumptions for using Pearson correlation coefficient, we consider it more appropriate to use the non-parametric Spearman rank correlation (Hauke and Kossowski 2011). Other favorable properties, such as relaxed assumptions regarding linearity and homoscedasticity, further support the use of Spearman rank correlation. Emphasizing the suitable characteristics with regards to non-normally distributed data, related literature, such as Byström (2005) and Norden and Weber (2008), apply Spearman rank correlation in their analysis between CDS spreads and stock indices.

Spearman correlation is a modified version of Pearson correlation, calculated between the ranked variables. By assigning a rank to both variables for all pairs of variables in the data set, Spearman rank correlation calculate a coefficient based on the difference between the rank of the variables. The coefficient, normally denominated as rho, is given as:

$$\rho_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \tag{3}$$

where d^2 is the squared difference of statistical rank between the corresponding variables and n is the number of pair wised variables observed. Ranging from –1 to + 1, the estimated coefficient offers a measure for the magnitude and the associated direction of the relationship between the variables. The sign of the coefficient signals whether the relation is positive or negative, while a coefficient closer to –1 or +1 indicates a stronger relationship. Finding the correlation between the CDS spread and stock price to be negative, imply that the CDS spread tends to narrow when the stock price increases and widen if the stock price decreases. However, it should be noted that the correlation measure is diffuse and suffer under clear limitations. Correlation between two variables does not imply causation, as it merely suggests that the variables have a mutual relation. Hence, it cannot serve a price discovery measure. Also, as a foundation to design arbitrage strategies, the correlation measure is not sufficient. The fact that a set of variables are correlated, does not imply that they are cointegrated. Correlation does not secure the efficiency of an arbitrage strategy, as the variables can diverge from each other without any mechanism that makes them converge in the long run.

7.2 Price equilibrium

Merton's theory, along with arbitrage arguments, makes it interesting to test for the existence of an equilibrium price relationship between country-specific CDS and equity markets. The hope to find such a relationship relies on the markets' simultaneous pricing of sovereign risk, and, hence, their shared dependency to given pieces of information. If the markets price the risk of sovereign default equally in the long run, one would expect their prices to be cointegrated. That is, the time series may deviate from each other in the short run, but share a common stochastic trend binding them together in the long run. With no cointegration, the sovereign CDS spread and its associated stock index may wander apart without boundaries. Following the prevailing convention, the analysis of long-term price relationships is conducted in two steps. First, the price series are tested for unit roots to ensure stationarity. Next, we use cointegration tests to conclude on the presence of long-term equilibrium relationships.

A (weakly) stationary series has a constant mean, a constant variance and a constant autocovariance structure[20], implying that the process is stochastic and whose probability distribution is time independent. A regression containing non-stationary series may lead to spurious results, i.e., OLS may falsely indicate that the variables move together in a close relationship even though they are totally unrelated. Moreover, the standard assumptions for asymptotic analysis will be invalid as the relevant test statistics will no longer follow their associated distributions. In other words, it is not possible to validly draw conclusions about the estimated regression parameters if non-stationary data is employed. So, in order to analyze the equilibrium relationships between country-specific CDS spreads and stock indices, it is required that the variables are stationary. To ensure stationarity we rely on Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. The basic objective of both tests is to examine the null hypothesis that the series contains a unit root against the alternative of a stationary series. Generally, the ADF test for a specific variable y is carried out by assessing ψ in the following regression:

[20] If the process is weakly stationary and also satisfies normality requirements, it is said that the process is *strictly* stationary. However, in practice weak stationarity is sufficient.

$$\Delta y_t = \psi y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + u_t \tag{4}$$

where the null of a unit root is rejected for $\psi < 0$. The lags of Δy_t are included to soak up any left-over autocorrelation in the error term. The PP procedure is similar to ADF test, but instead of including lags it incorporates an automatic correction for autocorrelation.

Initially, tests are run on the level series of the variables. According to the efficient market hypothesis along with rational expectations, financial prices should follow a random walk, possibly with a drift. Given the time period under investigation, which is dominated by financial turmoil, we consider it likely to find stock indices (CDS spreads) drifting downwards (upwards). A random walk typically exhibits long swings from its rarely-crossed average value and it is thus expected to find the level variables to be non-stationary. In such cases, there is a stochastic trend in the data, and differencing should be carried through to induce stationarity. Generally, a non-stationary series, y_t, that must be differenced *d* times before it becomes stationary is said to be integrated of order *d*. In other words, a series that must be differenced *d* times to induce stationary contains *d* unit roots. Formally, it may be written:

$$y_t \sim I(d) \quad then \quad \Delta^d y_t \sim I(0) \tag{5}$$

Most financial times series are integrated of order one, so-called I(1) series, and must be transformed into a stationary I(0) by differencing once (Brooks 2008: 326). Graphically, the data is transformed from a time series of a non-stationary random walk, or a random walk with a drift, to a stationary white noise process, which frequently crosses its mean value of zero. However, by differencing the time series to obtain stationarity, we lose a great deal of economic content and information about the long-term relationship between the variables. Equilibrium theories are normally in levels, and a differenced equation has little to offer in equilibrium. Cointegration, which may be seen as a statistical proof of a long-term relationship, serves as a solution to the undesirable complication.

If cointegration is detected between two variables, one may validly include their level terms in the estimated equations. Engle and Granger (1987) demonstrate that if there exists a linear combination of two non-stationary I(1) variables which is stationary, I(0), the time series are cointegrated. That is, the disturbances of the linear combination are stationary. So, if the country-specific CDS spread and stock index are non-stationary of the same order, we can combine them and prove that there exists a cointegrating relationship if the residuals are stationary. The *Granger representation theorem* proclaims that "if there exists a dynamic linear model with stationary disturbances and the data are I(1), then the variables must be cointegrated of order (1,1)" (Brooks 2008: 339). This implies that the linear combination is oscillating around a constant mean with constant variance and autocovariance. The stationary combination of the time series is then referred to as the cointegrating equation, and may be seen as a long-term equilibrium relationship between the variables. Even though the variables may deviate in the short run, it is expected that market forces, such as capital structure arbitrage, make them return to their association and move together in the long run.

Engle and Granger, themselves, have developed a residual-based single equation approach to test for cointegration. However, since there is no theoretical foundation for treating neither CDS spreads nor stock indices endogenously, the Engle-Granger two-step method is unsuitable for the purpose of our analysis. Specifying one variable as dependent only provides us with a chance of suffering under a simultaneous equation bias. Moreover, it is not possible to make statistical inferences about the cointegrating relationship if the Engle-Granger approach is employed. Instead, we rely on a VAR-based cointegration rank test as proposed by Johansen (1991). By turning a VAR into a VECM, the Johansen technique allows us to conclude on the presence of a price equilibrium relationship without making any assumptions about causality. A VAR of order *p* could be set up:

$$Y_t = \beta_1 Y_{t-1} + \cdots + \beta_p Y_{t-p} + \varepsilon_t \qquad (6)$$

where Y_t is a 2×1 vector of the two non-stationary price series and ε_t is a vector of innovations. Accordingly, the VAR is turned into a VECM of the form:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \tag{7}$$

where $\Pi = \sum_{i=1}^{p} \beta_i - I$, and $\Gamma_i = -\sum_{j=i+1}^{p} \beta_j$. A 2×1 vector of the price series in their first differences is modeled on the VECM's LHS, while $p - 1$ lags of the differenced price series are included on the RHS. The crux of Johansen's test is to determine the rank of Π, which may be interpreted as the long-run coefficient matrix. Essentially, all information about long-run effects is summarized in this matrix (Juselius 2006: 60). Finding the coefficient matrix Π to have reduced rank implies that there exists a cointegrating relationship between the two variables. Contrary, a matrix with rank equal to zero suggests that the null hypothesis of no cointegrating vectors cannot be rejected, implying that there is no price equilibrium relationship between the variables. In addition, concluding that the matrix has full rank implies that the original variables are stationary. Hence, the Johansen rank test also acts as a supplementary unit-root test.

7.3 Lead-lag relationship

Since both equity and CDS markets to a large extent rely on similar news, particularly in close-to-default situations, it is of economic interest to analyze which of the markets that dominate price discovery. Hasbrouck (1995: 1175) refers to the price discovery process as "the impounding of new information into the security price". More specifically, it may be seen as "the efficient and timely incorporation of information implicit in investor trading into market prices" (Lehmann 2002: 259). Essentially, price discovery takes place in the market where new information first is reflected. In frictionless and informationally efficient markets, new information is incorporated simultaneously into prices. Under these circumstances, the prices are perfectly contemporaneously correlated and price changes are expected to occur synchronous if relevant news is released. If, by contrast, one price is found to "lead" the other, the markets are cross-autocorrelated and pricing inefficiencies exist. The existence of such inefficiencies provides market participants with the opportunity to make use of price disparities by inspecting the market that incorporates news most quickly and hence dominates price discovery.

Conclusions on cointegration lay down the methodical approach that should be used in the price discovery analysis. In the absence of cointegration, a vector autoregressive (VAR) model is the appropriate starting point to analyze the lead-lag relationship between the variables. If cointegration is detected, the correct approach is to transform the VAR into a vector error correction model (VECM). The rationale for the split-up can, for instance, be extracted from econometric definitions: Variables will in the long run converge upon some long-term value and no longer be changing, forcing all difference terms to zero in equilibrium (Brooks 2008: 338). Basically, this implies that a model based on first differences has no long-term solution. If the null hypothesis of no cointegration cannot be rejected, the correct econometric modelling approach is to specify a VAR in first differences. Unsurprisingly, the model has no long-run equilibrium solution, but since cointegration tests already have revealed that no such equilibrium is present, the approach is correct. One of the major advantages of a VAR model is that it treats all variables as endogenous, allowing us to estimate the model without forcing one of the variables to be exogenous. By modelling the current value of one variable as a function of both its own p lags and the p lags of other endogenous variables, the VAR framework provide us with a structure that captures more features of the data than traditional autoregressive models. Most important, the VAR model gives us the opportunity to interpret the dynamic lead-lag relationship between CDS and stock markets. The general matrices representation in (5) can be extended to a bivariate VAR, involving two equations that should be estimated for all selected countries:

$$y_t = \alpha_1 + \sum_{i=1}^{p} \beta_{1i} y_{t-i} + \sum_{i=1}^{p} \gamma_{1i} x_{t-i} + \varepsilon_{1t} \quad (8)$$

$$x_t = \alpha_2 + \sum_{i=1}^{p} \beta_{2i} y_{t-i} + \sum_{i=1}^{p} \gamma_{2i} x_{t-i} + \varepsilon_{2t} \quad (9)$$

where y_t and x_t are stationary versions of the two price series and ε_t is a white noise error term[21]. Since the model is on reduced form, i.e., all RHS variables are predetermined, each equation can be estimated using ordinary least squares (OLS) without violating the requirement for consistency and unbiasedness.

[21] Transformations of the original price series are carried through to ensure that stationary variables are employed.

If the underlying theory holds, coefficient estimates should portray an inverse relationship between the country-specific stock return and CDS spread. That is, we expect to find negative coefficient values for the CDS spread changes in the stock equation, and vice versa. By inspecting the significance of each set of coefficients, we are able to extract information on the lead-lag relationship between the variables. For example, if the *x* market has a leading role, the gammas in (7) will turn out significant at the same time as the betas in (7) and (8) remain insignificant. However, since the equations involve several lags of each variable, variations in the coefficient signs and their degree of significance are expected. In the end, it may be difficult to decide on where the price discovery resides. To cope with the problem, we base the price discovery analysis on the presence of Granger causality. Granger causality, which was introduced by Clive Granger in 1969, answers whether all lags of a particular variable are jointly significant. In our bivariate system, *x* is said to Granger-cause *y* if the information in the former variable can improve the forecast of the latter variable. Similarly, *y* Granger-cause *x* if the opposite is true. Specifically, we test Granger causality from *x* to *y* by conducting a chi-squared test for the joint significance of $\gamma_{11},\dots,\gamma_{1p}$ in (7), while Granger causality from *y* to *x* is evaluated by testing $\beta_{21},\dots,\beta_{1p}$ in (8). It should be noted that "causality" in this context is somewhat misleading. Derived from correlations, Granger causality says nothing about causation between the series. Nevertheless, the test yields information about "the chronological ordering of movements in the series" (Brooks 2008: 312), and, thus, validly provides useful insight on the markets' responsiveness to new information.

If, on the other hand, the series are cointegrated, a VECM is applicable for the price discovery analysis. Lütkepohl (2007) argues that a VECM offer a particularly convenient parameterization for model specification and economic analysis if the variables are cointegrated. Additionally to the regular VAR component, the VECM consist of a common cointegrating vector, effectively capturing the long-term relationship. Although the cointegrating relationship prevents the variables to wander apart, they are frequently out of equilibrium in the short run. The lambda coefficients, as presented in the equations below, provide estimates for the error correction of the markets, coercing the markets back to their long-run relation. As the model is based on a combination of first differentiated and lagged levels of cointegrated variables, it overcomes the problem of no equilibrium faced by a VAR in differences. The VECM representation can be viewed as a restricted version of the VAR model. Accordingly, the VAR could be turned into a VECM on the form:

$$\Delta x_t = \lambda_1 \Pi + \sum_{i=1}^{p} \beta_{1j} \Delta x_{t-j} + \sum_{i=1}^{p} \gamma_{1j} \Delta y_{t-j} + \varepsilon_{1t} \quad (10)$$

$$\Delta y_t = \lambda_2 \Pi + \sum_{i=1}^{p} \beta_{2j} \Delta x_{t-j} + \sum_{i=1}^{p} \gamma_{2j} \Delta y_{t-j} + \varepsilon_{2t} \quad (11)$$

where $\Pi = (x_{t-1} - \alpha_0 - \alpha_1 y_{t-1})$ is the cointegrating vector, and λ_1 and λ_2 provides estimates for the speed of adjustment towards a long run equilibrium. A strong one-way adjustment is evident whenever one of these coefficients is negative and significant, while the other is insignificant, providing an opportunity to distinguish where the price discovery takes place. A significant negative lambda coefficient in the CDS equation implies a price adjustment of the stock market to the CDS market, indicating that the CDS market leads the stock market. The opposite is true if the lambda coefficient is significantly negative in the stock equation. Similar to the regular VAR, the rest of the components in the VECM provide estimates for the short run relationship of the variables.

If cointegration is found we use the Gonzalo-Granger (GG) measure as a robustness check in the price discovery analysis. In order to determine the contribution from each market to price discovery, the GG-measure can be calculated from a VECM. Gonzalo and Granger (1995) showed that the contribution of each market is proportional to the variables' relative weight in determining the common cointegrated vector. Hence, the contribution associated with x-variable is defined by:

$$GG_x = \frac{\lambda_2}{\lambda_2 - \lambda_1} \quad (12)$$

while the contribution from the *y*-variable is defined by:

$$GG_y = \frac{\lambda_1}{\lambda_1 - \lambda_2} \quad (13)$$

A GG-measure close to one implies that the market contributes to most of the price discovery, while an estimate of 0.5 implies that the two markets contribute equally to the price revelation.

8 Results

In this section, we present the results of our data analyses. First, to get a feeling of the interaction between stocks and CDS spreads, we examine correlations between the variables for each of the countries included. Secondly, the results on cointegration provide deeper insight about the integration between the markets. The results on cointegration yield the starting point for the price discovery analysis, which finally is presented to provide evidence on the lead-lag relationship. Subsequently, Section 9 is used to discuss our findings in more detail, particularly focusing on their relation to previous literature.

8.1 Correlation analysis

The correlation analysis is conducted on the raw data in our data set, giving us a general impression of the co-movements between the markets[22]. To discern variations related to credit quality, the analysis is performed independently for each country in the final sample. Recognizing the dynamics in the relationship, which is particularly affected by the fact that each country has faced *different* circumstances at *different* points in time, we further split the sample in yearly sub-periods. Before we formally estimate the correlation coefficients, we graph each pair of series over the investigated time frame. The country-specific graphs, found in Appendix 2, largely confirm the inverse relationship between CDS spreads and equity values. With exception of the DAX in Germany, all stock indices have moved in the opposite direction of their associated CDS spreads when the whole period is accounted for. As pointed out in the data section, the German stock market has moved upwards even though the creditworthiness of the country is slightly reduced. Further the graphs seem to suggest that the opposite movements become more pronounced when the countries face financial turmoil. Notice, for instance, the sharpness of the inverse movements visible in most SWEAP nations

[22] As you will notice, appropriate data transformations are carried through before we estimate the econometric models in the following subsections.

from late 2010, following the escalation of the European debt crisis. The visual impression is verified by Spearman's coefficients, presented in Table 3.

Table 3. Spearman's rank correlation: ρ [S,CDS]

Country	2009 - 2012	2009	2010	2011
Germany	0,32	-0,71	0,08*	-0,80
Greece	-0,96	-0,41	-0,87	-0,94
Hungary	-0,56	-0,88	-0,48	-0,91
Ireland	-0,40	-0,70	-0,78	-0,58
Italy	-0,77	-0,49	-0,80	-0,86
Portugal	-0,66	-0,39	-0,30	-0,90
Spain	-0,75	-0,10*	-0,72	-0,90
UK	-0,29	-0,43	-0,51	-0,75

Table 3 presents Spearman's rank correlation for each country in the final sample. The results are reported for the sample period as a whole and for yearly sub-periods. The 2012 sub-period is excluded since it contains a significantly lower number of observations than the remaining years. The marked (*) coefficients are *insignificant* at the 10 % level. The other coefficients are all significant at the 1 % level.

The results largely support H1 and H2. A significantly negative rho is observed for seven out of eight countries overall and for 22 out of 24 sub-sample coefficients, providing evidence for the negative relation deduced from theory. The inverse co-movement between the markets also seems to be stronger in close-to-default situations and in periods where credit deterioration is apparent. This conclusion is backed by a number of observations. First, in a comparison between risky and less risky nations, the overall correlation coefficient is relatively higher for all risky reference entities. The insignificantly positive and low-negative coefficients observed in Germany and the UK, respectively, seems somewhat arbitrary, signaling a lower sensitivity between the markets where default is an absent threat. Secondly, gradually increasing coefficients are observed for most countries, and, with exception of Ireland, the strongest correlations are attained in 2011. This is largely a sign of the intensification of the European debt crisis, which essentially has led the countries closer to a default. For example, Greece has been the most risky country in the sample since November 2009 and basically out-of-the-money for large parts of the investigated time frame. Accordingly, the country is also coupled with the highest correlation overall and also in the sub-periods of 2010 and 2011.

Finally, the correlations seem to adjust as the countries move closer and farther away from the default barrier. Being the first Eurozone country to enter recession, Ireland suffered credit deterioration at an earlier stage compared with the remaining SWEAP countries. Additionally, the Irish economy displayed signs of improvements, reflected by a lower CDS spread, towards the end of the observation period. Observing higher correlations for Ireland in the two first sub-periods is, thus, sensible from a theoretical point of view. A similar trend may be pointed out in Hungary, which was close to default in late 2008 and experienced a severe recession in 2009. The country opened with the highest CDS spread and also experienced highest correlation between the markets in the first sub-period. The economy showed signs of improvements, leading to a lower CDS spread and reduced correlation coefficient, in 2010. In contrast to Ireland, the Hungarian economy was again put under considerable pressure by the markets in the last part of the observation period, which explains the high correlation experienced in 2011.

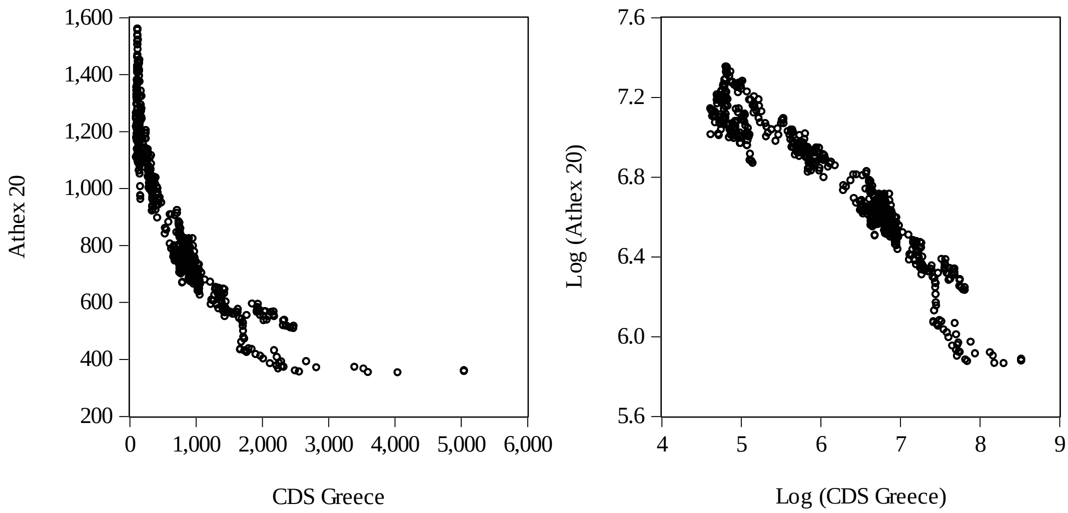
Again, it is important to emphasize the limitations of the correlation measure. The preceding analysis only tells that high CDS spreads are associated with low stock index values, and vice versa. In turn, this negative association seems to be stronger when default is a particular concern. However, it is not possible to draw any conclusions about convergence or causation. Even though the series are highly correlated the series may wander away from each other in the long run, i.e., the basis between them may widen over time, and severely harm the efficiency of arbitrage strategies. Moreover, it does not say anything about how their changes are related or which of the markets that react first to relevant news. Hence, the relationship is studied in more depth in the following sub-sections.

8.2 Price equilibrium

If the country-specific series are cointegrated, this largely implies that there exists market forces that keep them aligned. Even though they may wander apart, the variables share a common stochastic drift that makes them converge and return to the same basis in the future. Hence, finding such a relationship suggests that arbitrage strategies based on the series interrelation may be applicable. Further, this implies that an equilibrium correction term may be implemented in the price discovery analysis. Thus, we move on to test for the existence of a cointegrating relationship between the variables.

Prior to the econometric testing and model estimation, we log-transform both the CDS spread and the stock index values for all countries. While logarithmic transformation is the norm when working with stock values, there is no set convention in the case for CDS spreads. Early research mostly uses the untransformed variant, whereas more recent papers, such as Forte and Pena (2009) and Forte (2011), chose to log the spread. We motivate the data transformation by the wide data range seen for many of the countries in the sample. More specifically, we observe relatively low CDS spreads in the first stages as compared to the last stages, yielding close-to-exponential series for countries such as Greece. By transforming the data using natural logarithms, we obtain the linearity required for using OLS. As an example, Figure 3 shows the effect of the log-transformation for Greece.

Figure 3. Log-transformation for Greece



The effect on linearity is most pronounced for Greece. However, to obtain consistency, we choose to implement the transformation for all countries. The step is further motivated by improved normality of the sample as a whole. Appendix C shows that a reduced Jarque-Bera statistic is obtained for the majority of the sample when logs are taken. Furthermore, natural logarithms will also rescale the data, resulting in a more constant variance, to help us overcome heteroskedasticity issues. Conveniently, the log-transformation does neither disrupt the cointegration analysis, as log prices normally will be cointegrated when their actual prices are (Alexander, 2001: 348).

To test for existence of a long-term equilibrium relationship between the series, we employ the two-step procedure outlined in the previous section. Table 4 presents the results of the ADF and PP unit root tests[23].

Table 4. Unit root tests

Country	ADF		PP	
	Panel A. Levels			
	Log (CDS)	*Log (Stock)*	*Log (CDS)*	*Log (Stock)*
Germany	-1,237	-2,431	-1,051	-2,382
Greece	-0,048	-0,625	-0,161	-0,356
Hungary	-1,529	-3,234**	-1,288	-3,232**
Ireland	-0,960	-3,120**	-0,814	-3,013**
Italy	-0,890	-1,075	-0,878	-0,915
Portugal	-0,856	-0,423	-0,855	-0,261
Spain	-0,812	-1,054	-0,865	-0,886
UK	-3,074**	-2,907**	-2,937**	-2,875**
	Panel B. First differences			
	Log (ΔCDS)	*Log (ΔStock)*	*Log (ΔCDS)*	*Log (ΔStock)*
Germany	-22,728***	-26,282***	-22,376***	-26,265***
Greece	-16,047***	-21,733***	-17,121***	-27,665***
Hungary	-22,988***	-28,213***	-22,615***	-28,245***
Italy	-19,161***	-27,353***	-21,019***	-27,512***
Ireland	-21,821***	-28,734***	-21,228***	-28,938***
Portugal	-15,595***	-26,628***	-19,282***	-26,702***
Spain	-17,634***	-20,908***	-23,925***	-26,126***
UK	-24,604***	-27,261***	-24,443***	-27,371***

Table 4 presents the adjusted t-statistics of the Augmented Dickey-Fuller test (ADF) and the Phillips-Perron test (PP). Panel A shows the estimates for the test in levels, while Panel B reports the estimates obtained in first differences. One, two, and three stars next to the t-statistics represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A reveals that most of the level series are characterized by unit roots. However, ADF and PP suggest that the equity prices in Hungary and Ireland are stationary in levels, while both the CDS spread and equity prices are stationary in the UK. From a theoretical point of view, this is somewhat contradictory. As previously discussed, theory suggests, and have mostly found, that the majority of financial asset prices are I(1). This is well-known for stock values, but also the case for CDS spreads[24]. For example, finding the CDS spread and the stock

[23] The optimal lag length in the tests reported here is determined by the Schwarz criterion. The results are, however, consistent across different information criteria.

[24] To our knowledge, all literature on the topic use first differences to induce stationary CDS spreads.

market implied credit spread to be stationary in levels for a few companies, Forte and Lovreta (2012) conclude that both series are I(1) processes in levels and I(0) in differences. We believe that the findings in our case are a direct result of the specific observation period under study, and specifically due to the fluctuating movements caused by the financial turmoil in the given time frame. By inspecting the graphs in Appendix B, it seems clear that the series, which are tested to be stationary, intrinsically are non-stationary random walk processes. This is also verified by unit room tests on other time frames and by investigating a VAR in levels[25]. Recognizing that reputable literature, such as Plosser and Schwert (1978), argue that underdifferencing is far more serious than problems caused by excessive differencing, we move on to perform tests on the series first differences. As presented in Panel B, the null hypothesis of a unit root can now be convincingly rejected for all variables, implying that the variables are of order I(1).

Subsequently, the Johansen rank test is applied to test for equilibrium price relationships, and the p-values obtained from the trace statistics are presented in Table 5[26]. Since the null of no cointegrating vectors is rejected at the 5 % level in seven out of eight countries, indicating that the coefficient matrix has a rank equal to zero, a long-run equilibrium relationship seems to be absent between the variables. The UK variables appear to be cointegrated at the 10 % level, but, in light of the unit root tests, we fear that these results are biased. Since both the CDS spread and the stock values are found to be statistically stationary over the investigated time frame, one would expect the linear combination of them to be stationary as well. Since cointegration tests should be performed on non-stationary data, and the UK series seems to be a special case, we cannot draw any confident conclusions about cointegration based on the weak significance obtained here. Hence, we choose to keep the conservative null of no cointegration also in the case for UK. As a result, the linear combination of the two variables is found to be non-stationary for all countries, implying that there is no common stochastic trend between the CDS spreads and their associated stock index. On

[25] The VAR in levels for the UK actually yielded an R-squared of 0.98 for both the CDS and stock equation, largely confirming the spuriousness of using the level terms in the model estimation. The test results are available upon request.

[26] The lag length in the VECM is determined using Akaike's information criterion. However, the cointegration results are consistent across different lag lengths

statistical grounds, the results therefore suggest that the series are not bound together in the long run, which clearly weakens H3. Apparently there are some elements that disrupt the relationship between sovereign CDS spreads and local stock indices. The results further suggest that the inclusion of an error correction term in the regressions is invalid, effectively limiting the price discovery analysis to the use of bivariate VAR models.

Table 5. Johansen rank test

	None	At most 1
Country	**Trace stat.**	**Trace stat.**
Germany	10,6027	3,0078
Greece	14,4546	3,6610
Hungary	15,0549	1,5962
Ireland	13,3327	1,8229
Italy	10,9112	1,9226
Portugal	17,0186	7,9358
Spain	13,8885	4,8611
UK	19,5842*	6,4521

Table 5 presents Johansen's trace statistics. The column labeled "None" refers to the null hypothesis of more than zero cointegrating relationship. The column labeled "At most 1" refers to the null hypothesis of at most one cointegrating relationship. The marked (*) coefficient is significant at the 10 % level. All other coefficients are *insignificant.*

8.3 Lead-lag relationship

While the cointegration analysis gives us insight on the characteristics of the CDS spread-equity relationship, this sub-section further investigates how the markets are related in terms of price discovery. Both markets rely on much of the same information, and, from a theoretical point of view, the markets should react simultaneously to relevant news. As discussed, this is not always the case in practice, where one market often is found to lead the other. Essentially, the leading market is more efficient in terms of incorporating credit related news, i.e., it leads the credit risk discovery. Such information is highly relevant to both market participants and regulators, who effectively can span the market that leads the other and utilize the information advantage. To investigate the dynamic lead-lag relationship, we estimate the following bivariate VAR for the eight countries in our final sample:

$$R_t = \alpha_1 + \sum_{i=1}^{p} \beta_{1i} R_{t-i} + \sum_{i=1}^{p} \gamma_{1i} \Delta LCDS_{t-i} + \varepsilon_{1t} \quad (14)$$

$$\Delta LCDS_t = \alpha_2 + \sum_{i=1}^{p} \beta_{2i} R_{t-i} + \sum_{i=1}^{p} \gamma_{2i} \Delta LCDS_{t-i} + \varepsilon_{2t} \quad (15)$$

where R_t is the continuously compounded local stock index return, $\Delta LCDS_t$ is the associated sovereign CDS spread change in logarithms, and ε_t is a white noise error term. To keep the VAR unrestricted, we use the same number of lags in each pair of equations. With a goal of forming parsimonious representations, without suppressing the importance of a dynamically well-specified model, the appropriate lag structure is specified by inspecting the multivariate version of Akaike's information criteria (MAIC)[27]. Appendix D reports the estimation results for each of the countries in the sample and, with a lag length ranging from one to four, the models satisfy our requests.

Before we continue with the specific price discovery findings some elements in the VAR output should be noted. First, the majority of the significant CDS coefficients are negative in the stock equation, at the same time as most of the significant stock coefficients are found to be negative in the CDS equation. As the negative relationship anticipated also is verified between CDS spread changes and stock returns, this provides further support for H1. So, an increase in the CDS spread is *associated* with decreasing stock returns. Second, the size of the coefficients is generally larger in the CDS equation, implying that lagged stock returns and CDS spread changes on average have a relatively larger effect on current CDS spread changes when compared to the effect on stock returns. The R^2 obtained in both equations is summarized for each country in table 6, and further confirms the above implication.

[27] Residual inspections show that MAIC performs better in providing white noise error terms, effectively soaking up all left-over autocorrelation.

Table 6. R^2 summarized

	Germany	Greece	Hungary	Ireland	Italy	Portugal	Spain	UK
				Panel A. Stock equation (R)				
R^2	0,0264	0,0220	0,0228	0,0103	0,0211	0,0525	0,0533	0,0009
Adj. R^2	0,0188	0,0157	0,0127	0,0052	0,0160	0,0426	0,0435	-0,0016
		Average most risky countries				*Average least risky countries*		
R^2		0,0303				0,0137		
Adj. R^2		0,0226				0,0086		
				Panel B. CDS equation (∆CDS)				
R^2	0,0695	0,0782	0,0570	0,0653	0,0803	0,1369	0,0709	0,0221
Adj. R^2	0,0622	0,0722	0,0472	0,0605	0,0756	0,1279	0,0612	0,0196
		Average most risky countries				*Average least risky countries*		
R^2		0,0814				0,0458		
Adj. R^2		0,0741				0,0409		
				Panel C. Stock equation (R) - Fixed lag length				
R^2	0,027474	0,0314	0,0228	0,0159	0,0272	0,0525	0,0533	0,0106
		Average most risky countries				*Average least risky countries*		
R^2		0,0338				0,0190		
				Panel D. CDS equation (∆CDS) - Fixed lag length				
R^2	0,0745	0,0942	0,0570	0,0784	0,0860	0,1369	0,0709	0,0283
		Average most risky countries				*Average least risky countries*		
R^2		0,0872				0,0514		

Table 6 presents the R^2 and Adjusted R^2 for all the countries. The estimates obtained in the original stock equations are reported in Panel A, while estimates from the original CDS equation are reported in Panel B. In both panels, the average R^2 and Adjusted R^2 for the most risky and least risky countries are presented. Panel C and Panel D show the R^2 for all the countries with a fixed lag length of 4, corresponding to the highest lag length discovered. Additionally, the average R^2 for the most risky and least risky countries is presented.

The values remain rather low, as expected in a regression of daily changes, but display a clear difference between the stock and CDS equations across all nations. With exception of Spain, the R^2 in the CDS equations, presented in Panel B, more than doubles the values obtained in the stock equations given in Panel A. Furthermore, the R^2 for Spain, which is relatively high in the stock equation, also show considerable improvement. Hence, previous values of our variables explain a comparatively smaller share of the variations in current stock returns, i.e., stock returns are clearly the least forecastable variable. Whilst this provides informal support of the Efficient Market Hypothesis (EMH), it also signals that the stock market is widely affect by other factors than credit risk.

Finally, the explanatory power of the models is on average higher for the risky nations in the sample. This is the case in both the CDS and stock equation. Since the R^2 is biased towards favoring higher order models, we report the adjusted R^2 in the comparison of the country-specific regressions[28]. In the CDS equation, the adjusted R-square varies between the high 0.13, obtained in Portugal, and the UK's low 0.02. The same pattern is seen in the stock equation, where Spain, with a value above 0.04, holds the highest R^2 and the UK remains at the bottom. The adjusted R^2 in the UK actually turns negative in the stock equation, implying that the regressors are not able to predict the response in the effect variable at all. This is largely a signal of the price efficiency in the UK stock market, but when we also account for the results in the CDS equation and compare it to the remaining countries, it can also be an indicator of the low association between stock returns and CDS spread changes. Basically, the combined observations of stock returns and CDS spread changes are so dispersed, i.e., the relationship is weaker and vague, that the regression line is doing a bad job in fitting the data. A horizontal line at the average observation would more or less do a better job than the fitted line.

On average, the model fit is better in the risky countries. The average adjusted R-square for the risky nations is approximately 2.6 and 1.8 times the size of the values obtained in the least risky nations' stock and CDS equations, respectively. As the adjusted R^2 also tends to favor large models with marginally significant or insignificant variables, we further run a VAR where we employ the same number of lags for all countries. Panel C and D in Table 6 reports R^2-results of a VAR(4) estimated for each country[29]. Even though the difference is slightly reduced, there is still an apparent disparity in favor of the most risky nations. To some extent, the better model fit may indicate that the relationship between CDS and stock markets is more pronounced in risky countries. Note, however, that the least risky average is severely dragged down by the low R^2 in the UK. The R^2 obtained in Germany is in the area of some of the risky countries. We believe that this is a result of

[28] Since the adjusted R^2 accounts for the loss of degrees of freedom associated with adding more variables in the regression, it generally provides a better basis of comparison when models with different lag structures are evaluated.

[29] Four lags are chosen only because this is the maximum lag length found in the original estimation.

Germany's close linkages to the risky Eurozone countries and their overall credit deterioration over the sample period. However, given the unstable results obtained in the correlation analysis, we hypothesize that the R^2 is unstable as well. Table 7 presents estimates of Germany's R^2 obtained in two different periods:

Table 7. German sub-sample R^2

	Sub-sample I	Sub-sample II
	Panel A. Stock equation (R)	
R^2	0,0306	0,0230
	Panel B. CDS equation (ΔCDS)	
R^2	0,0965	0,0351

Table 7 presents the estimated R^2 for the German sub-sample. Sub-sample I refers to the time period April 24, 2009-December 31, 2010, while sub-sample II refers to the time period January 3, 2011-April 25, 2012. Panel A and Panel B corresponds to the stock equation and CDS equation, respectively.

In the CDS equation, the R^2 square falls from a high of 0.0965 in the first section to low a 0.0351, largely pointing out the unstable relationship anticipated. Note further that the risky averages are still higher than the individual averages found for Germany, even when the risky country with the highest R^2 is excluded. In accordance with the correlation analysis, the finding on R^2 may be used as informal support of H2. Both analyses point out that the relationship between CDS spreads and stock values is related to the credit quality of the underlying obligor. Overall, there is a negative association between CDS spreads and equities which seems to be stronger when a country is closer to the default barrier. Given the R^2-results on the UK, it may further be inferred that the relationship appear to be weakest in low risk countries with improving credit quality.

Moving on to the specific price discovery analysis, we observe that lagged CDS spreads changes have significant impacts on stock returns in Germany, Greece, Hungary, Ireland, Italy, Portugal, and Spain. Excluding Germany, Hungary, and Portugal, none of the lagged stock returns in these countries are statistically significant in the CDS equation. This is a clear indication of a lead-lag relation in favor of the CDS market. In Germany, Hungary, and Portugal, stock returns also appear significant in the CDS equation, which may be a sign of a bi-directional causality between the stock and CDS market. In contrast to the rest, only stock returns are found to have significant effects on CDS spread changes, and not vice versa, in the UK. This implies that the stock market reacts before the CDS market in the UK. Due to variations across lags and differing strength of significance, we formally test the lead-lag relationship by performing the Granger causality test. Table 8 summarizes the results of the Granger causality tests performed over the whole sample period.

Table 8. Granger causality test - Overall

	CDS DOES NOT CAUSE STOCK		STOCK DOES NOT CAUSE CDS	
Country	Chi-sq	p-value	Chi-sq	p-value
Germany	13,792	**0,0032**	17,450	**0,0006**
Greece	9,436	**0,0089**	1,732	0,4207
Hungary	11,564	**0,0209**	7,038	0,1339
Ireland	6,172	**0,0457**	2,704	0,2588
Italy	14,265	**0,0008**	2,375	0,3050
Portugal	33,681	**0,0000**	12,748	**0,0126**
Spain	27,512	**0,0000**	5,689	0,2237
UK	0,800	0,6702	6,325	**0,0423**

Table 8 reports the Chi-square value and p-value corresponding to the Granger causality test applied to CDS spreads and equity prices. P-values below 0.05 are marked with bold font.

First of all, the tests reveal significant coefficients in all countries, which imply that the movements in the two markets are dependent on each other. This is not a surprise given the strong correlations and significant coefficients observed. In accordance with the discussion in the above paragraph, the CDS spread changes Granger-cause stock returns in Greece, Ireland, Italy, and Spain. Additionally, the results show that the CDS spread changes also Granger-cause stock returns in Hungary. Even though the stock return appeared significant in the Hungarian CDS equation, the CDS spread changes have significantly more explanatory power. As anticipated, there is a bi-directional feedback in Germany and Portugal, with both hypotheses being rejected. However, by closer inspection of the p-values, it is evident that the stock returns have greater explanatory power in Germany, while CDS spread changes have the largest impact in Portugal. Finally, UK stock returns Granger-cause UK CDS spread changes. Again, this is not surprising given the R^2-results evaluated above. Overall, the results imply that CDS spread changes are relatively more important in explaining stock returns in all the risky countries in the sample. In other words, the CDS market leads the stock market in countries closer to default. There is a feedback between the Portuguese equity and CDS market, but the CDS spread remain highly significant and therefore seems to be more important in terms of price discovery. Contrary, the stock market has relatively more explanatory power and leads the CDS market in low risk countries. The feedback effect present in the German markets again suggest that the country is relatively more attached to the risky Eurozone countries, effectively giving credit risk a larger impact on stock returns when compared to the UK. However, their stock market remains most important in price discovery. Thus, it seems like the credit market has an informational advantage in countries were sovereign risk is severe, while the liquid stock market incorporates new information relatively faster in low risk countries.

To discern the time-varying effects that have been revealed in the existing literature, we form two sub-samples and re-estimate the VAR models for each country. We further focus on the results of the Granger causality tests obtained in both sup-periods[30]. Table 9 present the results of the block significance tests, wherein sub-sample I in Panel A refers to the time period April 24, 2009-December 31, 2010, while sub-sample II in Panel B refers to the time period January 3, 2011-April 25, 2012[31].

Table 9. Granger causality test – Split-sample

	CDS DOES NOT CAUSE STOCK		STOCK DOES NOT CAUSE CDS	
Country	Chi-sq	p-value	Chi-sq	p-value
	Panel A. April 2009-December 2010			
Germany	12,784	**0,0017**	20,161	**0,0000**
Greece	4,611	0,0997	0,467	0,7917
Hungary	8,828	0,0656	7,241	0,1237
Ireland	4,329	0,1148	1,239	0,5382
Italy	12,138	**0,0023**	0,524	0,7694
Portugal	35,709	**0,0000**	7,228	0,1243
Spain	37,506	**0,0000**	2,333	0,6748
UK	2,815	0,2447	6,477	**0,0392**
	Panel B. January 2011-April 2012			
Germany	0,003	0,9983	3.335	0,1887
Greece	6,849	**0,0326**	1,643	0,4397
Hungary	3,248	0,1972	0,090	0,9559
Ireland	2,547	0,2799	2,791	0,2477
Italy	2,375	0,1233	0,174	0,6762
Portugal	3,364	0,3389	7,391	0,0604
Spain	2,179	0,3362	5,658	0,0591
UK	3,718	0,2936	6,530	0,0885

Table 9 presents the Granger causality test for the two sub-samples. Chi-square values and the corresponding p-value are reported. Statistical significant p-values at the 5 % level are highlighted with bold font. Panel A refers to the time period April 24, 2009 to December 31, 2010. Panel B provide the estimates for the period January 3, 2011 to April 25, 2012.

[30] The sub-period VAR outputs are available upon request.
[31] The conclusions remain the same if time frames with similar lengths are used.

First, it is important to acknowledge that the test loses some of its power in smaller samples, effectively making it harder to reject the null hypotheses. This is evident through a smaller number of variables appearing significant at the 5 % level. However, the Granger causality test still yields some interesting results. First, the results in the first sub-sample are very much the same as the overall results. The null of no CDS lead can be rejected at the (borderline) 10 % level for all of the risky nations[32]. Additionally, the Portuguese equity feedback is no longer significant. Thus, the lead is in the CDS market for the all risky nations in the first sub-period. Similarly, the stock market is the leader in the least risky nations, with significant feedback effects still being present in Germany. On the other hand, when we examine the second sub-sample, the pattern has more or less vanished. With exception of Greece, there is no definite leader market in any of the countries at the 5 % level. Moreover, the UK stock market still leads the CDS market at the 10 % level. More interesting, the CDS market has lost its lead in five out of six risky countries. At the 10 % level, the Spanish and Portuguese stock markets are now actually the leading market. The results from the sub-sample analysis indicate that the CDS market has lost its informational advantage in the risky countries, while the stock market has lost some if its benefit in the least risky category. The lead-lag pattern is thus less evident and it seems like both markets incorporate new information simultaneously.

To sum up, the data analyses provide support for H1 and H2. A clear inverse relationship is evident between sovereign CDS spreads and local stock indices. The relationship is defined both in levels and first differences, and the association seems to be stronger in risky countries. The finding is also backed by a larger explanatory power in the risky countries' VAR models. Furthermore, we do not find any supportive evidence of H3, indicating that an equilibrium price relationship is disturbed by factors that complicate capital structure arbitrage strategies. Overall, the evidence backs up H4. When the whole time period between 2009 and 2012 is considered, we find that CDS spread changes lead stock returns in all risky countries in the sample. Contrary, the liquid stock market has the leading role in the least risky nations. However, the split-sample analysis

[32] Ireland appears with a p-value of 0.11 and defined to be borderline significant at the 10 % level.

suggests that the lead-lag relationship has weakened in the escalation of the European debt crisis.

9 Discussion

The finding of an inverse relationship, strengthening in close to default situations, is in line with Merton's theory. The predictions of Merton's theory are confirmed in corporate studies on the CDS-equity relationship. For example, Byström (2005) find negative correlation between the European sector iTraxx CDS indices and the stock market. Fung et al. (2008) find that the relationship between high-yield CDSs and the stock market is stronger than in the case of investment-grade CDSs, and the integration between the markets become especially strong in the eruption of the recent subprime crisis. Moreover, Norden & Weber (2009) reports that the co-movement between the stock and CDS markets increases with lower credit quality. Our results further support Chan-Lau and Kim's (2004) extension to sovereign obligors and the evidence in the Asian market provided by Chan et al. (2009). Widening sovereign CDS spreads are associated with falling local stock indices, and the relationship is more pronounced in countries with low credit quality. Following Merton's theory, this suggests that credit risk has a larger impact on equity values when default is a substantial threat. Theoretically, small adverse movements in the asset values in a close-to-default scenario will lead to a decline in equity values since this may leave the call option out-of-the-money and the residual claim worthless. In solid nations the sensitivity is smaller since the country still remains in-the-money and far from the default barrier. Overall, the results may prove valuable to credit analysts since they suggest that stock index parameters may be used in a Merton-type model to assess sovereign default risk.

Our result of no cointegration between the sovereign CDS market and the benchmark stock index for all countries included in the sample is in sharp contrast to the *conclusion* by Berg and Tjemsland (2011). Investigating several of the same countries as our paper, they conclude on a cointegrated relationship for all countries in their sample. However, we choose to question their conclusions on cointegration and, thus, the strength of their results. Three reasons for this stand out. First, in light of the prevailing literature and limited findings on cointegration, a conclusion of cointegrating relationships in six out six countries seems unrealistic. Second, the use of monthly data is not only conflicting with the literature on the topic but also seems counterintuitive. How can you capture an arbitrage mechanism that swiftly adjusts disequilibrium in the use of a long frequency? Finally and most important, by closer inspection, we notice that Berg and Tjemsland (2011) *conclude* on the presence of a long-term equilibrium relationship in all investigated countries, even though the *results* of the statistical test only yields two cointegrating relationship. Contrary to the prevailing convention, they run a VECM in all countries, both with and without positive cointegration results. Hence, they have modeled long-run equilibrium relationships even in countries where this relationship is statistically not present. This also weakens their price discovery results, as they estimate a misspecified model with a spurious relationship that is in danger of yielding false results. More in line with our result, Chan-Lau and Kim (2004) and Chan et al. (2009) only detect cointegration for one and three emerging economies, respectively.

The lack of cointegration indicates that the arbitrage relationship, proved in practice at the corporate level, appears hampered by various elements at the sovereign level. In extension of Chan-Lau and Kim (2004) and Chan et al. (2009), we hypothesize that the disruption is caused by a combination of practical and technical factors. First, the whole concept of cointegration relies on market forces that adjust for pricing inefficiencies and keep the variables in a tight leash. However, if market frictions such as low liquidity, short sale restrictions, borrowing impediments and transaction costs prevent arbitrageurs to take advantage of the relationship, there is no longer a mechanism that impedes the variables from wandering apart. For instance, short selling of stocks has been banned in several European countries the last years. Moreover, European regulators have, in order to ensure that sovereign CDSs are used for their designated purpose as a hedging instrument, also permanently prohibited naked sovereign CDSs across EU. Taking effect in November 2012, the ban may further complicate a potential arbitrage mechanism.

The recent European debt crisis has also been dominated by market fear, contributing to high volatility that further may have hampered the possibilities for arbitrageurs. Hull et al. (2004) show that structural models provide poor estimates when the volatility is extreme, effectively harming the tool used to exploit arbitrage strategies. If the potential mechanism to exploit such strategies is inoperative, this explains why the series are not bound together in a price equilibrium relationship. Although Yu (2006) shows that capital structure arbitrage strategies can be employed in the corporate CDS market, no research has examined whether such strategies is applicable in the market for sovereign CDSs. Thus, further research should investigated whether arbitrage strategies is appropriate to use in the sovereign CDS market.

The lack of cointegration may also stem from more technical or theoretical factors. As highlighted by Forte and Peña (2009), the CDS spread is an explicit measure of credit risk, while the same risk only is implicitly reflected in stock prices. As discussed, the hope to find such a relationship relies on the markets' simultaneous pricing of sovereign risk. Even though both markets should reflect credit risk, CDS spreads and stock prices are *not* proxies for the same latent variable, namely the "pure" credit spread. Stock prices are to a much larger extent than the CDS spread incorporating other information than default probabilities and recovery values. Being unable to detect the dependency to the same common stochastic trend, i.e., find cointegration, is thus reasonable from a theoretical point of view. The fact that sovereigns do not have a formal equity value further complicates the matters. In this connection, Longstaff, Pun, Pedersen, and Singleton (2007) points out some flaws in the use of stock indices as a proxy for sovereign equity value. Thus, a similar approach applied on sovereigns should be an interesting task for future research.

Furthermore, Forte and Lovreta (2012) illustrate that cointegration tests have lower power when the sample cover a short time frame[33]. Due to infrequent trading in some parts of the market for sovereign CDSs prior to the European debt crisis, we found the most suitable data limited to a three-year span. As cointegration tests are designed to detect common long-run trends between variables, they are not suitable for too short data periods (Alexander 2001: 354). Finally, in terms of methodological issues another factor may also be pointed out.

[33] With a sample period less than two years, Forte and Peña (2009) find cointegration in 23.5% of the companies investigated. Using a three year sample Forte and Lovreta (2009) detects cointegration for 25.8%, while Forte and Lovreta (2012) find cointegration for 55.4% of the companies analyzed with a sample period of seven years.

The recent volatility in Europe has possibly made the relationship between CDS spreads end stock prices non-linear. As noticed by Chan-Lau and Kim (2004), cointegration analysis cannot capture such a relationship as they are based on linear regression techniques. Hence, researchers may falsely fail to reject the null hypothesis of integration between the markets.

In terms of price discovery, theory suggests that the markets should incorporate new information simultaneously, effectively maintaining the law of one price. In other words, changes in the credit risk should be visible in the CDS spread and the stock market at the same time. Academic studies have, however, pointed out a time-varying lead-lag relationship where one market is found incorporate new information quicker than the other. Earlier findings on price discovery between the stock and sovereign CDS market have been miscellaneous. Consistent with Chan et al. (2009), our results suggest that the CDS market leads the stock market in terms of price discovery. As noticed by Forte and Lovreta (2012) the market for credit derivatives is expected to provide a pure measure of credit risk. Hence, it is likely that credit news is reflected more quickly in the credit derivatives market than in the stock market.

Finding the CDS market to lead the more liquid stock market on days with negative credit news, Acharya and Johnson (2007) argues that insider trading in the CDS market is the reason for the leading role. They argue that the insider trading is conducted by major banks with lending exposure and access to privileged information. In support of this view, Fung et al. (2008) and Chan et al. (2009) explain the leading role of the CDS market with the information advantages of the participants. Although Forte and Lovreta (2012) find the stock market to lead the CDS market in financial crisis, they stress that the information share of the CDS market is positively related to the presence of *severe* credit shocks. Considering the financial position and increased probability of default during the time period we investigates, our results are in line with Acharya and Johnson (2007), Chan et al. (2009), and Forte and Lovreta (2012). Further our results also corroborate the discussion on informed traders in several of the other studies on the topic.

Overall, finding the CDS market to be dominant in all our risky countries, while the stock market contributes the most in the two safe countries, suggest that the lead-lag role of the markets is dependent on credit quality. Since equity represents the residual claim, small changes in credit risk are relatively more important in countries closer to the default barrier. Credit risk essentially has a larger impact on stock returns and new credit information is more important for the stock market development. Following the arguments of Acharya and Johnson (2007), this gives insiders a larger incentive to exploit informational advantages. Even though we cannot conclude that insider trading takes place in the credit derivatives market based on our analyses, they give an indication of trading performed by informed players. However, the split sample-analysis suggests that the CDS market has lost its advantage in most of the risky countries, while the stock market is not a clear leader in the least risky category anymore. As the economic situation in Europe has become public ownership, we argue that the lack of a dominating market in the last sub-period may be due to a shift in publicity. Based on the evidence, we believe that players in all financial markets have become more aware of the situation for most of the risky countries in Europe, and thereby improving the efficiency of the price discovery process in all markets.

The results of our analyses seem to be consistent with the prevailing literature on the topic. However, one should be aware of some potential drawbacks in our study. First, due to our non-existing budget, we had to choose a database that we could access without leveraging our position. Since the CDS market exists without an organized exchange, in contrast to standardized stock markets, data providers gather price information from various players in the market. Mayordomo, Peña, and Schwartz (2010) investigate six major sources of CDS data and find systematic differences between the different providers' data sets and their informational efficiency[34]. With the validity and power of empirical results being clearly dependent on data quality, the data source used in our analyses should also be accounted for. Regarding Merton's theory, it should be noticed that explicit volatility parameters are left out of the study. Volatility spillover between the markets has not been the focus in the previous literature on the sovereign CDS-equity relationship, and is therefore a subject for further study.

[34] The six data sources included in the study was GFI, Fenics, Reuters EOD, CMA Datavision, Markit, and JP Morgan.

10 Conclusion and further research

In this paper we investigate the price equilibrium and dynamic relationship between sovereign CDS spreads and national stock indices in Europe over a three-year time period from April 2009 to April 2012. The time period under investigation encompasses the European debt crisis, and, to our knowledge, we are pioneers in investigating the relationship at the sovereign level in a period dominated by financial distress. To discern differences related to the obligors' credit quality, we include a set of risky and less risky nations in our analyses.

Overall, and in accordance with the prevailing literature, we find a negative relationship between sovereign CDS spreads and stock prices. Moreover, the magnitude of the correlation is found to be stronger for countries closer to default. Second, our findings suggest that a price equilibrium relationship between the sovereign CDS and stock market is absent for all countries under investigation. In addition to technical problems, we believe that practical issues regarding the exploitation of pricing inefficiencies between the markets lead to this result. Finally, the overall results provide evidence of a leading role of the CDS market for all countries experiencing high credit spreads, while the stock market primarily contributes to price revelation in the two safer economies. Following earlier research, this supports the presence of informed players in the credit derivative markets. However, observing a less dominant lead-lag relationship from 2011, we hypothesize that the credit risk has become increasingly important for all financial players, thereby improving the incorporation of credit news in exterior markets.

As longer data series with liquid trading will be available in the future, further research should focus on investigating how the relationship evolves in both crisis and more tranquil financial period. Even though the evidence is against the application of capital structure arbitrage strategies at the sovereign level, we cannot totally reject that such opportunities are absent at all times. Hence, further research ought to examine whether sovereign level arbitrage strategies are applicable *in practice*. To strengthen the results on price discovery, future papers should also try to incorporate a procedure with stock market implied CDS spreads, e.g., as proposed by Forte and Lovreta (2012).

References

Acharya, Viral V., and Timothy C. Johnson. 2007. "Insider trading in credit derivatives." *Journal of Financial Economics,* 84(1): 110-141.

Alexander, Carol. 2001. *Market Models: A Guide to Financial Data Analysis*. Chichester, UK: John Wiley & Sons Ltd.

Ammer, John, and Fang Cai. 2011. "Sovereign CDS and bond pricing dynamics in emerging markets: Does the cheapest-to-deliver option matter?" *Journal of International Financial Markets, Institutions and Money,* 21(3): 369-387.

Becker, Sebastian. 2009. "EMU sovereign spread widening – Reasonable market reaction or exaggeration." *Deutsche Bank Research*. EU Monitor No. 68, June 29, 2009.

Berg, Ole Marius and Andreas Ystgaard Tjemsland. 2011. En studie av Credit Default Swaps: Eksisterer det en feilkorreksjonsjustering mot et langsiktig likevektsforhold mellom sovereign Credit Default Swaps og det europeiske aksjemarkedet. Masteroppgave, Universitet i Nordland, Bodø.

Blanco, Roberto, Simon Brennan, and Ian W. Marsh. 2005. "An empirical analysis of the dynamic relationship between investment-grade bonds and credit default swaps." *Journal of Finance,* 60(5): 2255-2281.

Brooks, Chris. 2008. *Introductory Econometrics for Finance*. Cambridge: Cambridge University Press.

Byström, Hans N. E. 2005. "Credit default swaps and equity prices: The iTraxx CDS index market." Working Papers 2005:24, Lund University, Department of Economics.

Chan, Kam C., Hung-Gay Fung, and Gaiyan Zhang. 2009. "On the relationship between Asian credit default swap and equity makets." *Journal of Asian Busniness Studies,* 4(1): 3-12.

Chan-Lau, Jorge A., and Yoon S. Kim. 2004. "Equity prices, credit default swaps, and bond spreads in emerging markets." IMF Working Paper No. WP/04/27.

DTCC – The Depository Trust & Clearing Corporation. 2012a. "Trade information warehouse data (section I), Table 1." Accessed May, 2012. http://www.dtcc.com/products/derivserv/data_table_i.php.

DTCC – The Depository Trust & Clearing Corporation. 2012b. "Trade information warehouse data (section I), Table 2." Accessed May, 2012. http://www.dtcc.com/products/derivserv/data_table_i.php?tbid=2.

DTCC – The Depository Trust & Clearing Corporation. 2012c. "Trade information warehouse data (section I), Table 6." Accessed May, 2012. http://www.dtcc.com/products/derivserv/data_table_i.php?tbid=6&tabid=0&tid=0&kid=4&asc=0.

ECB – European Central Bank. 2009. "Credit default swaps and counterparty risk." Accessed January, 2012: http://www.ecb.int/pub/pdf/other/creditdefaultswapsandcounterpartyrisk2009en.pdf.

Engle, Robert F., and Clive W.J. Granger. 1987. "Co-integration and error correction: Representation, estimation and testing." *Econometrica*, 55(2): 251-276.

Ericsson, Jan, Joel Reneby, and Hao Wang. 2005. "Can structural model price default risk? New evidence form bond and credit derivate markets." *EFA 2005 Moscow Meetings Paper*. Accessed April 15, 2012. http://ssrn.com/abstract=637042.

FitchRatings. 2009. "Global credit derivatives survey: Surprises, challenges and the future." Accessed February, 2012: http://www.esaf.fazenda.gov.br/esafsite/CCB/program_2010/BT-01/RECOMENDADAS/L 113_Global_Credit_Derivatives_Survey_FitchRatings.pdf.

Forte, Santiago. 2011. “Calibrating structural models: A new methodology based on stock and credit default swap data.” *Quantitative Finance,* 11(2): 1745-1759.

Forte, Santiago, and Juan I. Peña. 2009. “Credit Spreads: An empirical analysis in the informational content of stocks, bonds, and CDS.” *Journal of Banking and Finance*, 31 (11): 2013-2025.

Forte, Santiago, and Lidija Lovreta. 2012. “Credit Risk Discovery in the Stock and CDS Markets: Who Leads in Times of Financial Crisis?” Accessed April 15, 2012: http://ssrn.com/abstract=2038800.

Fung, Hung-Gay, Gregory E. Sierra, Jot Yau, and Gaiyan Zhang. 2008. “Are the U.S. stock market and credit default swap market related? Evidence from the CDX Indices.” *Journal of Alternative Investments*, 11(1): 43-61.

Gonzalo, Jesús, and Clive W.J. Granger. 1995. “Estimation of common long-memory components in cointegrated systems.” *Journal of Business and Economic Statistics,* 13(1): 27-35.

Granger, Clive W.J. 1969. “Investigating causal relations by econometric models and cross-spectral methods.” *Econometrica,* 37(3): 424-438.

Gray, Dale F., Robert C. Merton and Zvi Bodie. 2007. “Contingent claims approach to measuring and managing sovereign credit risk.” *Journal of Investment Management*: 5(4): 5-28.

Hasbrouck, Joel. 1995. “One security, many markets, determining the contribution to price discovery.” *Journal of Finance,* 50(4): 1175-1199.

Hauke, Jan, Tomasz Kossowski. 2011. “Comparison of values Pearson’s and Spearman’s correlation coefficients on the same sets of data.” *Quaestiones Geographicae*, 30(2): 87-93.

Hull, John C. 2012. *Options, futures, and other derivatives*. 8th ed. Pearson Education: Prentice Hall.

Hull, John, Izzy Nelken, and Alan White. 2004. "Merton's model, credit risk, and volatility skews." *Journal of Credit Risk*, 1(1): 3-28.

Hull, John, Mirela Predescu, and Alan White. 2004. "The relationship between credit default spreads, bond yields and credit rating announcements." *Journal of Banking and Finance*, 28(11): 2789-2811.

ISDA – International Swaps and Derivatives Association. 2010. "ISDA market survey." Accessed January 7, 2012. http://www2.isda.org/attachment/Mjk5Nw== /ISDA-Market-Survey-results1987-June%202010.pdf.

ISDA – International Swaps and Derivatives Association. 2011. "The first rule about CDS: Don't talk about CDS (unless you've read the contract)." Accessed April 7, 2012. http://isda.derivativiews.org/2011/11/08/the-first-rule-about-cds-read-the-contract/.

Jeanneret, Alexander. 2012. "The dynamics of sovereign credit risk." EFA 2009 Bergen Meetings Paper. Accessed August, 2012: http://ssrn.com/abstract =1071665.

Johansen, Søren. 1991. "Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models." *Econometrica*, 59(6): 1551-1580.

Juselius, Katarina. 2006. *The cointegrated VAR model: Methodology and applications*. NY: Oxford University Press Inc.

Kiff, John, Jennifer Elliot, Elias Kazarian, Jodi Scarlata and Carolyne Spackman. 2009. "Credit derivatives: Systemic risk and policy options." IMF Working Paper. WP/09/254.

Lehmann, Bruce N. 2002. “Some desiderata for the measurement of price discovery across markets.” *Journal of Financial Markets*, 5(3): 259-276.

Leland, Hayne E. and Klaus Bjerre Toft. 1996. “Optimal capital structure, endogenous bankruptcy, and the term structure of credit spreads.” *Journal of Finance*, 51(3): 987-1019.

Longstaff, Francis A., Jun Pan, Lasse H. Pedersen, and Kenneth J. Singleton. 2011. “How sovereign is sovereign credit risk?" *American Economic Journal: Macroeconomics*, 43 (2): 75-103.

Longstaff, Francis A., Sanjay Mithal, Eric Neis. 2003. “The credit-default swap market: Is credit protection priced correctly?” Working Paper, University of California, Los Angeles.

Lütkepohl, Helmut. 2007. “Econometric analysis with vector autoregressive models.” Working Paper ECO2007/11. European University Institute Economics.

Mayer, Manuel. 2012. “Stock market implied sovereign CDS during the European debt crisis.” Accessed May, 2012: http://ssrn.com/abstract=2000662.

Mayordomo, Sergio, Juan Ignacio Peña and Eduardo S. Schwartz. 2010. “Are all credit default swap databases equal?” Accessed June 8, 2012: http://ssrn.com/abstract=1713325.

Merton, Robert C. 1974. “On the pricing of corporate debt: The risk structure of interest rates.” *Journal of Finance,* 29(2): 449-470.

Norden, Lars and Martin Weber. 2004. “Informational efficiency of credit default swap and stock markets: The impact of credit rating announcements.” *Journal of Banking & Finance*, 28(11): 2813-2843.

Norden, Lars, and Martin Weber. 2009. “The co-movement of credit default swap, bond and stock markets: An empirical analysis.” *European Financial Management*, 15(3): 529-562.

OCC - Office of the Comptroller of the Currency. 2012. "OCC's quarterly report on bank trading and derivatives activities – First quarter 2012." Accessed June 15: http://www.occ.treas.gov/topics/capital-markets/financial- markets/trading/derivatives/derivatives-quarterly-report.html.

Palladini, Giorgia, and R. Portes. 2011. "Sovereign CDS and bond pricing dynamics in the Euro-area." Accessed January 11, 2012. http://www.nber.org /papers/w17586.

Plosser, Charles I. and G.William Schwert. 1978. "Money, income, and sunspots: Measuring economic relationships and the effect of differencing." *Journal of Monetary Economics*, 4(4): 637-660.

Weistroffer, Christian. 2009. "Credit default swaps – Hedging towards a more stable system". Accessed via British Bankers' Association (BBA) January, 2012: http://www.bba.org.uk/media/article/Credit-default-swaps-Heading-towards-a-more-stable-system.

Yu, Fan. 2006. "How profitable is capital structure arbitrage?" *Financial Analyst Journal*, 62(5): 47-62.

Zhu, Haibin. 2006. "An empirical comparison of credit spreads between the bond market and the credit default swap market." *Journal of Financial Services Research*, 29(3): 211-235.

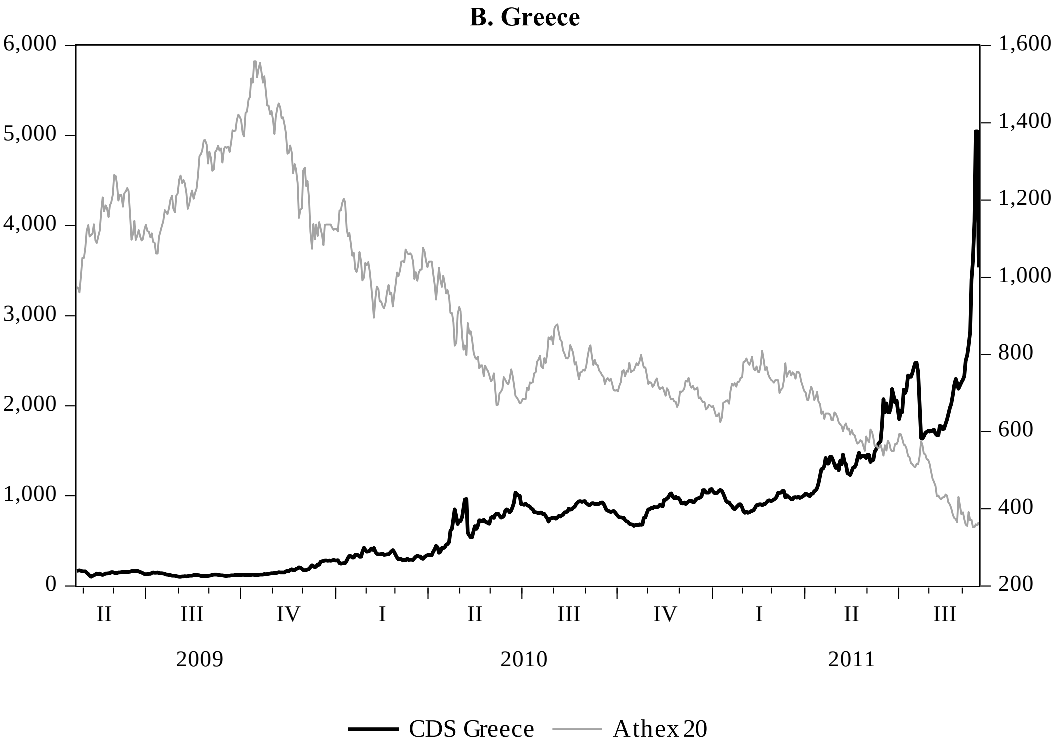
Appendices

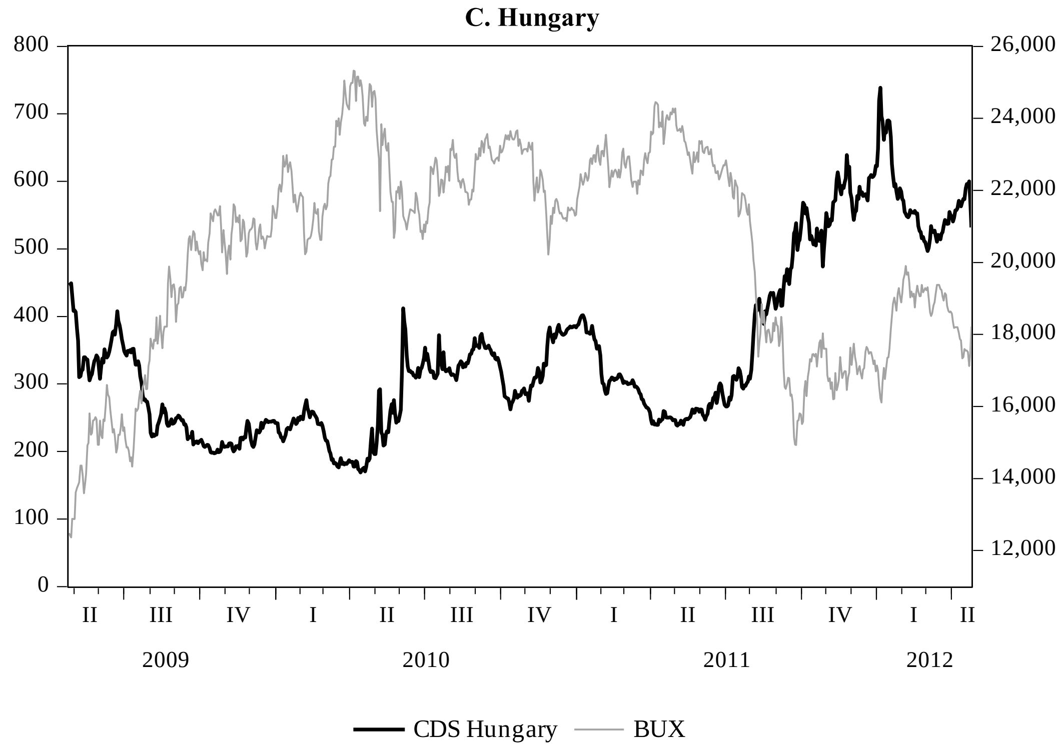
Appendix A. Synopsis of CMA Global Sovereign Credit Risk Report

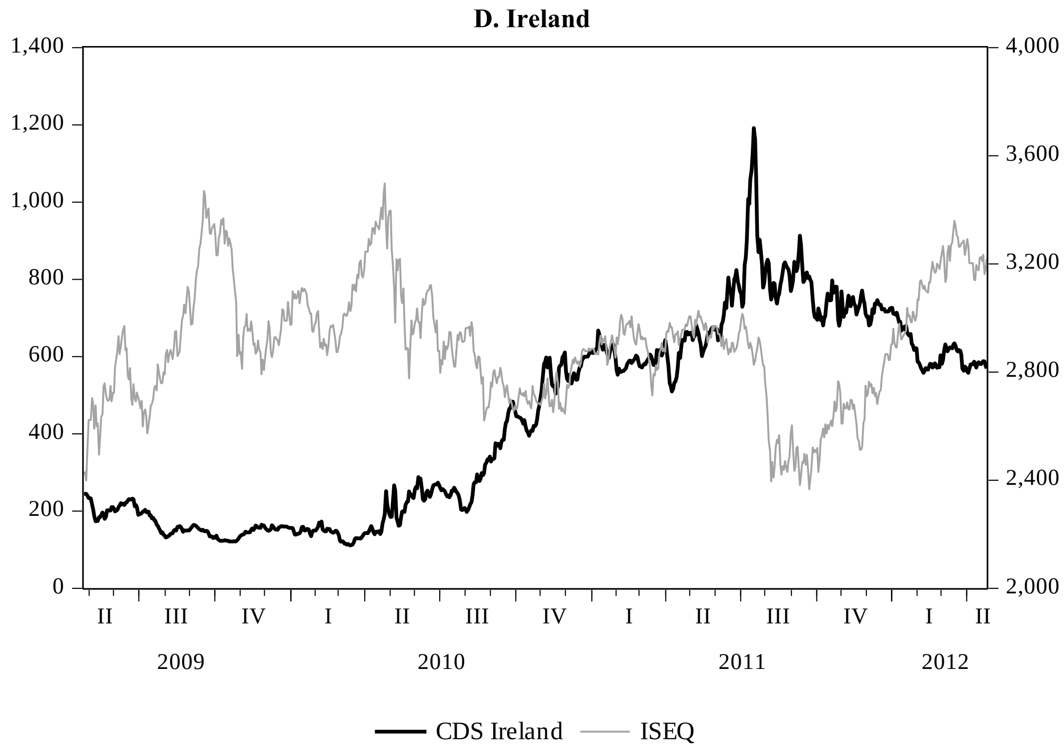
Country Ranking		CPD (%)	CDS Spread
		Panel A. Most risky sovereign credits	
1.	Greece	93,80 %	8453,3
2.	Portugal	60,80 %	1153,7
3.	Pakistan	50,90 %	979,6
4.	Venezuela	49,40 %	927,1
5.	Argentina	49,20 %	917,4
6.	Ireland	46,40 %	747,3
7.	Ukraine	45,50 %	860,2
8.	Egypt	36,30 %	621,4
9.	Hungary	35,30 %	610,6
10.	Italy	34,90 %	486,4
11.	Croatia	32,50 %	546,8
12.	India (Proxy)	30,20 %	400,1
13.	Spain	28,60 %	379,3
14.	Dubai	28,00 %	452,2
		Panel B. Least risky sovereign credits	
1.	Norway	3,90 %	44,6
2.	USA	4,30 %	49,6
3.	Switzerland	5,90 %	67,9
4.	Sweden	6,60 %	76,7
5.	Finland	6,70 %	77,3
6.	Australia	7,10 %	83,1
7.	Hong Kong	7,70 %	89,2
8.	New Zealand	8,20 %	96,0
9.	UK	8,40 %	97,7
10.	Germany	8,70 %	100,8
11.	Qatar	8,70 %	127,2
12.	Abu Dhabi	8,80 %	127,4
13.	Saudi Arabia	8,90 %	130,5
14.	Chile	8,90 %	130,7

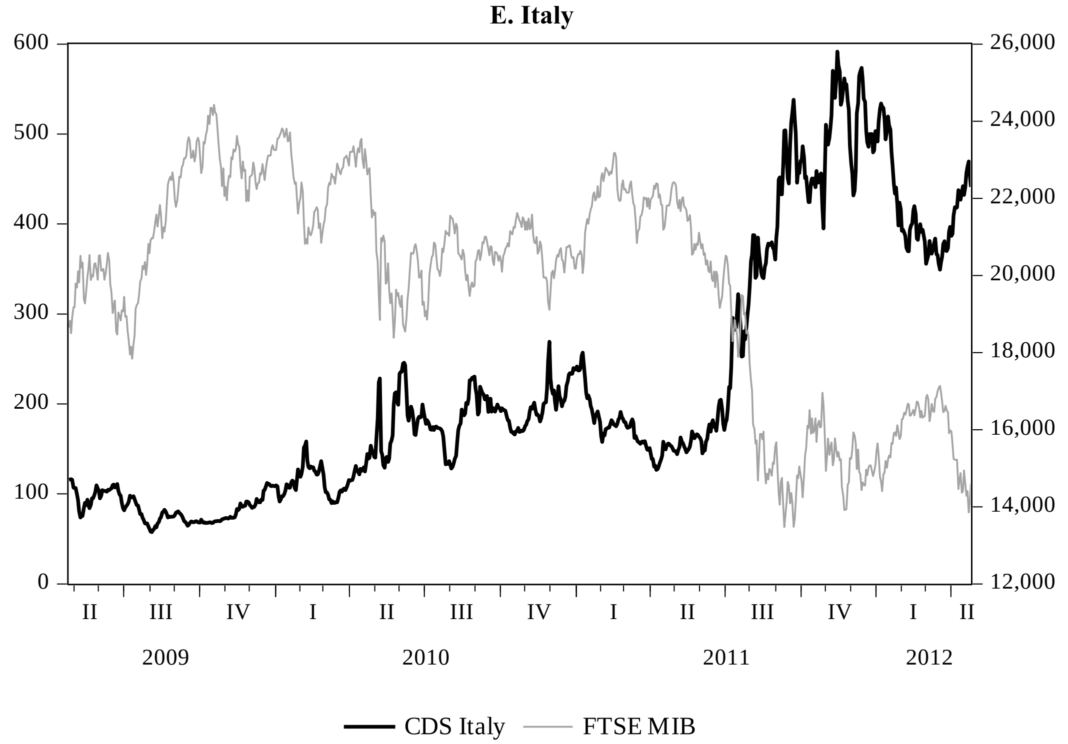
Appendix A presents a synopsis of CMA's Global Sovereign Credit Risk Report from the 4th Quarter of 2011. The table is available in its full length on: www.cmavision.com

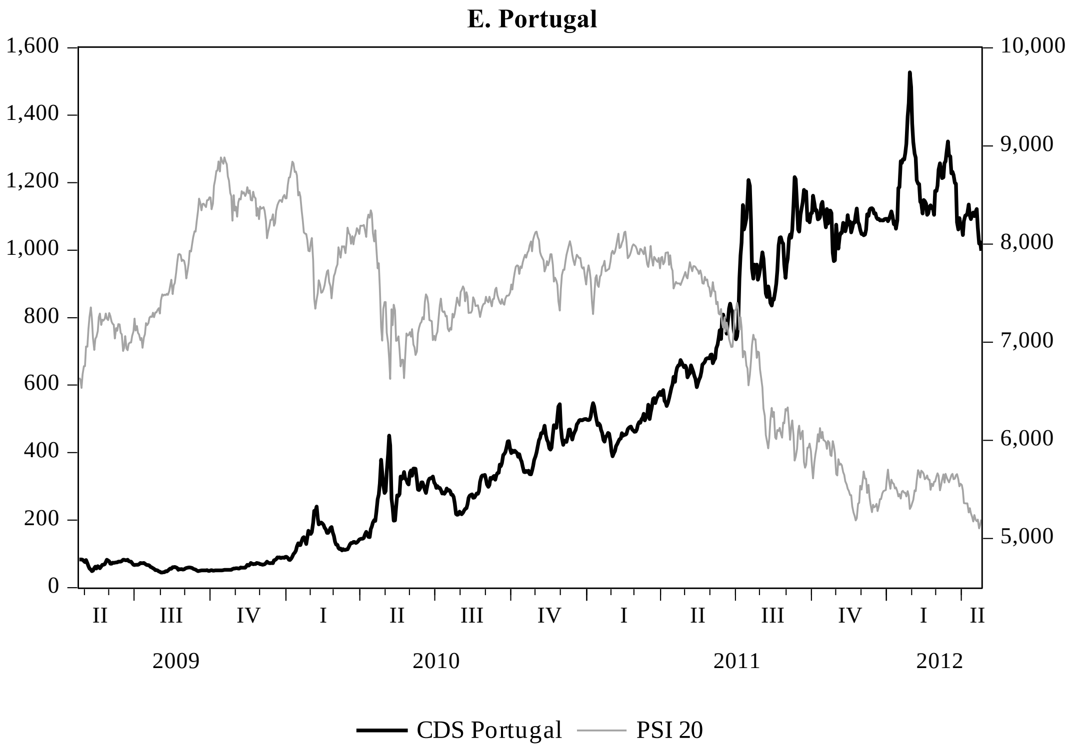
Appendix B. 5-year sovereign CDS spread vs. National stock index

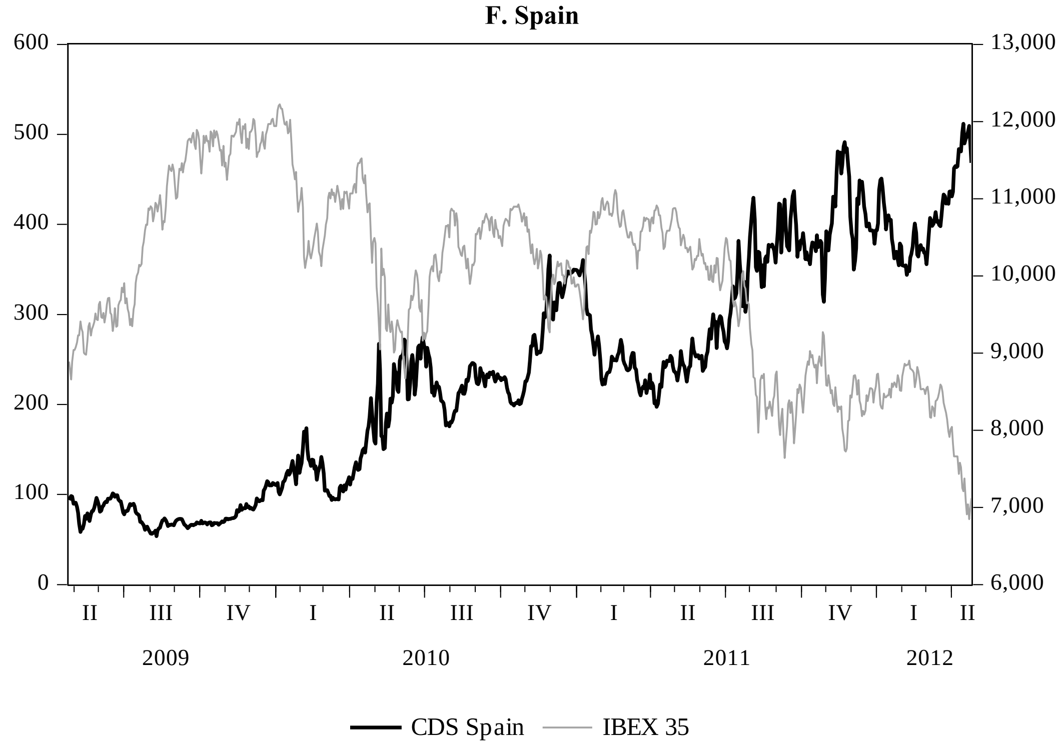


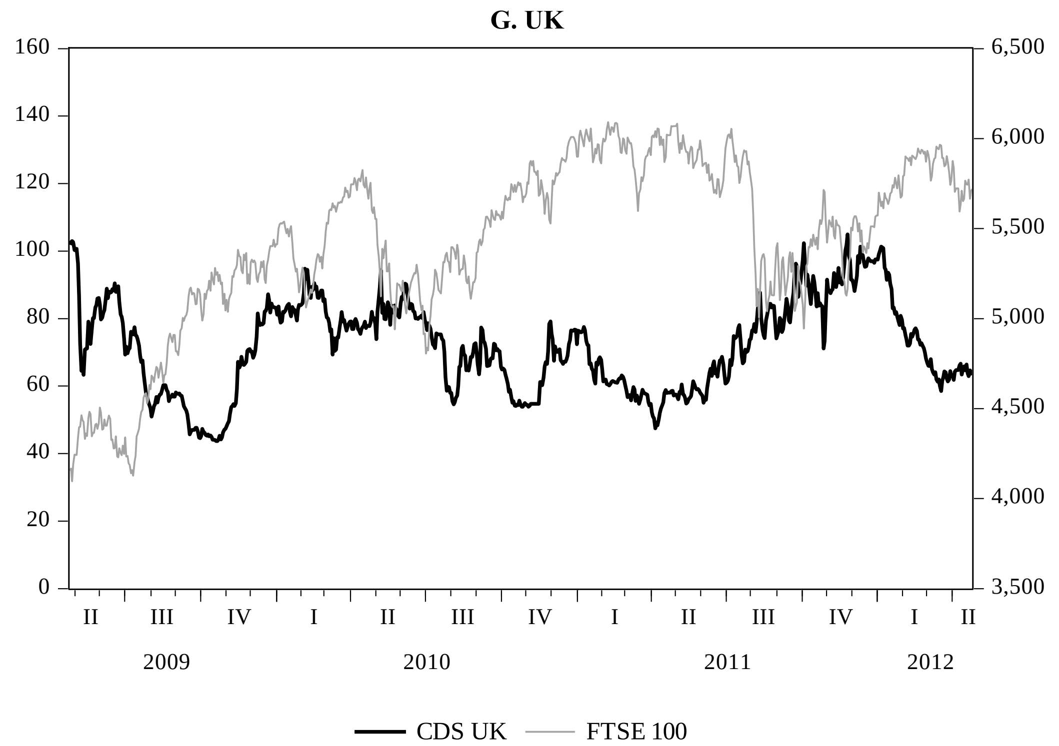

C. Hungary
800
700
600
500
400
300
200
100
0
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
II III IV I II III IV I II III IV I II
2009
2010
2011
2012
CDS Hungary
BUX


D. Ireland
1,400
1,200
1,000
800
600
400
200
0
4,000
3,600
3,200
2,800
2,400
2,000
II III IV I II III IV I II III IV I II
2009
2010
2011
2012
CDS Ireland
ISEQ


E. Italy
600
500
400
300
200
100
0
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
II III IV I II III IV I II III IV I II
2009 2010 2011 2012
CDS Italy
FTSE MIB


E. Portugal
1,600
1,400
1,200
1,000
800
600
400
200
0
10,000
9,000
8,000
7,000
6,000
5,000
II III IV I II III IV I II III IV I II
2009 2010 2011 2012
CDS Portugal
PSI 20


F. Spain
600
500
400
300
200
100
0
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
II III IV I II III IV I II III IV I II
2009
2010
2011
2012
CDS Spain
IBEX 35


G. UK
160
140
120
100
80
60
40
20
0
6,500
6,000
5,500
5,000
4,500
4,000
3,500
II III IV I II III IV I II III IV I II
2009
2010
2011
2012
CDS UK
FTSE 100

Appendix C. Normality characteristics

	Germany	Greece	Hungary	Ireland	Italy	Portugal	Spain	UK
				Panel A. CDS Spread				
Skew.	0,91	1,87	0,90	0,20	0,99	0,55	0,20	0,08
Kurt.	2,77	9,37	2,79	1,73	2,72	1,89	1,91	2,27
Jarq.-B.	110,92	1421,30	106,51	57,58	130,97	80,17	44,14	18,15
Prob.	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Obs.	784	626	784	784	784	784	784	784
				Panel B. Log (CDS Spread)				
Skew.	0,19	-0,26	0,38	-0,24	0,23	-0,39	-0,48	-0,29
Kurt.	2,21	1,86	2,21	1,43	2,02	1,79	1,92	2,40
Jarq.-B.	25,24	40,83	38,70	88,13	37,84	68,52	68,66	22,84
Prob.	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Obs.	784	626	784	784	784	784	784	784
				Panel C. Stock Index				
Skew.	-0,03	0,38	-0,59	0,09	-0,64	-0,61	-0,25	-0,88
Kurt.	2,17	2,28	2,39	2,82	2,21	2,26	2,24	3,22
Jarq.-B.	22,8	28,6	57,0	2,2	73,7	65,6	27,2	102,0
Prob.	0,000	0,000	0,000	0,329	0,000	0,000	0,000	0,000
Obs.	784	626	784	784	784	784	784	784
				Panel D. Log (Stock Index)				
Skew.	-0,25	-0,27	-0,84	-0,12	-0,81	-0,79	-0,48	-1,08
Kurt.	2,38	2,66	2,93	2,84	2,42	2,41	2,48	3,69
Jarq.-B.	20,47	10,87	91,54	2,59	97,78	91,84	38,28	168,11
Prob.	0,000	0,004	0,000	0,274	0,000	0,000	0,000	0,000
Obs.	784	626	784	784	784	784	784	784

Appendix C presents normality measures for the variables. Panel A and Panel C show normality characteristics for the raw data of the countries' CDS spread and stock index, respectively. Panel B and Panel D show normality characteristics for the log transformed data of the countries' CDS spread and stock index, respectively.

Appendix D. VAR estimation

Dep. var	**R**		**ΔCDS**	
	Coefficient	**p-value**	**Coefficient**	**p-value**
		Panel A. Germany		
R_{t-1}	0,02	0,6185	**-0,33**	**0,0023**
R_{t-2}	-0,05	0,2166	**0.30**	**0,0059**
R_{t-3}	0,00	0,9536	-0,03	0,7685
ΔCDS_{t-1}	**-0,04**	**0,0049**	**0,17**	**0,0000**
ΔCDS_{t-2}	0,01	0,5310	0,06	0,1585
ΔCDS_{t-3}	**0,03**	**0,0120**	**-0,08**	**0,0333**
Constant	0,00	0,3759	0,00	0,5717
Observations	780		780	
R-squared	0,0264		0,0695	
Adj. R-squared	0,0188		0,0622	
		Panel B. Greece		
R_{t-1}	-0,05	0,2588	-0,09	0,2762
R_{t-2}	**-0,11**	**0,0184**	-0,07	0,4179
ΔCDS_{t-1}	**-0,07**	**0,0027**	**0,27**	**0,0000**
ΔCDS_{t-2}	0,00	0,9780	**-0,12**	**0,0077**
Constant	0,00	0,1753	0,00	0,0544
Observations	623		623	
R-squared	0,0220		0,0782	
Adj. R-squared	0,0157		0,0722	
		Panel C. Hungary		
R_{t-1}	-0,08	0,0602	0,11	0,1782
R_{t-2}	-0,06	0,1845	-0,06	0,4213
R_{t-3}	-0,03	0,4250	**-0,16**	**0,0494**
R_{t-4}	0,06	0,1412	-0,05	0,5424
ΔCDS_{t-1}	**-0,07**	**0,0014**	**0,21**	**0,0000**
ΔCDS_{t-2}	0,02	0,3613	-0,04	0,3566
ΔCDS_{t-3}	-0,02	0,3250	**-0,12**	**0,0062**
ΔCDS_{t-4}	0,01	0,7403	-0,08	0,0691
Constant	0,00	0,4177	0,00	0,7247
Observations	779		779	
R-squared	0,0228		0,0570	
Adj. R-squared	0,0127		0,0472	

Continued

		Panel D. Ireland		
R_{t-1}	-0,06	0,1459	0,10	0,2910
R_{t-2}	-0,02	0,5745	0,12	0,1936
ΔCDS_{t-1}	**-0,03**	**0,0338**	**0,27**	**0,0000**
ΔCDS_{t-2}	0,03	0,0809	-0,05	0,2287
Constant	0,00	0,4549	0,00	0,5649
Observations	781		781	
R-squared	0,0103		0,0653	
Adj. R-squared	0,0052		0,0605	
		Panel E. Italy		
R_{t-1}	-0,07	0,1382	0,04	0,7462
R_{t-2}	-0,03	0,5592	0,17	0,1279
ΔCDS_{t-1}	**-0,06**	**0,0004**	**0,29**	**0,0000**
ΔCDS_{t-2}	0,03	0,6220	-0,08	0,0618
Constant	0,00	0,6487	0,00	0,3777
Observations	781		781	
R-squared	0,0211		0,0803	
Adj. R-squared	0,0160		0,0756	
		Panel F. Portugal		
R_{t-1}	-0,07	0,1260	0,25	0,0783
R_{t-2}	-0,04	0,3493	0,26	0,0636
R_{t-3}	-0,05	0,2013	**0,37**	**0,0101**
R_{t-4}	0,01	0,8421	0,02	0,8640
ΔCDS_{t-1}	**-0,06**	**0,0000**	**0,36**	**0,0000**
ΔCDS_{t-2}	0,02	0,2217	-0,04	0,3360
ΔCDS_{t-3}	-0,02	0,1632	0,04	0,3799
ΔCDS_{t-4}	**0,03**	**0,0080**	**-0,12**	**0,0053**
Constant	0,00	0,5441	0,00	0,0830
Observations	779		779	
R-squared	0,0525		0,1369	
Adj. R-squared	0,0426		0,1279	

Continued

		Panel G. Spain		
R_{t-1}	-0,01	0,7985	0,01	0,9502
R_{t-2}	-0,07	0,1100	0,16	0,1992
R_{t-3}	-0,04	0,2915	0,09	0,4935
R_{t-4}	-0,01	0,8714	-0,23	0,0659
ΔCDS_{t-1}	**-0,06**	**0,0001**	**0,14**	**0,0008**
ΔCDS_{t-2}	0,03	0,0542	-0,06	0,1664
ΔCDS_{t-3}	-0,02	0,1574	-0,05	0,2678
ΔCDS_{t-4}	**0,03**	**0,0194**	**-0,20**	**0,0000**
Constant	0,00	0,5927	0,00	0,1494
Observations	779		779	
R-squared	0,0533		0,0709	
Adj. R-squared	0,0435		0,0612	
		Panel H. UK		
$\Delta Stock_{t-1}$	0,03	0,4025	**-0,26**	**0,0260**
ΔCDS_{t-1}	0,01	0,6025	**0,09**	**0,0287**
Constant	0,00	0,3412	0,00	0,6991
Observations	782		782	
R-squared	0,0009		0,0221	
Adj. R-squared	-0,0016		0,0196	

Appendix D presents the estimated VAR coefficients for all countries included in the analysis. Significant coefficients at a 5 % level and p-values below 0.05 are marked with bold font.

Preliminary Thesis Report

The remaining pages include the preliminary thesis report handed in January 16, 2012, and should not be considered as a part of the final thesis.

Introduction

The borrower's overall ability to meet contract specified obligations determines the credit risk in an investment situation, and investors have always been exposed to the risk that their counterparties are unable to fulfill their liabilities. The demand for ways to hedge and diversify credit risk initiated the development of products that liberated financial institutions from the undesirable exposure. Credit derivatives' entry into the world of finance has made it possible to transfer the underlying risk to entities that have the capacity to bear it, and these instruments have since its birth in the 1990s seen a rapid evolution. Offering protection against counterparty default, credit default swaps (CDSs) currently dominate the credit derivatives market.

Being directly linked to the reference entity's default probability, CDSs offer a useful benchmark for measuring credit risk. Hence, market prices on sovereign CDS provide a platform to measure market views on a country's default risk. Theory suggest that default risk should be reflected in equity values, and thus be visible in a nation's stock market. Research by Chan et al. (2009) has found a negative relationship between sovereign CDS spreads and equity markets in several Asian countries, consistent with the model for measuring credit risk proposed by Merton (1974). Further, the relationship seems to be stronger the closer to default. Consequently, the recent financial problems and credit downgrade of European countries inspire us to examine the link between sovereign CDS spreads and equity markets on the European continent.

Detecting a long-run relationship infer several implications. First, capital structure arbitrage strategies can be applied in these markets. Second, if a negative relationship is found, implying that the stock index falls (increases) with widening (narrowing) CDS spreads, the equity market is a good candidate for assessing the country-specific factor for sovereign risk. Further, this should motivate arbitrageurs to examine where the price discovery occurs by evaluating the error correction adjustments in the markets.

Background and applicable theory

Credit Default Swaps

One of the most used credit derivatives is a Credit Default Swap (CDS), and its popularity has grown significantly since institutions began to focus on hedging credit risk in the 1990s. CDSs are financial derivatives that offer insurance against credit or default risk of bonds or loans. Purchasers of such derivatives obtain the right to sell the reference security issued by the reference entity, usually a company or government, for their face value if a credit event occurs. Effectively, credit risk is transferred from the protection buyer to an insurer, represented by CDS seller, through periodic payments in exchange for protection against default or other adverse credit events. The "insured" credit events are specified in the CDS contract and usually include failure to pay, restructuring of debt, or bankruptcy (Hull 2012), but may also refer to events such as obligation acceleration, obligation default, and repudiation/moratorium. If the CDS is triggered, the contract terminates and the insurer has the obligation to cover the protection buyer's incurred loss.

Settling the CDS involves either physical delivery or cash payment. In case of physical settlement, the protection seller receives the underlying reference security in exchange for compensating the CDS buyer with the face value. With cash settlement, the protection buyer receives the difference between the recovery value, i.e., the value of the reference security at the time of settlement, and the face value. Due to the difficulty of predicting post-default recovery values, physical delivery was the most commonly used form of settlement for a long time. However, as auction settlement procedures have been incorporated in standard CDS contracts, cash payment is now becoming more widespread (Weistroffer 2009).

Broadly speaking, CDS products are used for hedging, speculation, and arbitrage. While hedging purposes dominated in the early years, other trading objectives soon became equally important (Weistroffer 2009). Since CDSs are traded privately in the over-the-counter (OTC) market, they allow counterparties to tailor the contracts in accordance with their specific needs. The various types of CDS products that exist satisfy heterogeneous investor preferences, and can in general terms be split into two categories; single-name and multi-name CDSs. Single-name CDSs represent the traditional form, in which the derivative contract is referenced on individual corporate or sovereign borrowers, while the multi-name CDSs are written on various entities. As of December 2011, single-name CDSs accounted for 57% of the market, while multi-name products such as Index CDSs and Tranched Index CDSs amounted to 35% and 8%, respectively (DTCC 2011). However, the increased use of proxy hedges has led to a rapid growth in the multi-name segment the recent years (Weistroffer 2009).

Despite the possibility to customize the contracts, most traded CDSs are standardized according to a framework provided by the International Swaps and Derivatives Association (ISDA). Along with the increased attention on credit risk hedging and speculation, the introduction of standard contracts in 1998 fuelled the growth of the CDS market (Hull 2012). The notional amount outstanding of CDSs grew from $918.9 billion in 2001 to a peak of $62.2 trillion in 2007 (ISDA 2010). During the financial crisis, the lack of transparency and the market's vulnerability to systemic risk started to concern regulators, and the development of clearing houses for CDS trades was one answer to the prevailing concerns (Hull 2012). Moreover, efforts were focused on portfolio compression, i.e., a process that reduces the overall notional size and number of outstanding contracts in credit derivative portfolios without changing the net risk position of a financial institution. Due to a fall in CDS trading activity and effective portfolio compression during and after the financial crisis, the outstanding amount declined to $26.3 trillion in 2010 (ISDA 2010).

CDS spread

The periodic payments made by the purchaser of the CDS, in exchange for default protection, are derived from what is known as the CDS spread or premium. The CDS spread is basically the payments expressed as a percentage of the notional principal, in which the notional principal refers to the total face value covered by the CDS contract. Even though contracts with semiannual and annual transfers exist, protection payments are normally made every quarter. The quotation of the CDS spread, however, is done in basis points per annum. For example, a CDS spread of 200 basis points for default protection on a notional amount of $10 million costs $200,000 per year. Following the market norm, the protection buyer pays the seller $50,000 every quarter until the maturity of the CDS or until an insured credit event occurs. The mechanisms of a CDS agreement are represented in figure 1.

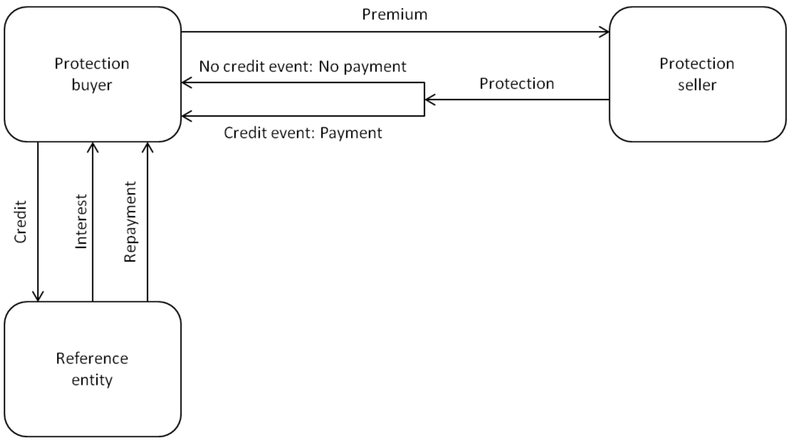


Figure 1: CDS mechanisms

On the trading day, the two parties involved in a CDS deal agree upon the spread required for default protection, and this market price reflects the risk of the underlying credit. Logically, if everything else is equal between two CDSs, the one with the highest premium is associated with the reference credit perceived as most risky. In other words, a purchaser of a CDS pays a relatively higher spread to protect an investment in a company or sovereign that by the market is considered to have the largest likelihood of default. Contrary, a decline in the premium signals an improvement in the perception of the credit quality. In principle, the CDS spread should reflect the expected loss of the reference entity, which again is a function of the probability of default (pd) and the recovery rate (rr). Hence, the CDS spread can be expressed as follows (Weistroffer 2009):

$$CDS\ spread = pd * (1 - rr)$$

If the recovery rate is assumed to be zero, a protection buyer insuring credit, issued to a reference entity with a 2% default probability, would have to pay a spread of 200 basis points on the notional amount. Naturally, the CDS spread is a rising and declining function of the default probability and recovery rate, respectively. As with other credit dependent instruments, the default probabilities used to value a CDS should be risk-neutral. While actual probabilities are calculated from historical data, risk neutral probabilities differ in that they are backed out from bond prices and CDS spreads (Hull et al. 2005). For instance, if a

CDS quote is observed in the market, reverse engineering can be used to determine the implied default probability.

Being directly related to default probabilities, both the bond yield and the CDS spread provide useful information on credit risk, and due to arbitrage arguments these measures should be closely related. Specifically, the CDS-bond basis, defined as the difference between the CDS spread and the bond spread, should be close to zero for no arbitrage opportunities to exist. Essentially, this is because the purchase of a CDS turns a bond "approximately risk-free". If the bond spread, i.e., the excess of the bond yield over the risk-free rate, is significantly larger than the CDS spread for a specific reference entity, an investor can earn more than the risk-free rate by taking a long position in the bond and buying default protection. Equivalently, if the CDS spread is markedly above the bond's risk premium, investors can borrow at less than the risk-free rate by shorting the bond and selling a CDS. Prior to the credit crunch in 2007, the CDS-bond basis was on average slightly positive. However, due to a relatively high risk premium in the bond market, the basis turned negative and drifted far away from its theoretical equilibrium during the financial crisis (Hull 2012).

In theory, integrated behavior between the markets makes sense, but several factors complicate the relationship in practice. In addition to credit risk, bond yields are considerably affected by interest rate risk and liquidity, while the CDS spread depends heavily on elements such as recovery rates and counterparty risk (Weistroffer 2009). Empirical studies conclude that CDS spreads in general lead the bond market, and thus serves as a better market indicator for distress (see literature review). The reasons for this are attributed to some favorable characteristics of the CDS premium. First, the CDS spread separates credit risk from the interest rate risk incorporated in bond yields, effectively removing one source of pricing uncertainty. Second, CDSs are generally more liquid than their underlying bonds for risky credit (Kiff et al. 2009). Third, while the liquidity in bond markets shrinks, CDS trading seem to continue in periods of distress (Becker 2009). The relatively high risk premium in the bond market during the financial crisis provides evidence for the latter attribute. Due to the favorable characteristics, CDS spreads have gained widespread acceptance as a platform to gauge market views on the default risk of corporate and sovereign borrowers.

Merton's model

A model proposed by Robert C. Merton (1974) formalizes the relationship between bond and equity prices, and can also be used to draw a link between CDS and equity markets. Recognizing that equity represents a residual claim, Merton defines the equity of a company, partly financed by debt, as a call option on the company's assets. If the value of a company's assets (V) is less than the debt repayment (D), it is rational for equity holders to default on the debt since the equity (E) is worthless, i.e., E = V – D < 0. However, if the assets exceed the debt value, the company should repay the debt and obtain an equity value of E = V – D > 0. Using option-pricing theory, the company's equity is:

$$E = \max (V - D, 0)$$

Phrased differently, the equity value is a call option on the value of the assets with an exercise price corresponding to the face value of the debt. Then, if the assets are worth more than the debt, the call option is "in-the-money". Contrary, the option is "out-of-the-money" and a default occurs if debt repayment goes beyond the asset values.

A company's liabilities constitute a barrier level for the value of its asset. The higher the debt level is relative to assets, the higher is the default risk. In this connection, Merton notes that bond and equity prices exhibit positive correlation, in which the degree of correlation will be stronger when debt-to-asset values are high and default is a substantial threat. If the current asset values in a company are close to what is owned to the creditors, the slightest negative move can send the call option out-of-the-money and provoke a default situation. In other words, if the firm's value is just enough to cover the company's debt, then relatively small changes in firm value may cause it to default. Adverse movements will lead to a decline in equity prices, since the residual claim is in danger of becoming worthless, and bond prices will plunge as a result of increased default risk. Rising default risk reduces the expected payoff for bond holders, and since this is incorporated into a higher risk premium, equity prices and bond spreads will move in opposite directions. Given the close relationship between bond spreads and the CDS premium, as described in the section above, the negative association should also hold between equity prices and CDS spreads.

Capital structure arbitrage

As mentioned, CDSs are primarily used for hedging, speculation, and arbitrage purposes. In practice, arbitrage plays an important role in maintaining the integration between the CDS and equity markets. More precisely, a hedge fund strategy referred to as capital structure arbitrage utilizes the negative association and aims to exploit pricing inefficiencies in the capital structure of a firm. By applying Merton's model, arbitrageurs are able to predict default probabilities and, hence, theoretical CDS spreads based on equity values (Hull 2012). The theoretical price is subsequently compared to the prevailing CDS spread in the market, and if inconsistencies are detected arbitrage opportunities may exist. In other words, the CDS and equity markets should price default risk equally for price efficiency to be present.

If the premium obtained in the market is significantly larger than the model implied CDS spread, the arbitrageur may sell credit protection if it is believed that the equity market reflects the correct price. Essentially, the arbitrageur then believes that the CDS market has incorporated a default risk that is too high. To hedge the position, equity should be shorted. Due to the integration between the markets, it is now expected that the CDS premium converges towards the predicted spread, making profit for the arbitrageur. If it, on the other hand, turns out that the default risk was higher than predicted by the stock market, the idea is that the loss on the credit protection can be offset by the gain on the short equity position. In the latter case, the stock market has priced in too little credit risk, and a drop in equity values is thus predicted to uphold the negative relationship between CDS spread and equity values.

Extension of Merton's model to sovereigns

Chan-Lau and Kim (2004) justify how Merton's framework can be extended to sovereigns. The main difference between corporate and sovereign issuers is that a country may choose to default on its debt even when it is able to pay, i.e., the asset values of the country exceed the debt repayment but still the country refuses to fulfill its obligations. This may be due conflict of interest, where liquidity and political factors come into play. Since a "willingness-to-pay factor" enters the system, the asset values in which a country may choose default are higher than in the case with firms. Being the only substantial difference, this implies that the default risk for a sovereign is higher for every asset value. However, the relationship between CDS spreads and equity values remains unaltered.

Intuitively, higher default or sovereign risk is related to deteriorating economic fundamentals and a negative outlook for the national economy, elements that also have adverse impact on the stock market. Due to an increase in the risk premium required by investors, equity values will depreciate. At the same time, increased sovereign risk will be incorporated in CDS prices and also push up the total demand for insurance against default. Since protection sellers typically neutralize their exposure by shorting bonds or equity, a further downward pressure will hit the stock market (Chan et al. 2009). Therefore, a country's sovereign risk, captured by CDS spreads, should be inversely related to its stock prices. Similarly, the degree of correlation is higher if sovereign risk is a major concern and capital structure arbitrage will also here correct pricing inefficiencies.

Literature review

Rating agencies, such as Moody's and Standard and Poor's, have for many years provided credit ratings for sovereign and corporate bond issuers. These ratings give us an indication of credit risk's impact on equity prices. Examining the effect of credit rating announcements on stock prices, Hand et al. (1992) finds instantaneously negative abnormal stock returns following a downgrade or downgrade announcement. Positive credit rating signals however, had no effect on the stock price. Contradictory, Holthausen and Leftwich (1986) find that both upgrades and downgrades are already priced by the stock market, consistent with the discrete nature of credit ratings and the efficient market hypothesis.

Due to the infrequent revision, credits rating suffer under clear limitations as a variable for exploring the relationship under study. CDS spreads quoted on a daily basis provide investors with the opportunity to evaluate the default risk of an entity on a continuous basis. Considering CDSs' relatively short history as a credit derivative, prior research on the field is limited. The rapid development and increased use of credit derivatives have, however, boosted the interest for CDSs and extended the literature base on the topic the recent years. The existing literature involving the link between the CDS, bond and equity markets primarily investigates relationships on the corporate level. When examining the relationship between CDS spreads and bond yields, Hull et al. (2004) find that the theoretical relationship holds reasonably well, consistent with Blanco et al. (2005) conclusion of a valid equilibrium relation between CDS prices and credit spreads for all U.S and most European firms analyzed. Additionally, Zhu (2006) confirms the theoretical equilibrium relationship. By analyzing the relationship between sovereign CDS premiums and bond yield spreads for nine emerging countries, Ammer and Cai (2011) discover a stable long-run relationship. The finding is consistent with the results of Palladini and Portes' (2011) study of sovereign CDS and bond pricing dynamics in the Euro area. However, Ammer and Cai (2011) notice that the two prices of credit risk often diverge in the short run.

In their analysis of the firm-specific market co-movements, Norden and Weber (2009) find CDS and bond spread changes to be negatively correlated with stock returns for a sample of over 1000 U.S and non-U.S. entities. Fung et al. (2008) study the relation between the U.S. stock market and corporate CDSs, and detect strong feedback effects from the high-yield CDS market to the stock market. However, this feedback effect is absent for the investment grade CDS market. Additionally, the feedback from the high-yield CDS market is only present when the stock market is declining and the credit conditions are worsening. This is in line with Merton's theory that predicts CDS spreads to show a stronger correlation with the stock price when the reference entity is closer to default.

Chan-Lau and Kim (2004) extend Merton's model from firms to sovereign issuers in order to examine the equilibrium price relationship between CDS, bond and equity prices in eight emerging markets around the world. Results show a strong correlation between CDS and bond spreads, suggesting that arbitrage forces make them converge. However, the authors do not detect any equilibrium relationship between CDS and equity prices. Consistent with Merton's theory, the authors suggest that low debt-to-equity ratios can explain the absent relationship. In their study of the relationship between Asian sovereign CDS and equity markets, Chan et al. (2009) reports a strong negative correlation between CDS spreads and stock prices, and they observe long-run equilibrium relationships in three countries. Also here, the correlation between sovereign CDS spreads and the stock index has stronger correlation the higher the default risk is. This implies that changes in credit risk are more important drivers of stock prices when the probability of default is higher. Authors speculate that low default risk or volatile leverage can explain why a long-run equilibrium is absent in the other countries.

For price discovery, empirical findings are mixed. Byström (2005) analyze the relationship between a sample of European sector iTraxx CDS indices and the stock market. His results suggests that firm-specific information is embedded into stock prices before CDS spreads, implying that the stock market leads the CDS market in transferring firm-specific information. Cointegration between CDS and bond spreads is found for most firms investigated by Norden and Weber (2009), and a vector error correction model (VECM) reports the CDS market to lead the bond market, while evidence suggest that the stock market lead both the CDS market and bond market.

The research on price discovery for sovereign CDSs is limited. Using a VECM, Chan-Lau and Kim (2004) provides evidence of equal importance of the sovereign CDS and bond markets in some of the countries under investigation and a negligible role of the equity market. Further, Chan et al. (2009) analyzes the sovereign CDS market and the stock market to find a lead-lag relationship. Findings suggest that price discovery primarily takes place in the CDS market in five out of seven countries. The authors speculate that fewer restrictions, broader investor base and greater information advantage in the CDS market in the emerging markets under consideration leads to this result. For Japan, there were no findings of a lead-lag relationship, strengthening the authors' theory, as Japan is a more developed country with low sovereign risk and better liquidity in the financial markets.

Research question

Considering earlier research primary focus on the dynamic relationship between corporate CDSs, bonds and equity markets, our master thesis will contribute to the field of sovereign CDSs. Influenced by the research conducted by Chan et al. (2009) in Asian emerging markets and in light of the ongoing sovereign debt crisis, we want to provide an outline of the sovereign CDS market in Europe and investigate its link to equity markets. In particular, we want to examine whether there exists a long-term equilibrium relationship between the fluctuations in a country's sovereign CDS spread and its equity market. Moreover, we want to study where the price discovery occurs. The following research questions have been formulated:

3. Are sovereign CDS markets and equity markets in Europe bound together in a long-run equilibrium relationship?
4. Which of the markets is more important for price discovery in European countries?

Methodology

We are interested in examining the long-term relationship between the sovereign CDS spread and the equity markets in several European countries, and our procedure is closely linked to the methodology outlined by Chan et al. (2009). In order to answer our research question, we find quantitative analysis of time series data to be applicable.

Investigating the long-term relationship between variables requires the variables to be stationary, as conducting regular OLS regressions to non-stationary variables could lead to spurious regressions, not suitable for interpretation. Consequently, we will examine whether our variables are stationary or not by performing an Augmented Dickey-Fuller test. Further, the variables can be made stationary by taking the first differences. If the variables become stationary after this transformation they are integrated of order one, implying one unit root in the original variables. Graphically, the data should be transformed from a time series of a non-stationary random walk to a stationary white noise process.

Since a model based on first differences does not have any equilibrium because of the absence of a long term relationship between the variables, a great deal of economic content is lost. In order to deal with the problem, we have to prove that a set of variables is cointegrated. If a linear combination of the variables is stationary (Brooks, 2008), we can test whether our variables are cointegrated by conducting either the Engle-Granger two-step method or the Johansen test for cointegration, depending on our data. Given that cointegration is detected, a VECM is employed. The general VECM can be formulated as follows:

$$\begin{pmatrix}\Delta y_{1t}\\ \Delta y_{2t}\end{pmatrix} = \begin{pmatrix}\mu_1\\ \mu_2\end{pmatrix} + \begin{pmatrix}\alpha_1\\ \alpha_2\end{pmatrix}(y_{1t-1} - \beta_0 - \beta_1 y_{2t-1}) + \begin{pmatrix}\varepsilon_{1t}\\ \varepsilon_{2t}\end{pmatrix}$$

The model is a combination of first differentiated and lagged levels of cointegrated variables (Brooks 2008), capturing the long-term relationship between the stock index and the CDS spread. In addition to providing information on equilibrium relationships, the model gives us the opportunity to investigate where the price discovery takes place. If the variables are cointegrated there is a correction towards a long-term equilibrium when the variables are out of balance, and the VECM provides us with estimates on how this correction evolves. Since the model is estimated on stationary data, it offers interpretable standard measures and coefficients. The estimated alpha values indicate how the variables affect each other, yielding information about where the price discovery occurs. However, if the variables are not cointegrated, we need to estimate a vector autoregressive (VAR) model on stationary differentiated variables. In combination with the concept of Granger causality, the VAR model can then be used to test for price leadership.

To ensure robust and reliable results, tests for normality, heteroscedasticity and autocorrelation will be performed and alarming results will be reported and dealt with in the final thesis.

Data

Our research will focus on the relationship between sovereign CDS spreads and the country's stock index. In order to obtain a robust result and discover possible differences in the relationship, we will study several European countries. Consequently, we need data on the historical development of sovereign CDS spreads and stock indices for the selected countries. Being most liquid, five-year CDS spreads will be used together with the main stock index in the selected country. Depending on the available data we will use monthly data in order to minimize noise in the dataset.

Data on equity values can easily be found for most European countries in Thomson Reuters DataStream (DataStream), while quality data on historical CDS spreads is more complicated to get hold of. Seeing that Chan et al. (2009) use Markit Group Ltd. as their provider of CDS data, our first choice was to use the same source. We have been in contact with Markit, but not been able to achieve the required data on sovereign CDS spreads due to BI Norwegian Business School's limited access and fund restrictions. Consequently, we will most likely use DataStream as a source for historical sovereign CDS spreads. Although sovereign CDS spreads are possible to find in DataStream.

Implementation plan

Recognizing the value of an implementation plan to ensure a continuous progress, we outline a draft version. Due to several elements of uncertainty regarding data gathering, date of the thesis presentation and how our progress evolves, changes will presumably occur.

After delivering the preliminary thesis report, we will alternate our work between the approaching presentation of our thesis and the data gathering process. Considering the importance of gathering the necessary data, we will spend the amount of time needed to collect the required quality of our data. However, we would like to be in possession of the requisite data by March 1st. Depending on when our data is gathered, we will start the laborious task of analyzing the data, employing the methodology and interpret our results. Seeing the increased workload, due to double lectures in Advanced Corporate Finance in this period, the number of days spent on this part will be somewhat increased. Nevertheless, finishing the data analysis by April 15th is preferable.

We seek to finish a draft version of the thesis as early as possible in order to get the necessary feedback and guidance from our supervisor. Aiming for a complete master thesis by July 1st gives us a buffer to overcome unanticipated changes and difficulties that may arise during the period, and secures that the complete thesis is finalized before the deadline of hand-in September 1st.

References

Ammer, John, and Fang Cai. 2011. "Sovereign CDS and Bond Pricing Dynamics in Emerging Markets,: Does the Cheapest-to- Deliver Option Matter?" *Journal of International Financial Markets, Institutions and Money,* 21(3): 369-387.

Becker, Sebastian. 2009. "EMU sovereign spread widening – Reasonable market reaction or exaggeration." *Deutsche Bank Research*. EU Monitor No. 68, June 29, 2009.

Blanco, Roberto, Simon Brennan, and Ian W. Marsh. 2005. "An empirical analysis of the dynamic relationship between investment-grade bonds and credit default swaps." *Journal of Finance,* 60(5): 2255-2281.

Byström, Hans N. E. 2005. "Credit Default Swaps and Equity Prices: The iTraxx CDS Index Market." *Working Papers* 2005:24, Lund University, Department of Economics, revised May 15, 2005.

Chan, Kam C., Hung-Gay Fung, and Gaiyan Zhang. 2009. "On the Relationship Between Asian Credit Default Swap and Equity Makets." *Journal of Asian Busniness Studies,* 4(1): 3-12

Chan-Lau, Jorge A., and Yoon S. Kim. 2004. "Equity Prices, Credit Default Swaps, and Bond Spreads in Emerging Markets." *IMF Working Paper No.* WP/04/27

DTCC – The Depository Trust & Clearing Corporation. 2011. "Trade Information Warehouse Data (Section I)." Accessed January 11, 2012. http://www.dtcc.com/products/derivserv/data_table_i.php

Fung, Hung-Gay, Gregory E. Sierra, Jot Yau, and Gaiyan Zhang. 2008. "Are the U.S. Stock Market and Credit Default Swap Market Related? Evidence from the CDX Indices." Journal of Alternative Investments, 11(1): 43-61.

Hand, John R. M., Robert W. Holthausen, and Richard W. Leftwich. 1992. "The Effect of Bond Rating Agency Announcements on Bond and Stock Prices." *Journal of Finance*, 47(2): 733-752.

Holthausen, Robert W., and Richard W. Leftwich. 1986. "The Effect of Bond Rating Changes on Common Stock Prices." *Journal of Financial Economics*, 17(1): 57-89.

Hull, John C. 2012. *Options, Futures, and Other Derivatives*. 8th ed. Pearson Education: Prentice Hall.

Hull, John, Mirela Predescu, and Alan White, 2004. "The relationship between credit default spreads, bond yields and credit rating announcements." *Journal of Banking and Finance*, 28(11): 2789-2811.

Hull, John, Mirela Predescu, and Alan White. 2005. "Bond Prices, Default Probabilities and Risk Premiums." *Journal of Credit Risk*, 1(2): 53-60

ISDA – International Swaps and Derivatives Association. 2010. "ISDA Market Survey." Accessed January 7, 2012. http://www2.isda.org/attachment/Mjk5Nw== /ISDA-Market-Survey-results1987-June%202010.pdf

Kiff, John, Jennifer Elliot, Elias Kazarian, Jodi Scarlata, and Carolyne Spackman. 2009. "Credit derivatives: Systemic risk and policy options." *IMF Working Paper*. WP/09/254

Merton, Robert C. 1974. "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates." *Journal of Finance,* 29(2): 449-470

Norden, Lars, and Martin Weber. 2009. "The Co-movement of Credit Default Swap, Bond and Stock Markets: an Empirical Analysis." *European Financial Management*, 15(3): 529–562.

Palladini, Giorgia, and R. Portes. 2011. "Sovereign CDS and Bond Pricing Dynamics in the Euro-Area." Accessed January 11th, 2012. http://www.nber.org

/papers/w17586

Weistroffer, Christian. 2009. “Credit default swaps – Hedging towards a more stable system”. *Deutsche Bank Research*. Current Issues, December 21, 2009.

Zhu, Haibin. 2006. “An empirical comparison of credit spreads between the bond market and the credit default swap market.” *Journal of Financial Services Research*, 29(3): 211-235.