An analysis of Eurozone sovereign credit default swaps

An empirical investigation of the determinants of the spread on sovereign credit default swaps from 2003-2012

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Executive Summary

The thesis investigates the determinants of sovereign credit default swaps (CDS) from the period March 2003 and until January 2012. Following the European sovereign debt crisis, credit risk for a number of European countries increased enormously. The paper investigates the proposed pricing changes of sovereign risk by analysing the spread on CDS for seven Eurozone countries: France, Germany, Ireland, Italy, Portugal and Spain. The study sheds light on the mechanisms of sovereign CDS pricing. A set of compressive econometrics techniques is carried out to create the analysis. A Principal Component Analysis (PCA) is employed to investigate the commonalities in the CDS spread where the regression analysis finds there to be one main driver of sovereign credit risk, but less co-movement between the various CDS spreads are found during the debt crisis compared to the period prior to the crisis.

The paper develops an empirical model based on a set of country-specific and global risk determinants. The model tries to explain CDS spreads and determine whether the market pricing of risk differ for the indebted countries compared to more stable euro-zone countries. An analysis of the period prior to the crisis is compared to an analysis carried out of the time during the sovereign debt crisis.

The model finds significant effects from global variables, local stock markets and countries' credit ratings in addition contagion effects are detected. Country specific variables, such as government debt levels and fiscal balances, lack explanatory power and does not contribute significantly to the pricing of sovereign risk. Significant pricing differences are found for the various countries and prior to the debt crisis compared to during the crisis. The model does not explain the pricing of CDS to a satisfactory level for Greece, Portugal and Spain prior to the crisis, while the model has increased explanatory power during the sovereign debt crisis for the indebted countries. Sovereign risk in the stable economic, France and Germany, is explained by different determinants that the indebted countries.

The same empirical model is tested on the underlying bond yield spread, where the model lacks explanatory power. It becomes apparent that sovereign risk is affected by different determinants in the CDS and the bond markets. In addition the thesis investigated the relationships between two widely reckonings indicators of sovereign risk. By employing a cointegration test, the lead-lag relationship between the bond and the CDS market is investigated where a long-run relationship between two markets is detected in several countries. No clear price discovery mechanism is observed. It shows the CDS market leading the bond market in half of the tested sample, while price discovery takes place from the bond market to the derivatives more for the other half. The results show the increased leading role of the CDS market.

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1 Introduction

1.1 Introduction

The Eurozone has since 2009 experienced high economic instability and been severely affected by a sovereign debt crisis. The global financial crisis of 2007-2009 reached a peak in September 2008 with the collapse of the United States' investment bank Lehman Brothers. After the event, major banks in the United States (US) and in Europe were in severe distress and reached out to their respective governments for financial support. As government debt in several Eurozone countries was amplified, increased attention was drawn towards the sovereign credit market. The credit quality of many sovereign issuers was reassessed. High government debt combined with fiscal imbalances and increasing government deficits lay the ground for a sovereign debt crisis. The crisis has created a recession in several Eurozone countries stagnating economic growth and created the biggest challenge of the European Monetary Union (EMU) since its creation.

The credit risk for several Eurozone countries has increased tremendously since the outbreak of the financial crisis in 2008. The sovereign debt crisis has increased the focus on euro area default risk. Historically, government debt issued by Eurozone sovereigns has been considered a low risk investment, where the probabilities of default have been considerably low. Several credit crises in emerging market economies has resulted in increased focus in understanding the drivers of default risk in these markets, leaving the Eurozone a relative untouched study in terms of modelling default risk.

Recent concerns about the default risk of Eurozone's government debt have resulted in a dramatic increase in the spread on credit default swaps (CDS). CDS is a commonly traded credit derivative instrument introduced as a financial security in the 90's. The popularity of the derivative instrument has increased enormously since its introduction. A CDS contract is a bilateral contract where one counterparty buys default protection on a given reference entity, either a bond or a loan. The payoff from the contract is linked to changes in the credit quality of the underlying asset. Reference entities have primarily been corporations, but the use of CDS contracts written on sovereigns have increased steadily following several sovereign debt crisis. The spread on a CDS contract has become a commonly used measure of risk assessment of the probability of default in a country. Many consider it a better measure of credit risk than the spread on the underlying bond. Understanding credit risk and its components has become a major concern for all participants in the market and investigating the determinants of the CDS spread can help in assessing default risk. Investigating the drivers of the spread on Eurozone CDS contracts have received increased attention.

1.2 Problem statement

Motivated by the on-going sovereign debt crisis an analysis of the determinants of sovereign CDS spread is performed in order to shed light on new perspectives of European sovereign default risk. The following problem statement will be answered in the thesis:

"What are the determinants of the spread on sovereign credit default swap in Eurozone countries?"

The problem statement will be investigated by creating an empirical model including several macroeconomic and financial variables, which are expected to have an impact on sovereign default risk.[1] The thesis will not focus on a specific pricing model thus allowing to determine the effect from numerous variables not being contraction to a specific set of inputs. The study will investigate the pricing of monthly CDS contracts over the period from March 2003 and until January 2012 for seven Eurozone economies. Five countries severely affected by the sovereign debt crisis will be studied, notably Portugal, Ireland, Italy, Greece and Spain, commonly referred to as the PIIGS countries. Comparison will be done with two more stable countries; France and Germany. An investigation of the proposed re-pricing of credit risk during the debt crisis will be assessed by comparing the period prior to the crisis with the crisis period beginning in October 2008. As opposed to most recent studies, a country-based time series analysis is carried out, rather than a panel regression.[2] A panel regression analysis has not been employed as it is of interest to investigate the relative pricing difference between the various Eurozone countries.

The paper compares the pricing of credit risk in the CDS market to the underlying bond market in order to study the accuracy in measuring sovereign default risk between the two markets. In addition, the lead-lag relationship between the two markets will be investigated in order to determine the price discovery mechanism between the derivatives market and the bond market.

1.3 Literature review

CDS is a relatively new instrument in the fixed income market compared to the bond market, and thus research on the bond market greatly exceeds studies on the derivative instrument. Numerous researches have been done in trying to understand the drivers of bond spreads. In addition, corporate CDS have been dominating the credit derivatives literature whereas the studies on sovereign CDS have been scarce. From its introduction in the 90's and up until present time the literature on sovereign CDS can broadly be divided into two time groups: research based on emerging market economies and studies based on the European crisis.

[1] Default risk, default probabilities and sovereign risk will be used interchangeably throughout the thesis assuming similar meaning.
[2] Regression analysis including two dimensions; cross sectional and time series.

Prior to the sovereign debt crisis government debt in the advanced economies was considered to be relatively safe and thus little attention was drawn towards studying it. Following the debt crisis in Asia and several other emerging countries, the focus in the literature was related towards investigating the default risk in emerging markets. Pan and Singleton (2008) have contributed extensively to the study on emerging market CDS spreads. They study the evolution of sovereign CDS spreads in Mexico, Turkey and Korea from 2001-2006 and finds that variations in the CDS spread can be traced back to political, macroeconomic and financial market developments. Co-movements among the CDS spreads are related to global risk determinants, rather than fundamental country specific determinations. In addition, developments in the US economic growth greatly affect the spread.[3]

In similar fashion Longstaff et.al (2011) determines sovereign credit risk by studying 26 emerging market CDS spreads over the period 2000-2010. An extensive number of both local and global variables are included. The results are similar to that found by Pan and Singleton where the main determinants of sovereign credit risk are related to global factors, specifically US equity and high-yield markets. Local economic measures appear to have only a minor effect.[4]

Fontana and Scheicher (2010) are amongst the few who have extensively studied European sovereign CDS taking into account the on-going crisis. They employed a panel regression study including several European countries over the period from 2004 and until mid-2010 dividing the study into a prior crisis and crisis period. Including a series of both local and global variables, they study the effect on both CDS spread and the underlying bond spread. Their main findings is that the increased pricing during the crisis period can be related to common global factors, such as global risk aversion, whereas the corporate CDS market seems to be the main contributing factor over both periods. In addition, they study the lead-lag relationship between the bond market and the CDS market by employing a cointegration test. They find price discovery to take place in both markets.[5]

Alper et.al (2012) published a study on the pricing of sovereign credit risk over the period from 2008-2010 investigate the determinants of CDS and bond spread through a panel regression analysis for selected advanced economies. During the financial crisis, the CDS market has provided a better signal for sovereign credit risk. They find that fiscal measures are able to explain only a limited share of the variation in the CDS spread. Domestic financial variables and global determinants are the main predictors in explaining CDS pricing. An investigation of the cointegrated relationship between the two markets reveals that the CDS

[3] Pan and Singleton, 2008
[4] Longstaff et.al, 2010
[5] Fontana and Scheicher, 2010

market leads the process of price discovery in countries under market pressure, but there does not appear to be a significant pattern in the lead-lag relationship.[6]

Santis investigates Eurozone government bonds and CDS spreads studying the period from 2008-2011. The results from the two markets are similar, where only the point estimates differ. The study finds the increased spreads to be explained by regional aggregate risk factors, monetary policies and countries' credit ratings. In addition, significant spillover effects from credit rating announcements on Greek long-term government bond to several Eurozone counties are found. The results indicate that contagion effects have been present during the crisis. Santis employs a country-based regression model allowing for investigation of the increase in each country's spread. The explanatory variables have a higher level effect in the distressed countries.[7]

1.4 Delimitations

As the complexity of the sovereign debt crisis is wide, the thesis will not try to explain the technical reasons behind its origin, but give a brief understanding of the aspects of the Eurozone crisis that will help to shed light on possible determinants of sovereign default risk. The Eurozone includes a number of nations but the research has been limited to include only seven. The choice is based on the economic size of the countries and the desire to include the highly distressed countries in addition to comparative stable economies. In addition, it has been subject to data limitations. The situation of the European economy is constantly changing. The thesis will focus on studying the time period from 2003 and until January 2012 and thus changes occurring after this period are not accounted for.

Credit risk pricing is a widespread study, but the thesis is limited to explaining the concept of CDS contracts and introduces the basics of credit risk modelling. The focus of the study is on CDS contracts and not on the underlying bond. The underlying bond contract and its mechanisms will not be explained in detail, as it is not the purpose of this analysis. The explanation of the credit derivatives market will be restricted to include only CDS contracts, where the various other derivative instruments will be excluded.

1.5 Methodology

The paper will include a thorough investigation of European CDS spreads which will proceed in the following order. The next two chapters provide the theoretical aspects of the paper where the first chapter will provide an overview of to the European economy and the sovereign debt crisis in order to identify possible determinants of default risk. Following is a section on credit risk with a thorough explanation of the setup of a CDS contract and the pricing of credit risk. The next five chapters present the empirical model and the econometric techniques used to create a statistically correct analysis. Chapter 4 gives a full data

[6] Alper, Forni and Gerard, 2012
[7] Robert Santis, 2012

description. In chapter five, a principal component analysis is carried out to investigate the commonalities in the various CDS spreads. Chapter 6 presents the properties of the variables by investigating stationarity in the series. A cointegration test is employed in chapter seven to test for a long-run relationship between CDS and bond spreads. Chapter 8 assesses the assumptions of a regression model to obtain standard distributed estimates enabling for correct interface of the model. Chapter 9 interprets the empirical results where the final chapter presents concluding remarks.

2 The European economy

2.1 The European debt crisis

The world economy is currently in a state of high economic and financial instability. Some of the most successful nations of the world are now facing severe economic challenges. The sovereign debt crisis in Europe has questioned of the survival of the EMU. In order to investigate the determinants of sovereign default risk a more thorough understanding of the debt crisis and its drivers is necessary.

2.1.1 Creating the European monetary union

The origin of the crisis goes as far back as the beginning of the monetary union. The crisis was amplified by factors rooting back to the initial institutional design of the EMU. The EMU was established in 1999 creating a common currency between the countries participant in the monetary union. The European Central Bank (ECB) was given the responsibility of operating the monetary policy within the Eurozone.[8] The EMU was not accompanied by a banking and fiscal union such that member states still remained in control of the management of their fiscal policies and financial regulation. In addition, the introduction of a common currency eliminated the possibility for member states to use currency devaluation as an adjustment mechanism in case of an imbalanced economy.[9]

In order to become a member of the EMU strict requirements had to be fulfilled, known as the Maastricht Treaty. Three criteria were set; inflation was to be no more than 1.5% above the three lowest inflations rates among the EMU nations, government deficit could be no more than 3% of gross domestic product (GDP) and government debt was limited to 60% of GDP.[10]

2.1.2 The build-up of a sovereign debt crisis

The Eurozone experienced an enormous credit boom prior to the financial crisis. Loans to private sector increased enormously over the period from 1998-2007. Figure 2.1.2-1 illustrates private debt as a percentage of GDP over the period from 2003 until January 2012.

[8] Common reference for European Union countries that have adopted the euro currency. The terms Eurozone and euro area will be used interchangeably.
[9] Philip Lane , 2012, page 50
[10] Euro Economics, www.unc.edu

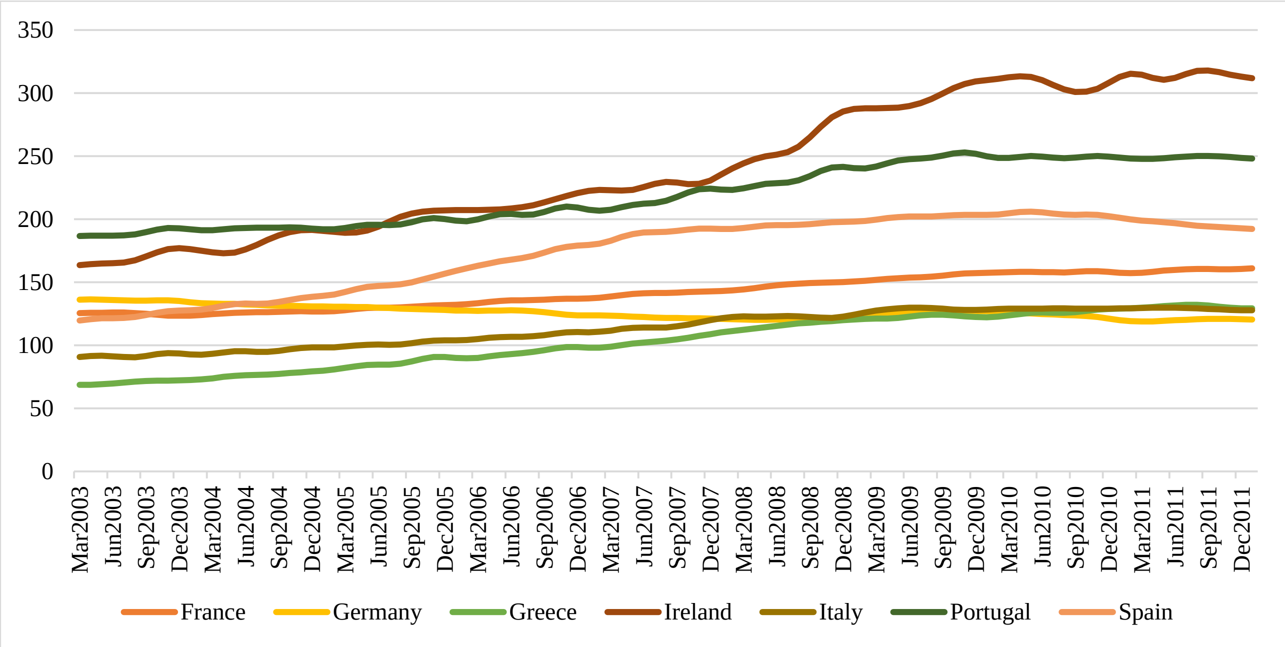

Figure 2 1.2-1 Private debt in % of GDP 2003-2012[11]

Ireland, Portugal and Spain had the most alarming numbers of private debt prior to the crisis. Private debt in Ireland reached approximately 250% in mid-2007. Greece obtained relatively low private debt number compared to other distressed countries at 100% of GDP in 2007 and approximately constant numbers during the crisis, it appears that the level of private debt was not a particular problem in Greece. The European Union (EU) commission has set an indicative threshold of private debt to GDP of 160%, exceeding the level should result in severe macroeconomic instability. Concern should have been directed towards the high private debt levels in several Eurozone countries prior to the crisis.[12]

The increase in private borrowing was partly due to the reduced exchange rate risk following the introduction of a common currency in Europe. Banks could now raise funds from international sources in their own currency removing the risk of the exchange rate moving in an unfavourable direction.[13] Related to the new common currency were lower interest rates in several European countries. Interest rate convergence occurred to match the low levels in Germany. Easier access to credit and low borrowing costs stimulated private borrowing. The private sector was taking on an enormous amount of risk. [14] A special case appeared in Ireland and Spain where the economies were balancing on a credit fuelled property bubble, where banks

[11] Eurostat, epp.eurostat.ec.europa.eu, DataStream
[12] Cuerpo et.al, 2012
[13] Lane, 2012
[14] Fagan and Gaspar 2007

had invested heavily in the increased real estate in the countries, taking on enormous amounts of credit risk. [15]

During the same period high current account imbalance across the Eurozone occurred.[16] The current account balance gives the difference between a country's savings and its investments. A positive current account balance measures the amount of a country's savings invested abroad. A negative current account balance measures the countries amount of domestic investments financed by foreigner's savings. The balance can be regarded as a measure of a country's economic performance.[17] Table 2.1.2-1 displays the average current account balance as a percentage of GDP for the given year.

Time	France	Germany	Greece	Ireland	Italy	Portugal	Spain
2002	1.3	2.0	-6.5	-1.0	-0.8	-8.2	-3.3
2005	-0.5	5.0	-7.5	-3.5	-1.6	-10.3	-7.3
2008	-1.8	6.2	-14.7	-5.7	-2.9	-12.6	-9.6
2011	-1.9	6.2	-11.0	1.1	-3.1	-7.0	-3.7

Table 2.1.2-1 Current account balance as a % of GDP 2002-2011[18]

The German current account surplus increased over the period while the rest of the Eurozone's main economies increased their deficits further.[19] The high current account deficits in Greece were partly a result of securing membership into the EMU in 2001. Greece needed to decrease their government deficits in order to meet the Maastricht requirements, which was largely financed by increased current accounts deficits and government debt amounting to 100% of GDP prior to entering. Ironically, Greece violated one Maastricht requirement to meet another. The current account deficits increased further and Greece was struggling with low competitiveness against other EMU nations due to high inflation levels.[20]

Current account deficit does not necessarily imply a period of negative economic growth. Current account imbalances can result in income corrections by reallocating resources from high-to low-income countries, boosting the economy. However, current account imbalances can create significant macroeconomic instability if capital is invested where it does not create future productivity growth, such as in real estate.[21] For the Eurozone the increased capital was not used in the most desirable manner and the high current account deficits should have been given more attention.

[15] Lane, 2012
[16] Fagan and Gaspar 2007
[17] Economics.about.com
[18] OECD Statistics, www.oecd-ilibrary.org
[19] Lane, 2012 page 52
[20] Lane, 2012 page 52
[21] Blanchard, 2007

Increased private debt and current account deficits occurred partly because the government in several European countries failed to tighten fiscal policies, control tax evasion and reduce inefficient spendings. In addition, poor performance of the analytical framework used to assess the relative riskiness of the countries contributed to a continued perception of appropriate sovereign risk levels. Government authorities and international organizations were not able to provide an accurate measure of total risk and thus risk management failed.[22]

2.1.3 A crisis hits Europe

The collapse of Lehman Brothers in September 2008 marks the beginning of a crisis severely affecting the financial systems of the world. [23] The financial crisis in the US quickly spread to the banking sector in Europe. The banking sector had been building up enormous liabilities by heavy lending to the private sector and experienced a time of distress. The problems in the banking sector quickly spilled over to the government. When stepping in to bailout banks, governments built up enormous amounts of debt. Table 2.1.3-1 illustrates government debt as a percentage to GDP for the European countries.

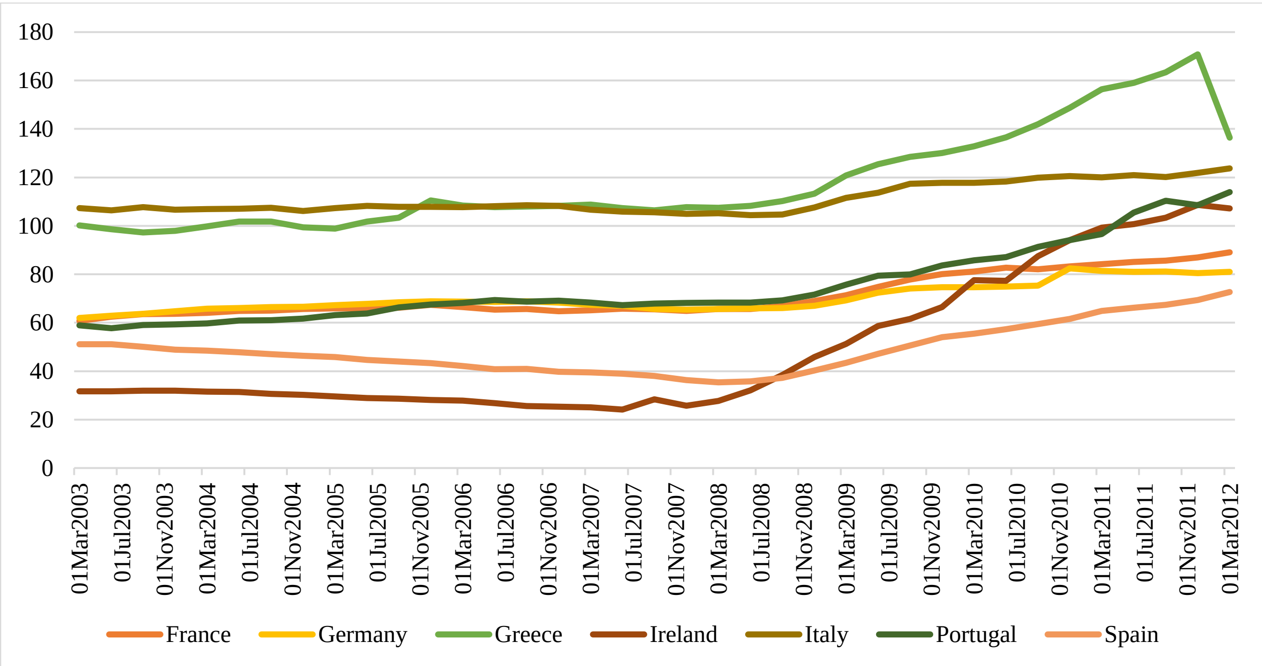

Figure 2.1.3-1 Government debt in % of GDP 2003-2012[24]

A significant increase in debt levels in mid-2008 is observed for all the European countries. Prior to the financial crisis debt levels in Greece and Italy were already at extreme levels. However, the level of

[22] Lane, 2012
[23] Overbeek, 2012
[24] Eurostat, epp.eurostat.ec.europa.eu

European government debt received little attention by the market during the financial crisis, as the focus was drawn towards addressing the on-going financial crisis and recovering the banking sector.[25]

During the crisis, the economy experienced slow growth, which exposed the unsustainable fiscal balances of the Eurozone members. Government deficits in the Portugal, Ireland, Italy, Greece and Spain (PIIGS) increased considerably following the financial crisis. The combined effects of large current account deficits, record breaking private debt number, high government debt and a financial crisis lay the grounds for a sovereign debt crisis.[26]

The beginning of the European debt crisis can be placed to the end of 2009 when Greece reported an actual government deficit of 12.7%, more than half of what was previously announced and a quadruple of the 3% limit set by the EU.[27] When Greece revealed their actual deficit numbers credit rating agencies lowered the country's rating, driving up interest rates. The Greek government was being closely watched and stakeholders demanded a reduction in spending. Investors lost confidence in the nation's ability to service its debt, consequently requesting higher risk premiums.[28] Lower spending by the government and increased financing costs combined with slow economic growth and decreased tax revenues increased government deficit further.

The situation in Greece quickly escalated to other European countries and sovereign risk increased sharply for most of the Eurozone economies. Many European banks had invested in Greek businesses and government debt. Government debt in a number of European countries continued to increase as they took on more outstanding debt for banks and business, which were struggling to stay alive. In addition, governments were exposed to Greek debt being major debt holder of Greek sovereign debt.[29]

France and Germany held a large amount of sovereign debt issued by the PIIGS countries, accordingly increasing credit risk for these counties as well. The amount of foreign debt was such that even a partial default by the PIIGS countries could cause major distress in France and Germany. [30] The increased sovereign risk for the Eurozone is indicated by a rapid increase in sovereign CDS spreads displayed in table 2.1.3-2.

[25] Lane, 2012
[26] Lane, 2012
[27] Lane, 2012
[28] Candelon and Palm, 2011
[29] Lane, 2012
[30] Candelon and Palm, 2011

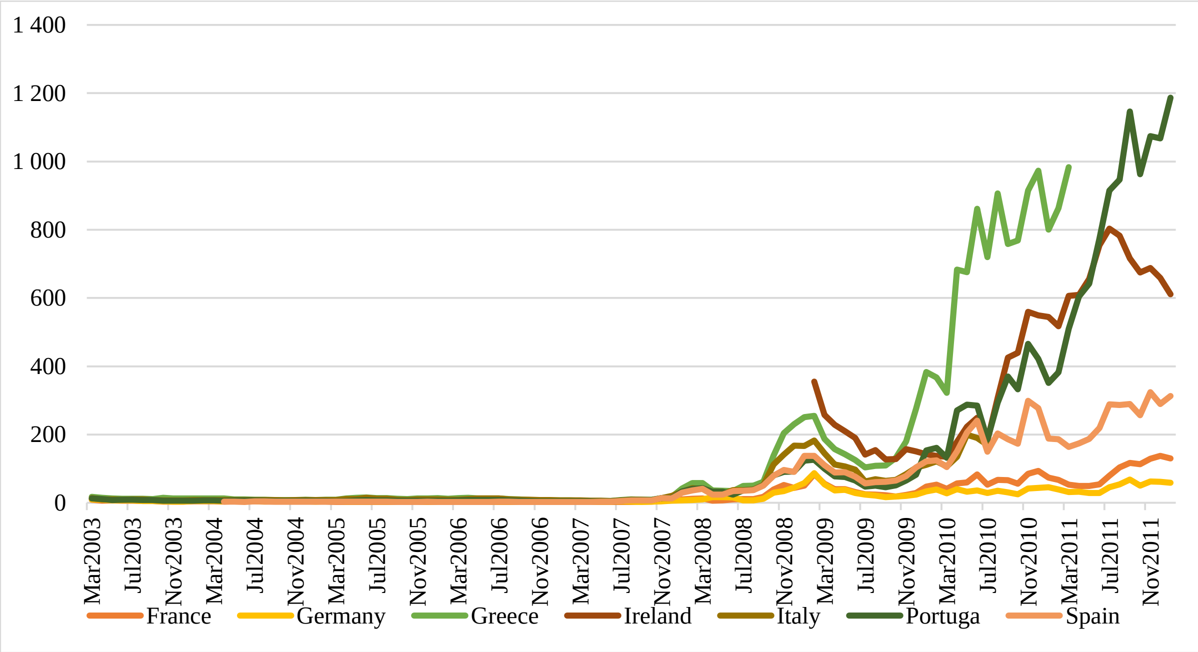

Figure 2.1.3.-2 CDS spread in basis points 2003-2012[31]

Prior to the financial crisis the spread on CDS contracts remained relatively stable. The outburst of the financial crisis at the end of 2008 resulted in a tremendous increase in the CDS spread for the troubled countries. Even the levels in France and Germany increased following the crisis indicating an overall increased sovereign risk in the Eurozone.

When the indebted countries started having difficulties meeting their debt obligations actions were carried out by EU and the International Monetary Fund (IMF). Greece was the first country to be bailed out of the bond market in March 2010, Ireland and Portugal (November 2010 and April 2011 respectively) soon joined. Following the bailout three year funding programs were established with the IMF and EU as lenders. In 2012, Spain and Italy turned to ECB for help to keep them from defaulting on their debt.[32]

The financial crisis aggregated existing macroeconomic imbalances and fiscal problems leading the economy to a tipping point.[33] This was the beginning of a European economy with years to come of high unemployment, financial and monetary instability combined with political stress with an overall concern for the future of the EMU.

2.2 Contagion

[31] Bloomberg terminal
[32] Economic Intelligence Unit, 2013
[33] Lane, 2012

During the debt crisis increased attention has been drawn towards the concept of contagion. Contagion effects can be said to have exacerbated the sovereign debt problems in the Eurozone. Contagion is defined as a situation where imbalances in a specific market are transmitted to one or several other markets causing simultaneous failure of the markets. Imbalances in the market often arise due to a shock to the system. In the Eurozone, instability was already present in the various economies causing the contagion effects to be much stronger than it would have been in the absence of such economic instabilities in terms of high fiscal deficits and debt levels. Contagion mechanisms can severely increase the dimensions of financial instability. [34]

Credit rating agencies have effectively taken into account contagion effect. When Moody's downgraded Portuguese long term bond in 2011 they argued that the rollover of Greek debt contributed to a reassessment of the Portuguese credit outlook. The market quickly reacted to this information in Spain and Italy. Even though no new data regarding the Spanish or Italian economy were released, the spread on government bonds in these countries increased considerably in mid-2011.[35] The ECB has implemented several monetary policies in order to cope with the problem of contagion, included provision of liquidity, changing the capital structure of fragile banks and implementing growth-enhancing policies.[36] Being able to identify contagion effects is crucial for implementing monetary strategies.

2.3 Political instability

Political risk is defined as the potential harm to businesses, investors and governments following political changes, instability in a country or actions by government or other influential domestic forces.[37] The European economy is affected by high political instability affecting the overall economic situation. Governments of the PIIGS countries have not been able to implement acute measures due to lack of credibility. Governments have left office before the end of their parliamentary terms and several governments are expected to be forced from office early or be replaced in upcoming elections. Corruption is a significant part of the Greek, Italian and Spanish political system with several political scandals over the last couple of year. [38] In Germany, there is deep resistance for accepting responsibility for other countries' debt where the uncertainty of the government's decision affects the political instability of the entire country. [39] Failure to maintain a stable political situation has caused the public to lose faith in the government's ability to improve the economic situation making it harder for the Eurozone to restore economic balance.

[34] V. Constâncio, 2012
[35] V. Constâncio, 2012
[36] European Central Bank , 2011, www.ecb.int
[37] R. McKellar, 2010 page 3
[38] Economic Intelligence Unit, 2013
[39] Economic Intelligence Unit, 2013

3 Credit risk

3.1 Credit risk

Credit risk is defined as the risk of loss resulting from a borrower failing to meet its due obligations. All market participants expecting a future payment are subject to credit risk. The concept of credit risk is as old as baking and borrowing itself, even though it has received increased attention following the introduction of credit derivatives.[40]

To compensate investors for holding credit risk a credit spread is provided. The credit spread is roughly composed of a risk neutral spread and a spread premium. The risk neutral spread is what an investor has to be paid in order to compensate for expected losses based on historical default probabilities and recovery rates. This is compensation due to expected default. The remaining part of the spread is compensation for the uncertainty of default and contains a default risk premium, volatility risk premium and liquidity risk premium:[41]

- Default risk premium: This is the additional premium paid to investors to compensate for the risk that the historical default figures and recovery rates cannot with certainty predict the default risk investors are exposed to.
- Liquidity premium: The premium compensates investors for increased illiquidity of the obligation. Reduced liquidity makes it harder for the investor to sell the instrument when they wish due to a lack of demand for the instrument.
- Volatility risk premium: Additional premium is given to investors to compensate for the risk that the credit quality of the issuer is reduced. This may reduce the value of the position even if there is no default. A realised loss would occur if the investor wanted to sell the credit position.

3.1.1 Credit risk in the sovereign debt market

Investors in the sovereign debt market are exposed to credit risk in similar fashion as investors in the corporate market. Sovereign risk is defined as the risk that a government fails to meet its contractual obligations. Sovereign default refers to any kind of restructuring of the contract by the government that offers less favorable terms for the investors than the original contract. Sovereign default differs greatly from a corporate default. A sovereign cannot go bankrupt meaning that it cannot be forced to repay its debt.

[40] Choudhry, 2011 page 21
[41] O'Kane 2007, page 55

Default by a sovereign is a decision by the government which is often related to some political or economic circumstances in the nation and goes beyond pure financial elements. [42]

Due to the underlying contractual characteristics of sovereign default, anticipating default by a nation is difficult and thus understanding the driver of sovereign default is crucial. Throughout the history predicting defaults has shown to be difficult as they contain several unpredictable components in addition to their relative rare existence. [43] Variables that may appear obvious in assessing the relative default risk of a country have shown to have little importance in some cases. Argentina has defaulted three times since 1980, but the country's level of outstanding debt remains at an acceptable rate. In comparison in Japan debt levels recently reached 170 percent of GDP without increasing the market tensions and sovereign risk. [44]

3.2 Credit derivatives

Credit derivatives are instrumental securities whose payoff is determined by the credit characteristic of a given obligation. They provide an easy way to trade credit allowing market participants both too take on and hedge credit risk.[45] Due to their favourably properties the securities have experienced a tremendous growth since it first entered the financial market in the early 90's. From 1996 to 2004 the market size double biannually and over the period from 2004-2006 the market quadrupled to over US $20 trillion.[46]

When first introduced the instruments where though to be mysterious and difficult to understand. The initial purpose was for banks to hedge their credit risk on bonds and loans. It has now become a mainstream instrument used by several different financial participants and recognised as an investment with an attractive risk-return profile. [47]

The return on a credit derivative contract depends on a change in the credit quality of the issuer. A simple setup of a derivative contract could be as follows: A bank is an investor on a loan issued by a company. The investor is shifting the credit risk associated with the company defaulting on the loan to some counterparty willing to accept the credit risk in exchange for a fee. The higher the risk of default of the company, the higher the fee paid to the counterparty will be. [48] Numerous varieties of credit derivative instrument exist, where single name CDS is the most widely used product. [49]

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[42] Kolb, 2011, page 3-4
[43] Schönbucher, 2003 page 10
[44] Kolb, 2011, page 15
[45] Schönbucher, 2003 page 8
[46] Wagner, 2008, Page 7
[47] Schönbucher, 2003 page 5
[48] Caoutte et.al, 2008, page 416
[49] Choudhry, 2011, page 59

3.3 Credit default swaps

The most commonly traded credit derivatives are CDS contracts amounting to over half of all outstanding credit derivative contracts noted in 2008. [50] The gross notional amount of all CDS contracts outstanding was reported by The Depository Trust and Clearing Corporation (DTCC) to be $25.9 billion in at the end of 2011 with a net notional outstanding as of that day of $2.7 trillion.[51]

3.3.1 The setup of a CDS contract

A CDS contract is an over-the-counter contract with two main parties, a protection seller and a protection buyer. [52] The protection buyer buys protection from the protection seller for the loss from face value of an obligation following a credit event. The exposure of the protection buyer in the contract is similar to shorting the underlying bond or loan, thus having a short position on credit risk. At the same time the protection seller who is short in the CDS contract is long on the credit risk. The protection buyer does not need to own the underlying obligation making a CDS contract more accessible and easier to trade than the underlying reference obligation. CDS contracts written on a reference entity frequently exceeds obligations issued by the same entity.[53]

Protection is given from the effective day following the trade and until a specified maturity date. The issuer of the obligation is known as the reference entity and the obligation that is bought protection for is the reference obligation. Default protection can be bought on bonds or loans .[54] Picture 3.3.1-1 provides an illustrative example of a CDS contract.

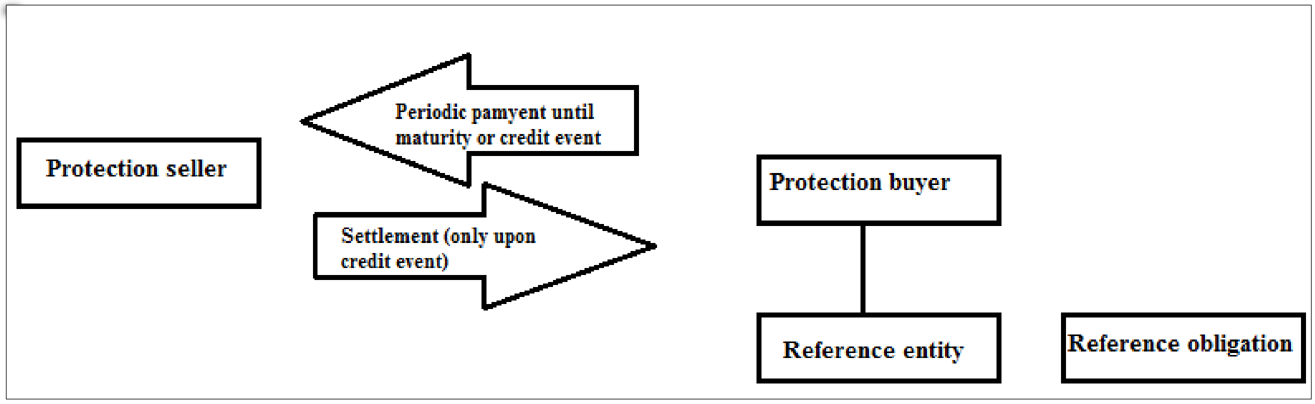

Figure 3.3.1-1 CDS setup

The protection buyer pays to the protection seller a periodic payment, until the maturity of the contract or until a credit event occurs whichever comes first. A credit event is defined as the action triggering the

[50] Choudhry, 2011, page 59
[51] ISDA CDS Marketplace, www.isdacdsmarketplace.com
[52] Tavakoli 1998, page 62
[53] Tavakoli, 1998, page 63
[54] Tavakoli ,1998, page 62

payment from the protection seller to the protection buyer. The premium is the CDS spread, which is quoted in basis points per annum of the contract's notional value. The CDS spread is the price that the buyer is willing to pay in order to receive the default protection. [55]

In case of a credit event a settlement between the protection seller and the protection buyer occurs. This settlement can be either in terms of a physical settlement or as a cash settlement, which is to be specified when entering the trade. In case of physical settlement the protection buyer delivers the reference obligation to the protection seller. In return the protection seller delivers the face value of the obligation in cash. Physical settlement is the dominant form of payment. If a cash settlement is specified the protection seller pays out the difference between the face value of the obligation and its recovery value.[56]

CDS contracts are frequently used for hedging and speculative purposes. When entering a CDS contract the protection buyer hedges the exposure to credit risk stemming from the underlying bond and protects himself against losses arising due to a credit event occurring. Going long in a CDS contract removes the credit risk of the investment making it a credit risk- free portfolio.[57]For speculative purposes an investors are speculating on the relative credit outlook of the issuer. If an investor believes a bond issuer will default on his obligation, the investor will buy a long position in a CDS contract. With a positive opinion, believing that the bond issuer is relatively undervalued in terms of credit quality the investor will sell a CDS contract. It is possible to use a CDS contract for speculation because the buyer of the contract does not need to own the protected asset.[58]

3.3.1.1 The Credit event

To ensure that settlement is not triggered by nonmaterial or staged events, there are strict rules about what can be classified as a credit event. Several actions classify as a credit event and whichever is relevant for a given CDS contract is to be specified prior to entering the contract. More than one credit even can be relevant for a given contract. The International Swap and Derivatives Association (ISDA) define six credit events:[59]

- *Bankruptcy*
  - Reference entity becomes insolvent or unable to pay its obligations.
- *Failure to pay*
  - Reference entity fails to make due payments.
- *Obligation acceleration*

[55] Wagner, 2008 page 5
[56] Wagner, 2008 page 4-5
[57] International Monetary Fund, 2013
[58] International Monetary Fund, 2013
[59] Wagner,2008 page 6

  - Obligation has become due and payable earlier than it would have been due to default or similar events.
- *Restructuring*
  - When either interest rate or the principal paid at maturity is reduced or delayed, credit rating of the reference entity is lowered or if there is a change in currency or composition of any payment.
- *Obligation default*
  - Obligation has become due and payable prior to maturity.
- *Repudiation/moratorium*
  - Governmental authority challenges or rejects the legitimacy of the oblations or imposes a standstill or postponement to an obligation. In addition, a restructuring or failure to pay must occur with respect to the obligation.[60]

The bankruptcy event is not relevant for sovereign issuers while repudiation/moratorium is only relevant for sovereigns.[61] Bankruptcy, failure to pay and restructuring are the most common types of credit events.[62]

A credit event can be classified as either soft or hard. All the noted events are classified as hard with the exception of restructuring. A hard event is one where following a credit event all outstanding CDS contracts on the reference entity are triggered and settlement between the protection buyer and seller occurs. Restructuring, as a soft credit event differs in that there is no automatic trigger of the CDS contract.[63] The protection seller and buyer have to decide on whether or not to trigger, with only one required to trigger for settlement to occur. If neither party triggers, the contract continues until maturity or until another credit event occurs. [64]

3.3.2 Pricing of credit risk

Extensive research has been done on the subject of pricing credit risk. It dates back to the 70’s and is still a debatable subject. In the literature of credit risk there are two primary models that attempt to explain the default process: the structural and the reduced form model.[65]

3.3.2.1 The structural model

[60] Haworth, 2011
[61] Haworth, 2011
[62] Wagner,2008 page 6
[63] O’Kane 2007, page 87
[64] Haworth, 2011
[65] O’Kane, 2007, page 38

The structural model for quantifying the probability of a credit event was first introduced by Merton in 1974. It is the first theory for pricing bonds where the probability of default is calculated. The model is based on Black and Scholes groundbreaking option pricing model introduced in 1973.[66]

The Merton model assumes a simplified capital structure where the firm's assets consist of only equity and debt. According to the model, default occurs when the value of the firm's assets falls below the value of the firm's debt. Default can only occur at maturity of the debt, and the firm can then be in two states, either solvent or insolvent. The main determinants of default according to Merton's Structural model are the firm's leverage, asset's volatility and the risk-free rate. [67]

The Merton model is the structural approach in its most basic form and several extensions of the model have appeared for both assessing corporate and sovereign credit risk. In 1976 Black and Cox developed an approach of the structural model known as the First Passage model where default occurs when the firm's assets falls below a given threshold. The firm is liquidated immediately after the default event. Opposed to the Merton model, default can occur at any time but the default barrier is exogenously fixed.[68]

Two new set of models have evolved, the Liquidation Process model and the State Dependent model. The models tries to incorporate into the pricing different real-life phenomena. In the liquidation process models default events does not immediately cause liquidation but instead triggers the liquidation process. The liquidation process may or may not end in liquidation after it is complete. Liquidation following a default event appears to be a long lasting process. As the process can take a while, past information is found to be a significant explanatory variable when analyzing default probabilities. Past values of the business cycle, credit markets and default cycle have been found to significantly affect the default probabilities.[69]

State dependent models assumes that some of the parameters affecting the firms default probability are state dependent and exogenously set, such as the business cycle the firm is currently operating in or the firm's external rating.[70]

Das was the first to apply the structural models to credit derivatives in 1995 followed by Pierides in 1997.[71] Gapen et.al (2005) are the first to apply the structural model to sovereign credit risk developing a contingent claims approach. They find that the key drivers of sovereign default are the volatility of a country's assets

[66] Elizalde, 2006
[67] Merton, 1974
[68] Elizalde, 2006
[69] Elizalde, 2006
[70] Elizalde, 200623
[71] Pierides, 1997

and its leverage.[72] The various models differs in approach but they all rely on the same determinants for pricing credit risk; firm's leverage, asset's volatility, the value of the firm's assets and the risk-free rate.

The structural model suffers from several drawbacks and thus is not widely used in credit derivatives pricing today. To apply the structural model for pricing credit risk input about the firm's asset value and asset volatility is necessary which both are unobservable variables. It is difficult to obtain an up to date real value of the capital structure. Even though the model is not widely used in pricing, the default mechanism closely resembles what happens in practice and can be used to assess credit risk.[73]

3.1.3.2 Reduced form model

The reduced form model has been developed to assess the limitations of the structural model. Jarrow and Turnbull (1995) developed a new framework for pricing credit risk. This approach does not attempt to calculate default based explicitly on the firm's value, but try to assess the default probability with information that is available in the market. Default is set exogenously which simplifies the process as one does not have to define what causes default. As with the structural model several approaches of the reduced form model have been developed. Jarrow and Turnbull (1995), Duffie and Singleton (1999), Hull and White (1990) are the main contributor to the model.[74]

In the reduced form model default is assumed to occur exogenously following a Poisson process. The stochastic default process is set by an exogenous intensity parameter, λ. The process describes the likelihood of default over any given time horizon. Default can be affected by a series of unobserved factors as it follows an exogenous process. As opposed to the structural model, default is now unpredictable[75]. An unconstrained selection of inputs can be used in the model, both macroeconomic factors and factors relating to the firm's assets and capital structure.[76]

Several studies have tested the relative accuracy of the recued form model versus the structural model. It is found that the reduced form approach provides a higher accuracy than the Merton approach. The structural approach is mostly used for predicting default and is a useful tool in credit risk analysis, while the reduced form model is mainly used to price credit derivatives.[77]

Modeling credit risk is difficult and there is no standard model to use. Each set of models has its advantages and disadvantages, where the choice of which to use depends heavily on what the model is being used for.

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[72] Gapen et.al, 2005
[73] O'Kane, 2007 page 42
[74] Jarrow and Turnbull 1995, Duffie and Singleton 1999, Hull and White 1990
[75] O'Kane, 2007, Page 45
[76] Giesecke, 2004
[77] Chen, 2003

For the purpose of this analysis the relative inputs into the pricing models will be considered when assessing the determinants of sovereign CDS spread.

3.4 CDS and bond market

A close relationship exists between the CDS spread and the underlying bond spread. The bond spread is the difference between the yield on a bond issued by a reference entity and the yield on a riskless bond.[78] The difference between the CDS and bond spread should be close to zero, but due to market frictions, this does not always hold. Investors take advantage of pricing differences between CDS spread and bond spread by taking offsetting positions in the two. This is known as basis trading. [79] The basis is the difference between CDS spread and the bond spread on a given obligation.

A positive basis where the CDS spread exceeds the bond spread is more often observed in the sovereign market than in the corporate market. However, after the outbreak of the crisis, a negative basis has been observed.[80] An increasing number of market participants are trading on the basis. Several factors has been identified as drivers of the basis. These related to both fundamental and market factor. Fundamental factors are those relating to the contractual differences. Market factors refer to the market in which the CDS and bond contracts are traded and include effects such as liquidity, and supply and demand.[81]

[78] Wagner, 2008, page 5
[79] International Monetary Fund, 2013
[80] Fontana and Scheicher, 2010
[81] O'Kane, 2007 page 93-94

4. Data description

4.1 Dependent variable

Two empirical models will be created in order to investigate the determinants of default risk. The dependent variable of the analysis is the 5-year CDS spread denoted in Euros. The 5-year maturity is considered to be the most liquid maturity group.[82] Monthly data on the CDS spreads are obtained from the Bloomberg terminal from March 2003 until January 2012 in mid-price quotes expressed in basis points. [83]

The bond spread is calculated as the difference between the 5-year sovereign bond yield and the risk-free rate. To proxy the risk-free rate the 5-year Euro swap rate is used. Euro swap rate is regarded as the market's perceived risk- free rate. The German benchmark Bund yield is commonly used as a proxy for the risk- free rate in Europe but this measure is not used as it would omit the German bond as a dependent variable. [84] Monthly data on the government bond yield and the Euro swap rate is extracted from the Bloomberg terminal. In order to carry out the regression analysis SAS, a statistical analysis system, will be employed.

4.2 Explanatory variables

In the literature on credit risk, both country-specific and global variables have been identified to affect sovereign credit risk.[85] The explanatory variables of the analysis have been closely investigated and chosen with regards to credit risk theory. In addition it has been subject to data limitations.

Seasonality patterns are detected in some of the collected data, which have been corrected for before applying the data. It is not desirable to obtain raw data but rather seasonally adjusted data as the purpose of the analysis is to investigate the overall behaviour of CDS spreads over time and not the behaviour affected by seasonality. A seasonally adjusted series is more informative regarding trends and irregular components.[86] The X11 method is applied to remove seasonality[87], a method frequently employed by official statistical bureaus.[88]

Several of the country-specific variables are only available on quarterly basis. In order to obtain monthly numbers interpolation is used. The variables are interpolated using the spline procedure. Spline interpolation fits a cubic spline curve to the input values. A cubic spline is a segmented function consisting of third-degree

[82] Mayordomo et.al 2010
[83] The last trading day of the month is used to express monthly numbers
[84] Fontana and Scheicher, 2010
[85] Longstaff et.al, 2008
[86] SAS/ETS (R) 9.2 User's guide. Getting Started: X11 Procedure
[87] Appendix page for 1 an explanation of the X11 method
[88] SAS/ETS (R) 9.2 User's guide. Getting Started: X11 Procedure

polynomical functions joined together making the whole curve and its first and second derivative continuous. The spline interpolation method is preferred to linear interpolation, which fits a continuous curve to the data by connecting successive straight line segments. [89]

A number of the variables are expressed in natural logarithms. The use of logarithms is supported by the fact that it makes the variable more normally distributed. In addition, it makes the relationship between the variables more linear, a key assumption of the linear regression model. [90]

4.2.1 Country-specific variables

The state of the local economy is an important determinant of the probability of default of a country. Several measures meant to proxy different areas of the wealth of the local economy are included.

Inflation

Inflation is a key indicator of macroeconomic stability and thus of great importance when assessing default risk. It is the relative evolution of prices on goods and services. Consequently, it should follow the economic growth of the economy. It is often used to proxy a country's fiscal and monetary policies, where high levels of inflation indicate macroeconomic instability. A stable economy is associated with a constant inflation level. [91] Aizenman et al. (2011) investigates how government's default probabilities are affected by fiscal macroeconomic variables and finds inflation to significantly affects the spread on CDS.[92]

An inflation measure is obtained from Eurostat on a monthly basis.[93] Seasonally adjustment is utilized to remove seasonality patterns. The variable is expressed in logarithms and the expected sign of $lCPI$ is positive, as higher inflation increases default risk.

Debt/GDP

The debt level of a country has been identified as a major contributing factor of sovereign default risk. In the framework presented by Gapen et.al (2005) debt as a ratio of GDP is a main contributing factor into the model that assesses a country's default probabilities.[94] Numerous empirical research have been done on the effect of debt levels on default probabilities. As the amount of debt to a country's GDP increases above a desirable level it becomes harder for a country to finance its existing debt and obtain enough resources to keep a healthy economy.

[89] SAS/ETS (R) 9.2 User's guide. The Spline method
[90] Gujarati and Porter, 2009 page 526
[91] Euro Economic, www.unc.edu
[92] Aizenman et.al, 2011
[93] Eurostat, epp.eurostat.ec.europa.eu
[94] Gapen et. al, 2005

Data is extracted from Eurostat on a quarterly basis as a measure of government's consolidated gross debt for the general government.[95] The measure is expressed as ratio to GDP. The variable is interpolated to obtain monthly numbers in addition seasonality patterns are removed. The variable is expressed in logarithm form and will hereafter be refer to as *ldebt.* The expected sign is positive.

Private debt/gdp

In the section on the European economy, the increased extended credit to private sector was identified as a major contribution factor to the crisis. Private sector debt refers to the amount of a country's total debt not held by the government; specifically it is the stock of liabilities held by non-financial corporations, households and non-profit institutions serving households.

Data on Spanish private debt numbers is collected from DataStream, while data for the other countries are extracted from Eurostat. The measure is a ratio of private debt to GDP. Data are interpolated from quarterly to monthly numbers, in addition seasonality affects are removed. The expected sign of *lprivatedebt* is positive, but there is a certain degree of uncertainty as moderate levels of private debt is often considered a sign of financial development that could result in economic growth. [96]

Government fiscal balance/GDP

Government's fiscal balance is the difference between a government's total revenues and expenditures. The measure assesses a country's fiscal performance and is a good indicator of imbalances in a country's economy. High deficits decrease the relative ease with which a government can repay its existing debt. Joy (2012) investigates how macroeconomic fundamentals affects the probability of sovereign default and finds that large budget deficits is a common tipping point for default.[97]

The variable is extracted from Eurostat on a quarterly basis and is a measure of net government spending.[98] The variable is seasonally adjusted. After removing seasonality affects the variable is interpolated from quarterly to monthly numbers. The expected effect from *Govbal* on sovereign risk is negative.

Current account balance/GDP

The current account balance as defined in the section of the European economy is an indicator of a country's economic performance. It provides information about a country's ability to repay its debt where a positive current account indicates that the country has a strong position in foreign countries' economy. The measure provides important information about economic relations the country has with the rest of the world. The

[95] Eurostat, epp.eurostat.ec.europa.eu
[96]International Monetary Fund, 2012
[97] Joy, 2012
[98] Eurostat, epp.eurostat.ec.europa.eu

measure has received increased attention as an economic indicator over the past years with the growing interdependencies of the economies of the word. This is particularly prominent within the EU where an increased part of a country's investments is funded by foreign savings.[99] Baldacci et.al (2008) finds that current account balance significantly affects risk premiums by investigating sovereign bond spreads.[100]

The variable is obtained from OECD statistics and is expressed as a total of GDP in order to get an appropriate ratio level. Being expressed in quarterly numbers the variable is interpolated.[101] The expected sign is negative where a higher current account surplus will reduce the spread. The current account balance will henceforth be referred to as *CA.*

Local stock market return

The development of an economy's financial market is closely related to its overall economic growth. It is regarded as a leading indicator of economic activity because it directly affects the wealth of the economy. Consumer confidence, private spending and firm's investments are highly affected by stock market developments. A well-functioning and developed financial market can boost economic growth.[102]

The equity market has historically been connected with the credit market. In the groundbreaking model by Merton discussed previously the level of a company's equity and debt determine the relative probability of default. Longstaff et.al (2011) includes the local stock market return as a proxy for the state of the local economy. They use the MSCI index to proxy local equity return and find it to significantly affect sovereign credit risk for a small number of the countries included in the analysis.[103] A country's MSCI index is included in the analysis to proxy the local stock market and is obtained from DataStream in monthly numbers. The index is expressed in logarithmic form and *lMSCI* is expected to a have a negative effect on the spread.

Liquidity

During a crisis liquidity tends to be valued more importantly and there is often a shift into more liquid assets, known as a "flight to liquidity". Understanding the effect that liquidity has on the spread will help government in setting the fiscal policies. The government can implement fiscal policies to increase liquidity of the security if a liquidity premium is found to increase. An increase in the spread due to macroeconomic imbalances, which directly affects the default probability, is outside of government's direct control. The

99 OECD, stats.oecd.org
100 Baldacci et.al 2008
101 OECD statistics, stats.oecd.org
102 money.cnn.com
103 Longstyaf et.al, 2008

ability to better disentangle the credit premium and the liquidity effect on bond and CDS pricing is important for policy recommendations.[104]

To control for the liquidity in the CDS market a measure based on the absolute bid-ask spreads is calculated. The bid- ask spread is one of the most widely used measures of liquidity in the financial market. It is the difference between the quoted ask price and bid price. Generally bid-ask spreads are measured in relative terms, in other words it is divided by the ask price.[105] This is not desirable when dealing with CDS spreads. Pires et. al (2010) show that contrary to stocks or bonds, bid- ask spreads on CDS should be measured by absolute rather than relative spreads. They argue that the relative CDS spread is appropriate due to the way CDS prices are quoted in the market being already expressed in a comparable way, i.e in basis points per period of the notional amount of the contract. They find CDS premium to significantly increase with the absolute bid-ask spread where an increase in the spread indicates lower liquidity.[106] In the bond analysis, the relative bid-ask spread is used. The data is extracted from the Bloomberg terminal. Bid and ask quotes are not available for the Greek bond, as it is a benchmark bond. The expected effect from *Liq* positive.

Credit rating

Standard and Poor's defines credit ratings as *"forward-looking opinions about credit risk"*. The rating will express the agency's opinion about the ability and willingness of an issuer to meet its due financial obligations. The rating on sovereign bonds is considered a common measure of sovereign default risk.[107] In the literature, sovereign credit ratings are found to frequently affect the development of sovereign spreads, where several studies finds the credit rating to significantly affect the spread on sovereign CDS for a selection of the European countries.[108]

S&P, Moody's and Fitch are the three main credit rating agencies. Studying the credit rating history for the European countries shows approximately same credit score given by the three different agencies over the time period of interest. S&P and Fitch are found to assign rating scores and changes more frequently than Moody's and thus the rating from S&P is applied in this analysis in order to obtain a more information measure. Only one rating agency is used to create a more transparent variable compared to averaging the ratings by each agency.[109] S&P expresses the rating in terms of a letter value, AAA being the highest value and D being the lowest. AAA indicates an extremely strong capacity to meet financial commitments and D is

[104] Ejsing et.al 2012
[105] Landschoot,2004
[106] Pires et. Al, 2010
[107] Standard & Poor's rating services , www.standardandpoors.com
[108] Santis, 2012; Keiler and Eder, 2013

given to an obligatory who has failed to meet its financial obligation (SD is given when it is believed that the obligator has selectively defaulted).[110]

The variable is constructed by transforming the letter rating into a discrete numerical variable. The rating is codified between 1-22 where AAA is given a score of 22 and D is given the score of 1. Several empirical studies investigating the effect from credit ratings translate using the same numerical score.[111] The score assigns the same numerical value to each rating group. This is found to be acceptable as Moody's present the percentage within each credit score group to be relatively similar for the sovereign market with the exception of the low percentage receiving a score of C or lower. [112] It is assumed to be approximately similar distributed for S&P rating.

The credit variable is only included for those countries where there is a change in the credit rating over the investigated time period. Germany and France maintains a constant rating of AAA over the period and thus the variable is excluded (France was downgraded in mid-January 2012 to AA+, the change in value is too small to be modelled). The expected effect form increased credit ratings is a reduction in the spread, which will be refereed to as *Rating*.

Political risk

Political risk of a country has been identified in the section on the European economy to and though to affect sovereign risk. Political instability will severely increase the probability of default.[113] Due to difficulties in quantifying political risk, it has often been excluded from similar analysis. The research on the effect from political instability on sovereign bond and CDS is limited. Some authors have found political instability to have a positive and significant effect on government bond spread. [114]Given the recent political and monetary instability in Europe there is reason to believe that political factors should affect the credit spread in the European countries.

Even though research is limited some authors proceed to create a political risk measure to investigate the effect on sovereign risk. Baldacci et.al (2008) introduced a set of political risk factors for assessing the effect from emerging market sovereign risk where they find political risk to significantly affect sovereign credit risk. A political risk index is created based on the method proposed by Baldacci et.al. The index is created using indicators from the World Governance Index (WGI) and the Heritage foundation economic

[110] Standard and Poor's, 2012
[111] Roberto. A De Santis, 2012; Afonso et.al, 2012
[112] Moody's 2013
[113] Kolb, 2011, page 5
[114] Baldacci et.al 2008; Moser,2007

freedom index (HFEFI).[115] Due to data limitations, WGI will be excluded but to substitute indicators from World Competitiveness online (WCO) is included.

Three indicators from WCO are used; personal security and private property rights, risk of political instability and justice.[116] In addition another five indicators from HFEFI are used; business freedom, financial freedom, freedom from corruption, monetary freedom and trade freedom.[117] The measures are all thought to be good indicators of political risk. The index proposed by Baldacci et.al (2008) is based on an article by Rolfini and Ferrari (2008) who identifies several determinants of political risk. They identify three broad measures of political risk; expropriation risk, transfer risk and political violence risk.[118]

Expropriation risk refers to the seizure of private property by the government for a country's own use. Expropriation risk is measured in terms of the variables personal security and property rights and freedom from corruption, justice.[119]

Transfer risk refers to the inability to convert local currency into foreign exchange currency. The risk increases with restrictions on free capital circulation. To proxy transfer risk various indicators of regulatory efficiency (monetary freedom) and openness of the market (investment freedom and financial freedom, trade freedom) are used.

Political violence risk refers to the overall social and political conditions of the country which is greatly affected by government's inability to implement development policies and to guarantee effective political participation.[120] Political violence is measured by the risk of political instability.

The political risk index is created by transforming the eight different indicators into one variable by using a principal component analysis (PCA) to obtain an optimally weighted linear combination of the various indicators. A PCA is a commonly used tool for data reduction. It identifies patters in the data and compresses the data without much loss of information.[121] The political risk index created has a unit of measure between -2.5 and +2.5, where a higher score indicates lower political risk in the country.[122] The expected effect from the constructed political risk variable on sovereign risk is negative and will be referred to as *Political risk.*

4.2.2 Global variables

With an increased level of globalization, a country's economic performance is likely to be influenced by the state of the global economy. In order to understand the economy of a country it is necessary to understand

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[115] Baldacci et.al 2008
[116] World competitiveness online, www.worldcompetitiveness.com
[117] Heritage foundation economic freedom index, www.heritage.org
[118] Ferrari and Rolfini, 2008
[119] Ferrari and Rolfini, 2008
[120] Ferrari and Rolfini, 2008
[121] Smith, 2002, the concept of PCA will be further explained in chapter 5
[122] Appendix 1: Data description for explanation of the construction

the overall economy of the world. Different measures are included to identify several areas of the global economy.

The risk-free rate

In the structural model, the risk-free rate is one of the main inputs into the model for determining default risk. Increases in the risk- free rate increase the expected future growth of the firm causing the market to believe in a higher future firm value, reducing the probability of default. Fontana and Scheicher (2010) finds the risk- free rate to have a significant effect on the highly distressed countries in Europe.[123] In general, lower interest rates are usually associated with a weakening economy and thus results in higher credit spreads. [124]The Euro swap rate is used to proxy the risk-free rate in Europe and will be known as R_f. The expected effect from the risk-free rate is negative. The risk-free rate is left out of the regression with bond spread as the dependent variable as it is used to create the dependent variable.

The US economy

The state of the US economy has been identified as an indicator of the overall world economy. There is widespread evidence from research that shocks to the US economy affects the global economy.[125] In addition, as the largest economy of the world, the US has a direct effect on the economic evolution of several countries, which are dependent on the US as a trading nation. To proxy the state of the US economy the S&P 500 index is included. The S&P500 index is extensively used to proxy the global economy. [126] Breitenfeller and Wagner (2012) study euro area corporate CDS from 2004 until 2010 finds the state of the global economy to significantly affect the corporate CDS spread.[127] Although sovereign credit risk differs from corporate credit risk, a similar effect from the global economy is expected in the sovereign market. Data on the S&P500 is obtained from Bloomberg on a monthly basis. The variable is expressed in logarithmic with the expected effect from *lS&P500* on the spread to be negative.

Volatility

The structural model developed by Gapen et.al (2005) identifies volatility of sovereign assets as a major variable in determining a country's default risk.[128] A volatility measure can be viewed as an indicator of investor's risk appetite. Higher volatility increases the risk of investing and thus increases the required

[123] Fontana and Schneider ,2010
[124] Landschoot, 2004
[125] Longstaff et.al 2008
[126] Collin-Dufresne et.al, 2001
[127] Breitenfellner and Wagner, 2012
[128] Gapen et.al, 2005

return. Investor’s risk appetite is a good indicator of their predictions on the future performance of the economy.[129]

The effect from increased volatility on CDS and bonds has been extensively studied where the effect is found to be significantly positive. [130] A well known proxy for volatility in the market is the volatility index of the Chicago Board Options Exchange, the VIX index, which is commonly viewed as a forward looking indicator on global risk aversion. The index measures the implied volatility from options contracts on the S&P100 index. [131] The measure is obtained from Bloomberg on a monthly basis. It is expressed in logarithmic form and the expected sign from *lVOL* is positive.

Contagion effects

Increased attention has been draw towards the concept of contagion following the sovereign debt crisis as identified in chapter of the European economy. Being able to separate the effect from contagion relative to country specific variables on the spread is important from a policy making perceptive. If spillover effects are detected, short periods of isolation strategies can be imposed by the central bank to reduce the effect.

Gande and Parsely (2005) suggested using credit ratings to proxy spillover effect between countries. They find a significant spillover effect using credit ratings.[132] To account for contagion effects the credit rating on Greek long-term government bond will be included as an explanatory variable. Santinga (2010) finds significant contagion effect on government bonds during the sovereign debt crisis period by employing the Greek credit rating as a measure of contagion effects.[133] The expected sign of *Greece rating* is negative.

A summary of the variables and expected sign is given in table 4.2.2-1

[129] Fontana and Schneider, 2010
[130] Pan and Singleton 2008; Fontana and Schneider, 2010; Longstaff et.al 2011
[131] Moser, 2007
[132] Grande and Parsley, 2005
[133] Santinga 2010

Variable name	Expected sign
ldebt	+
lMSCI	(-)
lCPI	+
lprivatedebt	+
Political risk	(-)
CA	(-)
Gov bal	(-)
Liq	+
Rating	(-)
lS&P500	(-)
lVOL	+
Greece rating	(-)

Table 4.2.2-1 expected sign of variables

4.3 Data restrictions

The Eurostoxx 50, an index containing 50 stocks from 12 Eurozone countries[134], was suggested as an explanatory variable to proxy the world economy with the potential of being more related to the European Economy. The index is not included due to high correlations with the various local MSCI indexes. The itraxx Europe, as an index of the corporate CDS market has been identified as a major contributor for sovereign CDS spreads in Europe.[135] The index is not included due to data restrictions as it is only available from 2004.

The Irish CDS spread is only accessible from February 2009 and until January 2012 and the underlying bond spread is not available from Bloomberg from 2009, thus the Irish bond is not included in the analysis. The Italian CDS spread is only available up until July 2010 and data on the Greek CDS spread is only provided up until March 2011. Data on Spanish CDS spread is provided from April 2004. It would have been desirable to study the period up until the end of 2012, but due to missing data from Bloomberg in the period from February 2012 until September 2012, the study has been restricted from including more recent data. Due to the restrictions from Bloomberg, substituting with data from DataStream was suggested. However, this was not found suitable as the pricing source of the two data providers differs and subsequently the provided data differ.

[134] Stoxx, www.stoxx.com
[135] Fontana and Schneider, 2010

5 Principal Component Analysis

5.1 Correlation matrix of the CDS spreads

The first step of analysing the sovereign CDS spread for the Eurozone countries is to study the commonalities in the spread for the various countries. This is done by computing a correlation matrix followed by a more thorough principal component analysis (PCA). The correlation matrix between the various CDS spreads is displayed in table 5.1-1.[136]

Country	France	Germany	Greece	Italy	Portugal	Spain
France	1.0000					
Germany	0.95763	1.0000				
Greece	0.86643	0.81279	1.00000			
Italy	0.76012	0.70733	0.91104	1.00000		
Portugal	0.91715	0.86463	0.93359	0.92716	1.00000	
Spain	0.95443	0.92027	0.86114	0.78946	0.92328	1.00000

Table 5.1-1 Correlation matrix

High correlations between the various CDS spreads are found. There are frequently correlations over 80%. The highest correlations are observed between France and Germany at 95.76%. The lowest correlations are found between Germany and Italy at 70.73%. The results are not surprising seeing that the German and French economy are relatively stable, while the other economies are struggling with fiscal imbalances and thus deviations in spreads are observed. Despite of some inequality in the degree of correlation the correlations are generally high, indicating that the CDS spreads share sources of commonality.

As is stated by Longstaff et.al (2011) the correlations between variables in financial markets often increase during crisis periods.[137] The correlation matrix is recomputed to account for this tendency where a prior crisis and crisis period matrix is computed. The prior crisis period is from March 2003 and until September 2008, while the crisis period is set from October 2008 and up until January 2012. The correlation matrix for the prior crisis period is presented in Table 5.1-2.

[136] Spreads with observations present in both periods will be calculated in order to obtain comparative results
[137] Longstaff et. Al, 2011

	France	Germany	Greece	Italy	Portugal	Spain
France	1.00000					
Germany	0.87136	1.00000				
Greece	0.60995	0.48444	1.00000			
Italy	0.44086	0.32219	0.80088	1.00000		
Portgal	0.69493	0.54076	0.80127	0.83567	1.00000	
Spain	0.79129	0.72823	0.48728	0.42212	0.61718	1.00000

Table 5.1-2 correlation matrix prior crisis period

The correlations have severely changed. The correlation between France and Germany remains high while the correlation with the remaining countries is considerably low. Italy, Greece and Portugal are highly correlated, where Spain has a higher correlation with France and Germany. The results can be related to the fact the Spanish economy was affected by a real estate bubble and heading in the direction of a banking crisis, while the other troubled countries had difficulties with unstable fiscal balances such that the spread was affected by different components. The correlation matrix for the crisis period given in table 5.1-3 sheds light on the evolution of CDS pricing during the crisis.

	France	Germany	Greece	Ireland	Italy	Portugal	Spain
France	1.00000						
Germany	0.79268	1.00000					
Greece	0.83270	0.40823	1.00000				
Ireland	0.75264	0.62162	0.73607	1.00000			
Italy	0.90740	0.75042	0.73348	0.71311	1.0000		
Portugal	0.84916	0.56773	0.97108	0.90116	0.82609	1.00000	
Spain	0.92139	0.63189	0.93904	0.83604	0.85884	0.94615	1.00000

Table 5.1-3 Correlation matrix crisis period

The correlation increases for the highly distressed countries. France increases the correlation with the distressed countries, while reducing the correlation with Germany indicating that France is moving towards the direction of the distressed countries. The results are in line with the observations stated by Longstaff et.al (2008) that during crisis periods troubled countries tends to be more correlated.[138] There is evidence of contagion effects as defined in the section of the European economy. The correlation matrixes indicates that the CDS spreads behaved differently prior to the crisis compared to during the crisis period where higher correlations were detected during the crisis.

[138] Longstaff et. Al, 2011

5.2 PCA

5.2.1 PCA CDS spread

A PCA can be employed to study the commonalities between a set of correlated variables.[139] The central idea of a PCA is to reduce dimensionality of a set of correlated variables by converting into a set of linearly uncorrelated variables called principal components (PCs). The PCs created will account for most of the variance in the correlated variables. [140] It will reveal common patterns in the data and identify the principal direction of which the data varies. A PCA is often found to be useful as it can reveal relationships between variables that would not appear in an ordinarily analysis.[141]

A PC is conducted by fitting a linear combination of optimally weighted observed variables. Several PCs can be conducted, but for the preceding analysis, only one PC is created. The first PC extracted account for the maximum amount of total variance in the observed variables and the results from the PCA is displayed in table 5.21-1 The proportion of explained variance by factor 1 means how much of the variations in the spreads can be explained by one common factor.[142]

Period	Proportion explained by factor 1
Whole period	91.07%
Prior crisis period	91.45%
Crisis period	74.58%

Table 5.2.1-1 PCA CDS

The result from table 5.2.1-1 reveals that the CDS spreads varies together where the common factor account for a high percentage of the correlation between the various CDS spreads. The first PC explains a relatively large amount of the variation over the whole period and in the prior crisis period. The results from the crisis period differ, where there is a significant reduction in the explained variance. The results sheds light on the fact that the various CDS spreads seems to be explained by a common component. Investigating what this common factor out to be is studied in the final regression model.

[139] Longstaff et. Al, 2011
[140] Jolliffe 2002, page 1
[141] Smith, 2002
[142] SAS/ETS (R) 9.2 User's guide. Principal Component Analysis

To express the first PC as a function of the component used to create it the factor loading matrix is useful. The factor matrix is displayed in table 9.2.2 which expresses the factor loading from each country's CDS spread to the first PC. It reveals the correlation between the various spreads with the common component.[143]

	Whole period	**Prior crisis period**	**Crisis period**
France	98	97	93
Germany	**89**	**82**	**47**
Greece	92	98	92
Ireland			87
Italy	98	98	
Portugal	96	99	94
Spain	99	99	95

Table 5.2.1-2 Factor patterns of PC 1 CDS

The factor patterns reveal that in the prior crisis period all the countries are loading highly on the common component, where Germany is loading with a minor effect than the other countries. In the crisis period there are distinct changes in the behaviour. Germany is loading significant lower on the common component. In becomes apparent that Germany is no longer to a similar degree affected by the same source as the other countries. Interestingly France appears to share source of commonalties with the indebted counties.

The results are in line with Fontana and Scheicher (2010) who finds there to be a single large determinant dominating the variation in the CDS spread, where the proportion of explained variance by factor 1 exceeds 80%. They find an increased importance of the common factor during the crisis period.[144] In addition, studies on the emerging sovereign CDS market such as Fender et.al (2012) and Longstaff et.al (2010) find a high proportion of explained variance by the first PC. They find the first PC to increases considerably during the financial crisis period. [145]

5.2.2 PCA bond spread

A similar PCA is computed for the bond spread. The results from the analysis are displayed in Table 5.2.2-1.

Period	**Proportion explained by factor 1**
Whole period	60.34%
Prior crisis period	63.51%

[143] SAS/ETS (R) 9.2 User's guide. Principal Component Analysis
[144] Fontana and Schneider, 2010
[145] Longstaff et.al 2011, Fender et al, 2012

Crisis period	56.33%

Table 5.2.2-1 PCA bond

The table gives the proportion of explained variance by the first PC. The results from the PCA differ greatly from that of the CDS spread. The variation explained by on common factor is only 63.51% in prior crisis period and 56.33% in crisis period. It becomes apparent that the bond spreads are not affected by a common factor to the same degree as the CDS analysis. In similar fashion as the CDS spread, the variance explained by factor 1 is reduced in the crisis period. The factor patterns in table 5.2.2-2 allows for a deeper investigation.

	Whole period	**Prior crisis period**	**Crisis period**
France	-1	90	8
Germany	-52	84	-18
Greece	95	67	98
Italy	90	79	
Portugal	95	84	95
Spain	86	-71	96

Table 5.2.2-2 Factor patterns of PC 1 bond

In the prior crisis all the countries appears to be loading with the same value on the first PC with the exception of Spain. The loading for Spain is negative meaning that the bond spread is negatively affected by the common factor positively affecting the other spreads. The results may be related to the Spanish economy being affected by a real estate bubble, and heading in a different direction that the other European economies. In the crisis period Germany and France are loading significantly differently on the common component, where in fact the German loading is negative. The loadings are positive and significantly large for the distressed countries. There appears to be a common component affecting the bond spread in the distressed countries while the same factor does not have the same effect in Germany and France.

The overall results from the PCA is that default probabilities seems to be driven by common risk factors for the Eurozone countries, where one factor can explain a relative large amount of the variation in both the CDS and bond spread. The German economy is diverging from the other euro area countries during the debt crisis in term of similarities in explaining default probabilities. The French sovereign risk is becoming more similar to the distressed countries measured in the CDS spread, while the bond spread continue to separate France from the distressed countries on terms of similarities. The sources of commonality will be investigated in the final regression model given in chapter 9. It is expected that the various countries are affected by similar determinants.

6 Stationarity

6.1 Stationary time series

Investigating the behaviour of each variable included in the analysis is essential. In order to draw valid conclusions from empirical work based on time series variables it is necessary that the underlying variables are stationarity. A stationary series is a stochastic process where the mean and the variance are constant over time and the autocovariance remains the same no matter at what point in time they are measured. The statistical properties are said to be time invariant. A stationary series will tend to return to its mean value and fluctuations around its mean will have relative constant amplitude.[146] The properties of a stationary series[147]:

Mean: $E(Y_t) = \mu$

Variance: $\mathrm{var}(Y_t) = E(Y_t - \mu)^2 = \sigma^2$

Covariance: $\gamma_k = E[(Y_t - \mu)(Y_{t+k} - \mu)]$

A time series that does not possess these properties is said to be nonstationary. A nonstationary series will have a time-varying mean or a time-varying variance or both. A type nonstationarity present in many macroeconomic and financial series is a unit root process. A unit root model is a process containing a stochastic trend.[148]

Working with nonstationary time series may results in a spurious regression. A spurious regression is one where a relationship between the variables occurs even though there is no direct connection between them.[149] In addition, a nonstationary process will exhibit large variations it its mean, variance and autocovariance making these measures non-constant and thus measuring these properties is generally difficult and in some cases impossible. Consequently undertaking valid hypotheses tests will be difficult.[150] It becomes evident that testing for nonstationarity is crucial.

6.2 Testing for stationarity

Testing for stationarity of the variables is done by both a graphical investigation and a numerical test. The procedure for testing the lMSCI variable for Germany will be explained in further detail.

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[146] Gujarati and Porter, 2009 page 740-741
[147] Gujarati and porter, 2009 page 740
[148] Gujarati and Porter, 2009 page 744
[149] Gujarati and Porter, 2009 page 737
[150] Patterson, 2000 page 76

6.2.1 Graphical investigation

An inspection of the autocorrelation function (ACF) and the partial autocorrelation function (PACF) can be used to analyze the properties of a time series. The ACF is the correlation between a given variable and lags of itself. The PACF is the correlation between observations that are *k* time periods apart after controlling for correlations at intermediate lags.[151] ACF and PACF correlograms plots the correlation for various lags. [152] Figure 6.2.2-1 displays the ACF and PACF graphs for lMSCI.

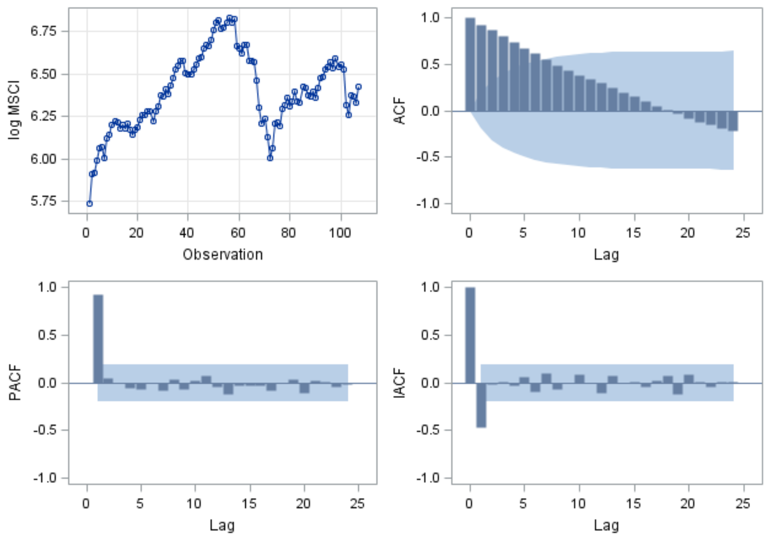

Figure 6.2.1-1 ACF/PACF lMSCI

If the ACF correlogram has values around zero or is quickly, declining to zero this indicates a stationary time series. A nonstationary series will have a correlogram starting at very high values and slowly declining as the lag lengthens. [153] The ACF graph in the upper right of figure 6.2.1-1 declines slowly with several significant lags, indicating a nonstationary series.

A time series with k significant spikes in the PACF should be fitted including k lags of the variable. If the spike has a value approximately equal to one, introducing a lag of the variable is equivalent to differencing the variable which is a common method for removing non stationarity. [154] Thus, significant spikes in the PACF approximately equal to one indicates a nonstationary process. The PACF in graph to the downer left points out one significant spike suggesting that lMSCI should be differenced once.

In addition, a line plot of the series over time will give an indication about the behaviour of the series and reveal any trending behaviour or fluctuations.[155] The line plot of lMSCI is found in the upper left of figure

[151] Gujarat and Porter, 2009 page 778
[152] Gujarati and Porter, 2009 page 749
[153] Gujarati and porter, 2009 page 751
[154] people.duke.edu
[155] Gujarati and Porter, 2009 page 749

6.2.1-1. It is clear from the graph that there are significant variations in the values without a constant mean value.

6.2.2 Augmented Dickey- Fuller unit root test

A common numerical test to check for the presence of nonstationarity is the Augmented-Dickey Fuller (ADF) test. The ADF test is an extension of the Dickey - Fuller (DF) test. The DF test is not applied due to test's underlying assumption of no autocorrelation, i.e. no correlation among the error terms, as autocorrelation is detected in the variables. The Breaush-Godfrey test is applied to test for autocorrelation in the variables.[156] The concept of autocorrelation and testing will be further explained in the section of the assumptions of the regression model.

Prior to applying the ADF test, any trending behaviour in the time series needs to be identified. There are three different trending forms that the series may have. The series may follow a stochastic or a deterministic trend or be a pure random walk model without any trending behaviour. Identifying the correct form is crucial as the critical values of the test differ according to each form.[157] A stochastic trend is an unpredictable trend, whereas a deterministic trend is a shock to the process that continues to following the series.[158] The majority of the variables in the analysis are found contain a stochastic trend. Investigating the line plot of lMSCI reveals a stochastic trend in the series and thus the ADF test is estimated based on a random walk model with a stochastic trend. The test statistic of the estimated coefficient follows the τ (tau) - statistic with following critical values.[159] Test statistics of the ADF test computed is displayed in table 6.2.2-1

Type	Lag	Tau	Critical value	Pr< Tau
Zero mean	0	1.01	1.95	0.9174
	1	0.64	1.95	0.8536
	2	-74	1.95	0.8730
Single mean	0	-3.03	2.89	0.0355
	1	-2.29	2.89	0.1779
	2	**-2.45**	**2.89**	**0.1317**
Trend	0	-2.50	3.45	0.3258
	1	-2.01	3.45	0.5921
	2	-2.09	3.45	0.5427

Table 6.2.2-1 ADF test statistic

[156]Appendix 2, Table 2
[157] Gujarati and Porter, 2009 page 755
[158] Gujarat and Porter, 2009 page 745
[159] Gujarati and Porter, 2009 page 755

The following hypotheses apply to the ADF test:

H_0: $\delta=0$ Nonstationary

H_A: $\delta< 0$ Stationarity

The tau statistic depends on the trend behaviour identified in the series and the number of lags necessary to reduce autocorrelation. The autocorrelation test of lMSCI found no autocorrelation to be present including two lagged terms of the variable. Introducing lagged values of the variable is often found to reduce autocorrelation. The tau statistic of interest is the value at single mean with two lags. The absolute value of the tau statistic is 2.45, which is smaller than the critical value of 2.89 at the 5% significance level.[160] The null hypothesis of nonstationary cannot be rejected, thus the series contains a unit root. The same procedure has been applied to the other variables in the German regression model where the results are displayed in table 6.2.2-2.

Variable	Type	Tau	Critical value	Test conclusion
CDS	Single mean	1.34	2.89	Nonstationary
Bond	Single mean	1.61	2.89	Nonstationary
ldebt	Singe mean	0.04	2.89	Nonstationary
lMSCI	Single mean	2.45	2.89	Nonstationary
lCPI	Single mean	0.09	2.89	Nonstationary
lprivate debt	Single mean	1.68	2.89	Nonstationary
Political risk	Single mean	1.94	2.89	Nonstationary
CA	Single mean	3.40	2.89	Nonstationary*
Gov bal	Single mean	2.56	2.89	Nonstationary
Liq	Single mean	7.23	2.89	Stationary
lS&P500	Single mean	1.49	2.89	Nonstationary
R_f	Single mean	0.99	2.89	Nonstationary
lVol	Single mean	3.04	2.89	Nonstationary *
Greece rating	Single mean	2.53	2.89	Nonstationary

Table 6.2.2-2 ADF test variables in levels
**borderline stationary*

[160] Gujarati and Porter, 2009 page 893

6.3 Correcting for nonstationarity

The variables in the regression model are found to be non-stationary and thus corrections are necessary. If a time series has a unit root it will become stationary by differencing[161].[162] As a unit root was identified in the variables, transforming the variables into first differences should be an appropriate transformation. The liquidity variable in table 6.2.2-2 is stationarity without differencing, however as the liquidity variables for a number of the other included countries are found to contain a unit root, differencing all the liquidity variable is desirable.[163] For appropriate comparison, it is desirable to model the variables in similar form. Transforming the variable lMSCI to a variable in first difference, results in the following ACF and PACF graph.

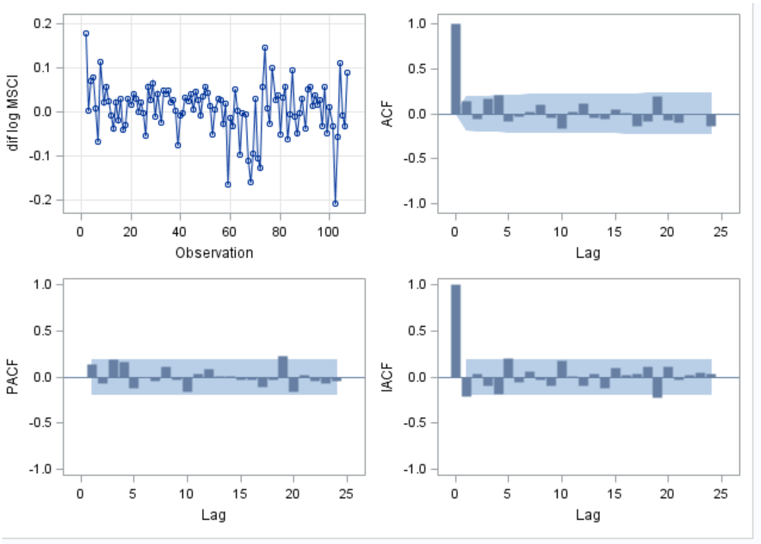

Figure. 6.3-1 ACF/PACF lMSCI in first difference

The ACF follows the patterns of a stationary series, and the PACF shows no significant spikes. Transforming the variable removes the effect of a stochastic trend. A new ADF test for the differenced variable is computed where the tau statistic is greater than the critical value and thus the null hypothesis of nonstationarity is rejected. The series is now stationary. Table 6.3-2 presents the results from the ADF test by transforming the non-stationary variables in the German regression model.

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[161] $\Delta Y_t = Y_t - Y_{t-1}$
[162] Gujarati and Porter, 2009 page 760
[163] Appendix 2, table 3

Variable	Type	Tau	Critical value	Test conclusion
ΔCDS	Zero mean	10.49	1.95	Stationary
ΔBond	Zero mean	12.54	1.95	Stationary
Δldebt	Single mean	3.02	2.89	Stationary
ΔlMSCI	Zero mean	9.12	1.95	Stationary
ΔlCPI	Single mean	8.13	2.89	Stationary
Δlprivate debt	Single mean	3.06	2.89	Stationary
ΔPolitical risk	Zero mean	3.24	1.95	Stationary
ΔCA	Zero mean	6.82	1.95	Stationary
ΔGov bal	Zero mean	2.11	1.95	Stationary
ΔGreece	Zero mean	7.32	1.95	stationary
ΔS&P500	Zero mean	8.81	1.95	Stationary
ΔR_f	Zero mean	5.92	1.95	Stationary
ΔlVOL	Zero mean	10.81	1.95	Stationary

Table 6.3.1 ADF test variables in first difference

The variables are now stationary. The same stationarity testing have been applied to the variables of all the countries included in the analysis. The stationarity testing is based both on the graphical and numerical investigation and the results can be found in appendix 2, table 2 and table 3. All the variables contains a unit root in level form however becoming stationarity by differencing.

7 Cointegration

7.1 The concept of cointegration

This section will test the price discovery relationship between the CDS and the bond market. In the previous section both the CDS and the bond spread were identified to contain a unit root. If two variables contains a unit root and it is expected to be a relationship between them, it is natural to test for a cointegrated relationship between the two variables. A cointegrated relationship exists between difference stationary variables if there is a long run relationship between them. In other words, the variables are trending together over time towards an equilibrium state. In the short-run the variables deviate from each other but in the long run they move together. An adjustment process towards equilibrium exists. It is important to note that a cointegrated relationship can only exists between variables that contain a unit root. If a cointegrated relationship is found the common linear combination between the two will be stationary. [164]

Investigating the lead-lag relationship between the CDS and the bond market can be done by testing for a cointegrated relationship between them. If price discovery is found between the two markets, a deeper investigation of the significance of the adjustment coefficient is desirable.. The investigation will determine if the bond market can anticipate the CDS market, or if the CDS market is merely affected by lagged values of itself. The same interference will be investigated based on the bond market. Testing for a cointegrated relationship allows for a deeper understanding of the behaviour of the markets.

7.2 Testing for cointegration

A number of methods for testing cointegration have been proposed in the literature. Two tests have become widely pronounced, the Engel-Granger (EG) test and Johansen's cointegration test. The EG two- step procedure is a simple test for cointegration which assumes only one cointegrated relationship between the variable where the order of causality between the variables is known.[165] Due to these underlying assumptions of the EG test it is not applied in this analysis. It is not the basic of economic intuition to assume that the causal relationship between the CDS market and the bond market is known.

7.2.1 Johansen's cointegration test

Johansen developed an estimation procedure allowing for more than one cointegrated relationship to exists, in addition taking into account the short-run dynamics of the system when estimating the cointegrated variables. Prior to testing for a cointegrated relationship verifying the existence of a unit root is necessary.[166]

[164] Juselius, 2006 page 80
[165] Juselius, 2006, page 80
[166] Patterson, 2000 page 613

This has already been done in the previous section on stationarity where both the CDS and bond spread series where found to be difference stationary with the exception of the Portuguese and Greek spread over the whole period and in the crisis period.[167] Proceeding is an explanation of the steps in Johansson's cointegration test.

7.2.1.1 VAR and VECM representation

The first step of the Johansen test procedure is to present the two variables in terms of a vector autoregressive (VAR) model. A VAR model is a set of vector models where several endogenous variables are considered together. Each endogenous variable is explained by lagged values of itself and the lagged values of the other endogenous variables in the model. There are no exogenous variables. The presence of unit roots in the VAR allows for investigation of a cointegrated relationship between the variables by reformulating the VAR as a vector error correction model (VECM). A VECM provides a convenient reformulation of the VAR model in terms of differencing the variables to remove unit root problems and estimating the long-run equilibrium relationship between the variables by introducing an error correction term (ECT) in the model [168]

The cointegration procedure will be explained by testing for a cointegrated relationship between German bond and CDS spread over the whole period. For the following analysis, the VAR representation consists of a vector of two variables in which the endogenous variables are the CDS spread and the bond spread. The VAR model for the analysis is defined as follows:

$$CDS_t = \alpha_1 + \sum_{j=i}^{k} \beta_{1j} CDS_{t-j} + \sum_{j=i}^{k} \gamma_{1j} Bond_{t-j} + u_{1t} \qquad (1)$$

$$Bond_t = \alpha_2 + \sum_{j=i}^{k} \beta_{2j} CDS_{t-j} + \sum_{j=i}^{k} \gamma_{2j} Bond_{t-j} + u_{2t} \qquad (2)$$

Where u_{1t} and u_{2t} are the error terms of (1) and (2).

The maximum lag length in (1) and (2) needs to be decided. An underlying assumption of the cointegrated relationship is that no autocorrelation exists. The VAR model will include enough lags such that no autocorrelation is present in the series.[169] The VAR model for Germany is presented including two lags in the VAR model, which is found to be sufficient to remove autocorrelation.

[167] Appendix 3, table 5
[168] Juselius, 2006 page 60,79-80
[169] Patterson, 2000 page 614

Constructing the VECM is a tedious task as there are different specifications of the VECM with different set of critical values. The various specifications are related to stochastic and deterministic trends in the data and as whether to include an intercept in the VECM and in the cointegrated relationship. [170] Determine which form is correct for the given estimation is a tedious task and close investigation of the behaviour of the variables is necessary. This is done by graphing the variables over time where figure 7.2.1.1-1 presents the CDS and bond spread in basis points for Germany from March 2003 until January 2012.

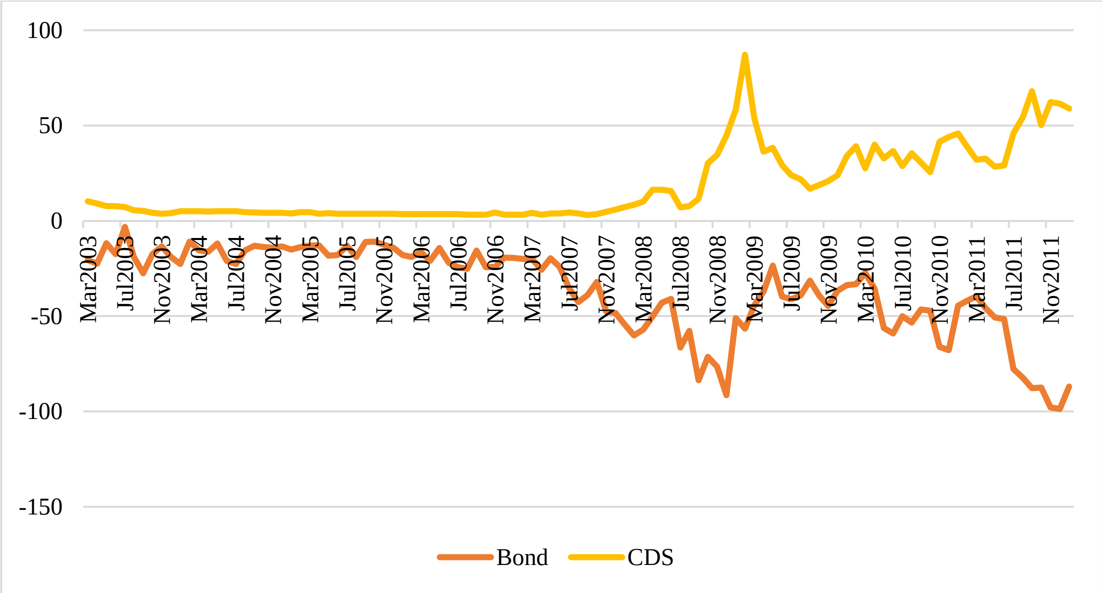

Figure 7.2.1.1-1 CDS and bond spread basis points Germany March2003-Jan2012

No intercept is specified in the VECM due to the anticipation that there is no deterministic trend in the cointegrated relationship, i.e. there is no linear trend behaviour of the variables in their level form. It is not expected that the CDS and bond spreads are to grow with a constant trend over time, but rather exhibit stochastic shocks to the system, which can be traced in figure 7.2.1.1-1. Deterministic trends are more common in macroeconomic data with minor changes in each period such as GDP. In their difference form, a zero mean value is expected over time accounting for various shocks to the system. However, an intercept term is included in the cointegrated relationship. This is due to the fact that the CDS spread is not expected to have a zero value when bond spread is zero, such that the equilibrium relationship is expected to be none zero resulting in the specification of an intercept in the VAR model in (1) and (2). The specification of the VECM has now been determined and can be written on the following form:

[170] SAS/ETS (R) 9.2 User's guide. *Vector Error correction modelling.*

$$\Delta Y_t = \lambda_1(Z_{t-1}) + \sum_{j=i}^{k} \beta_{1j}\Delta Y_{t-j} + \sum_{j=i}^{k} \gamma_{1j}\Delta X_{t-j} + u_{1t} \qquad (3)$$

$$\Delta X_t = \lambda_2(Z_{t-1}) + \sum_{j=i}^{k} \beta_{2j}\Delta Y_{t-j} + \sum_{j=i}^{k} \gamma_{2j}\Delta X_{t-j} + u_{2t} \qquad (4)$$

$$Where\ Z_{t-1} = CDS_{t-1} - \alpha_0 - \alpha_1 Bond_{t-1} \qquad (5)$$

Z_{t-1} is known as the ECT, where α_0 and α_1 is the long run parameters. The speed of adjustment to equilibrium is denoted by λ_1 (λ_2), which measures how much of the CDS (bond) market is corrected for in each period if an out of equilibrium state occurred.

7.2.1.2 Testing for cointegration

The model to be tested is now determined. The next step is to determine the number of equilibrium relationships among the CDS and bond spread variables. Number of variables in the model gives the limit of cointegrated relations. For the given test, the maximum number of cointegrated ranks is 1. A general hypothesis test is applied with a following test statistic. Several tests need to be performed in order to find the cointegrated rank. The first null hypothesis is to test the existence of zero cointegrated variables.[171] The hypothesis to be tested:

H_0: cointegrated rank =0

H_A : Cointegrated rank > 0

If H_0 is rejected a cointegrated rank of 1 is tested. The procedure goes on until H_0 cannot be rejected. Associated with each test is a test statistic and a critical value. The test statistic is known as the trace statistic.[172] The trace statistic from the Johansen test for Germany is given in table 7.2.1-1:

H_0: rank =r	**H_1: rank > r**	**Trace**	**5% critical value**	**Conclusion**
0	0	26.610	19.99	Reject H_0
1	1	2.421	9.13	Cannot reject H_0

Table 7.2.1-1 Johansen's cointegration test

The null hypothesis testing for one cointegrated rank cannot be rejected. The result from the cointegration test is that one cointegrated relationship is found. Table 7.2.1-2 summarizes the number of cointegrated ranks found for all the countries.[173]

[171] Patterson, 2000, page 621
[172] Patterson, 2000 page 621
[173] Appendix 3, table 6

	France	Germany	Greece	Italy	Portugal	Spain
Whole period	1	1	0	0	0	0
Prior crisis period	1	1	1	0	0	1
Crisis period	0	0	0	n/a	0	0

Table 7.2.1-2 number of cointegrated ranks

Several cointegrated relationships are found. The results are not surprising as the two markets would tend to move together in the long run. The spread on CDS and bond are evidently both the price of credit risk and thus should be priced in similar fashion. Where a cointegrated relationship is found the two markets price the credit risk equally in the long run, while deviations occur in the short-run.

When a cointegration relationship is found, an ECT is created on the form of equation (5):

$ECT = CDS_{t-1} - \alpha_0 - \alpha_1 Bond_{t-1}$

A new variable is created denoted as *ECT* and is included in the final regression model. The variable is constructed as the lagged error term from a regression model of the bond spread on the CDS spread. Including the ECT term in the final regression model will allow for statistical interference of the adjustment mechanism between the two markets. The size of the variable will be of specific interest as it denoted the speed of adjustment. The existence of a cointegrated relationship between the bond market and CDS market implies that at least one market has to contribute to price discovery and the other has to adjust.[174] The price discovery mechanism will be investigated in the final regression model.

[174] Fontana and Scheicher, 2010

8 Classical linear regression model

8.1 Assumptions of the classical linear regression model

The properties of the models have now been assessed and the final regression models to be estimated where the variables are transformed into first differences are as follows:

$$\Delta CDS_{it} = \beta_{0i} + \beta_{1i}\Delta ldebt_t + \beta_{2i}\Delta lCPI_t + \beta_{3i}\Delta lMSCI_t + \beta_{4i}\Delta lprivatedebt_t + \beta_{5i}\Delta political_t + \beta_{6i}\Delta ca_t + \beta_{7i}\Delta govbal_t + \beta_{8i}\Delta liq_t + \beta_{9i}\Delta rating_t + \beta_{10i}\Delta lS\&P500_t + \beta_{11i}\Delta r_{ft} + \beta_{12i}\Delta VOL_t + \beta_{13i}\Delta ECT_{CDSt} + u_{it} \quad (6)$$

$$\Delta bond_{it} = \beta_{0i} + \beta_{1i}\Delta ldebt_t + \beta_{2i}\Delta lCPI_t + \beta_{3i}\Delta lMSCI_t + \beta_{4i}\Delta lprivatedebt_t + \beta_{5i}\Delta political_t + \beta_{6i}\Delta ca_t + \beta_{7i}\Delta govbal_t + \beta_{8i}\Delta liq_t + \beta_{9i}\Delta rating_t + \beta_{10i}\Delta lS\&P500_t + \beta_{12i}\Delta VOL_t + \beta_{13i}\Delta ECT_{BONDt} + \varepsilon_{it} \quad (7)$$

Where u_t is the error term from (6) and ε_t is the error term from (7), i=1,2…7, denotes the respective countries.

Equation (6) will henceforth be referred to as the CDS regression model and equation (7) as the bond regression model. Three models of (6) and (7) will be estimated, respectively one for the whole period, prior crisis period and crisis period. In order to be able to draw correct interference from the regression model and the test statistics the assumption of the classical linear regression model (CLRM) needs to be fulfilled. The CLRM is the foundation of most econometric theory, where the following assumptions need to hold[175]:

1. Linear regression model
2. Zero covariance between the error term and each x variable, meaning fixed x values or x values independent of the error terms
3. Zero mean value of the error terms
4. Homoscedasticity or constant variance of the error terms
5. No autocorrelation, or serial correlation between the error terms
6. The number of observations must be greater than the number of estimated parameters
7. Variations in the x values must exists
8. No multicolliniearity; no exact collinieariy between the x variables
9. The model is correctly specified

[175] Gujarati and Porter, 2009 page 189

The estimated parameter of a regression model satisfying the assumptions of the CLRM will possess some ideal properties. These properties are known as the Gauss-Markov theorem which states that the estimated parameters will be the best linear, unbiased and efficient estimators, that is, the estimators will be BLUE.[176]

The following section investigates the regression models to ensure that the assumptions hold. For simplicity, the investigation will presented estimating the CDS regression model for Germany over the whole period. However, both the whole period, prior crisis period and crisis period for equation (6) and (7) have been tested in order to be able to conduct correct statistical interference. Investigating the presence of heteroscedasticity, autocorrelation and multicolliniearity will be emphasized assuming that the other assumptions hold. In addition, normality of the error terms will be tested.

8.2 Heteroscedasticity

When working with time series data it is necessary to obtain knowledge of the volatility in the series related to assumption four of no heteroscedasticity. A homoscedastic model is one in which the error terms, u_i all have the same variance, i.e. there is a constant variance over time. Homoscedasticity is defined as follows:[177]

$E(u^2_i) = \sigma^2$

Heteroscedasticity is present in the model if the variance of the error terms changes. OLS estimation in the presence of heteroscedasticity results in inaccurate t-statistics, thus the significance of the estimated parameters cannot be trusted. Interference draw from a model with heteroscedasticity can be misleading.[178] Consequently, it is important to identify and correct for the presence of heteroscedasticity in any regression models.

8.2.1 Detecting heteroscedasticity

White's heteroscedasticity test and the Bresch-Pagan Godrey test are two general tests for heteroscedasticity in cross-sectional data. In time series regression models it is usually the case that the error terms are correlated over time and thus testing for autoregressive conditional heteroscedasticity (ARCH) effects is more adequate.[179]

Testing for heteroscedasticity will be done by a graphical investigation as well as a numerical test. A graphical investigation is carried out by analysing the behaviour of the squared error terms from regression (6) and (7), u_i^2 and $\varepsilon_{it,}{}^2$, over time. The ACF and PACF or the squared residuals will reveal the volatility of

[176] Gujarati and Porter, 2009 page 71-72
[177] Gujarat and Porter, 2009 page 365
[178] Gujarati and Porter, 2009 page 374
[179] Gujarat and Porter, 2009 page 791

the series. If significant spikes are found in the PACF it indicated that heteroscedasticity is present in the model.[180] The ACF and PACF graph for the German regression model is presented in figure 8.2.2-1.

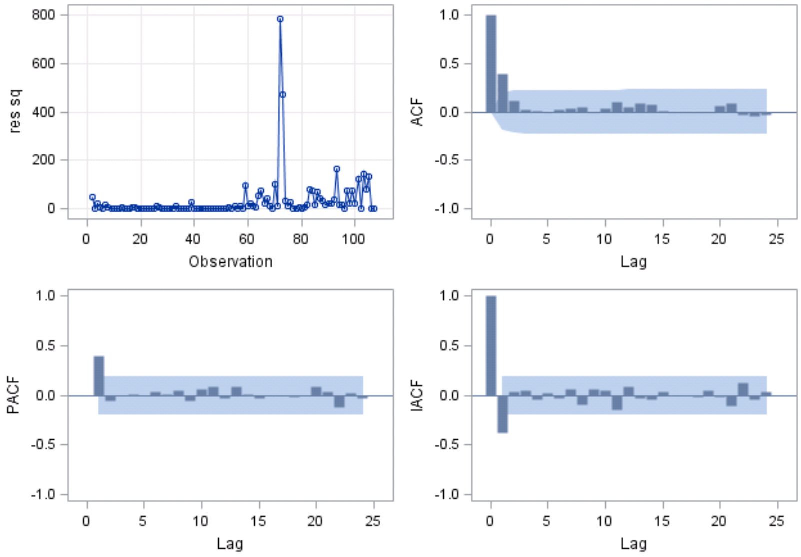

Table 8.2.2-1 ACF/PACF graph

The PACF reveals 1 significant spike indicating the presence of heteroscedasticity.

A numerical test is carried out by applying Engel's ARCH test for detection of non-constant variance in the error terms. The test involves running an auxiliary regression of the residuals obtained from the original regression model, and testing for the significance of the regression. The equation to be tested:

$$\hat{u}^2_t = \hat{\alpha}_0 + \hat{\alpha}_1 \hat{u}^2_{t-1} \qquad (8)$$

Where $\hat{u}^2_t$ are the OSL residuals obtained from original regression model (6). The hypothesis to be tested:

H_0: $\hat{\alpha}_1 = 0$ No heteroscedasticity

H_1: $\hat{\alpha}_1 \neq 0$ Heteroscedasticity

The test statistic is given by $n \cdot R^2$, where R^2 is obtained from the above regression and n is the number of observations. The critical value follows a chi-square distribution with degrees of freedom equal to the number of autoregressive terms in (8).[181] The test statistic is computed to 16.52 which is greater than the critical value of 3.84146 at 5% significance level indicating the presence of heteroscedasticity.[182]

[180] Gujarati and Porter page 793 -794
[181] Gujarati and Porter page 794
[182] Gujarati and Porter, page 887

Basing the conclusion on only one autoregressive order, as in equation (8), is not sufficient. Testing for 12 autoregressive terms are done, which is found to be sufficient to draw correct interference. Heteroscedasticity is present at several lags where the results can be found in appendix 4 table 8. The result from the graphical and numerical investigation indicates that heteroscedasticity is present in the German regression model.

8.3 Autocorrelation

Assumption five of the CRLM is the assumption of no autocorrelation, i.e. no correlation between the error terms. No autocorrelation is expressed as:[183]

$E\ (u_i u_j) = 0 \qquad i \neq j$

Autocorrelation is found in a regression model if there is dependency between the error terms, such that the correlation between them is not equal to zero. If autocorrelation is found in a regression model the consequences are similar to that in the presence of heteroscedasticity. The estimated parameters will no longer have minimum variance, thus they are not efficient estimates. The test statistic can no longer be trusted and statistical interference cannot be draw from the model. [184]

In most economic time series data autocorrelation is present as the error terms tends to depend on each other. It is not to be expected that the error terms of last month does not follow the similar patterns as the error terms in the current month, thus autocorrelation is expected to be present in the model. It is crucial to investigate the presence of autocorrelation. Testing for autocorrelation is done by applying a general numerical test for autocorrelation.

8.3.1 Detecting autocorrelation

A common test for testing the existence of autocorrelation is the Breusch-Godfrey test. By regressing the following model autoregressive schemes up to the fourth order is tested, which is equivalent to testing whether the error term depends on up to four lags of itself:

$u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + \rho_3 u_{t-3} + \rho_4 u_{t-4} + v_t$

The hypothesis to be tested:

H_0: $\rho_1 = \rho_2 = \rho_3 = \rho_4 = 0$ No autocorrelation

H_1: At least one $\rho_i \neq 0$ Autocorrelation

The test statistic of the Breusch-Godfrey test for the German regression model is presented in table 8.3.1-1.

[183] Gujarati and Porter page 413
[184] Gujarati and porter page 413

	LM	Critical value	Pr> LM
AR(1)	6.5407	3.8414	> 0.0105
AR(2)	9.3216	5.9914	> 0.0095
AR(3)	9.3868	7.8147	> 0.0246
AR(4)	10.9430	9.4877	> 0.0272

Table 8.3.1-1 Breusch-Godfrey test statistics

The test statistic follows a chi-square distribution with degrees of freedom equal to ρ_i. The test static at each ρ_i is greater than critical value and the null hypothesis of no autocorrelation is rejected. The conclusion from the Breusch Godfrey test is that autocorrelation is present in the series.

Following the same procedure the various regression models have been tested for heteroscedasticity and autocorrelation. The results from the regression model using CDS as the dependent variable for the whole period is presented in the appendix 4, figure 7, table 8 and 9.

8.4 Newey-West standard errors

A correction of the presence of heteroscedasticity and autocorrelation is necessary as both were detected in the previous section. Instead of trying to model the dependency, Newey west standard errors can be used to remove the dependency between the correlated error terms. They are standard errors that correct for the presence of autocorrelation and heteroscedasticity in a regression model.[185] When autocorrelation, heteroscedasticity, or both is detected Newey-West standard errors are used. It is important to note that the corrected standard errors do not change the estimated parameter values or the R^2, as heteroscedasticity and autocorrelation only affect the standard errors in an estimated model.[186]

Prior to obtaining the corrected standard errors, the lag length that reduced autocorrelation to an acceptable level needs to be decided. Introducing lagged values of the dependent and explanatory variables are often found to reduce autocorrelation. Enough lags have to be included such that autocorrelation is no longer a severe problem in the model and small enough to be ignored. [187]

Deciding the necessary lag length of each regression model is an extensive procedure. It should be note that autocorrelation is never expected to be zero in a time series model and judgement has to be made when deciding how far back it is necessary to go. Newey and West proposed an automatic lag selection model following a simple equation[188]:

[185] Gujarati and Porter, page 447
[186] Gujarati and Porter page 448
[187] SAS/ETS (R) 9.2. Newey-West correction of standard errors for heteroscedasticity and autocorrelation
[188] Newey and West, 1994

$$Lag = 4(\frac{T}{100})^{\frac{2}{9}}$$

Where T is the number of observations. Using the automatic lag length procedure for the whole period four lags is found to be appropriate and three lags for the prior crisis and crisis period. The selected lag length of three and four is found to be appropriate as it includes information as far back as three and four months. For robustness, a regression model with both a higher and lower order lag is computed. The estimated standard errors do not significantly change and the same conclusion of the significance level is drawn. The statistical interference can be trusted and the results are not subject to the choice of lag length. When heteroscedasticity is detected, but no autocorrelation the Newey-West standard errors are employed specifying 0 lags. If neither heteroscedasticity nor autocorrelation is detected the model is estimated based on a normal OSL estimation without any corrections.

8.5 Multicolliniearity

Assumption eight of the CLRM states that there is no exact multicolliniearity among the explanatory variables. Multicolliniearity refers to the existence of a perfect linear relationship among some or all over the explanatory variables in a regression model.[189] A regression model with high multicolliniearity will still make unbiased, consistent and efficient estimates with correctly estimated standard errors. The consequence of high multicolliniearity is that it makes it hard to obtain estimates with small standard errors. Due to larger standard errors, confidence intervals will ultimately be wider and the probability of accepting a false null hypothesis increases thereby making t-values smaller. [190] In addition the estimated coefficients are unstable. The sing of the coefficient may be the opposite of what is intuitively reasonable and correct for the given model. If high multicolliniearity exists between two variables, dropping one variable from the model can result in a change in the sign of the retained variable. [191]

8.5.1 Detecting multicolliniearity

Multicolliniearity is a question of degree and not of kind. It will usually be present in any regression model with more than one explanatory variable. Measuring the degree of multicolliniearity in a model is troublesome but several rule of thumbs have been develop to assess the relative existence of multicolliniearity.[192]In order to draw the most accurate conclusion about the existence of multicolliniearity the following rule of thumbs suggested will be closely investigated[193]:

- Rule 1: High R^2 but few significant t-ratios

[189] Gujarati and Porter, page 321
[190] Gujarati and Porter page 326-330
[191] Dielman, 2005 page 366
[192] Gujarati and Porter, 2009 page 337
[193] Gujarati and Porter, 2009 page 337-340

- Rule 2: High pairwise correlation among regressors
- Rule 3: High auxiliary regression
- Rule 4: Condition index (CI) over 30 and variance of inflation factors (VIF) over 10

The procedure for testing the German regression model will be explained in further detail. The R^2 is relatively high, at 35%, but there are few significant t-ratios indicating the presence of multicolliniearity.

Pairwise correlation between two regressors should help to identify highly correlated variables. High pairwise correlation is a sufficient but not a necessary condition for the existence of multicolliniearity.[194] Determining high pairwise correlation is a subject of judgement. A rule of thumb suggested by some researches is that multicolliniearity may be a serious problem if any pairwise correlation is bigger than 0.5[195], other suggest that pairwise correlation above 0.8 results in serious problems.[196] The local stock index variable, ΔlMSCI, is highly correlated with both the ΔlS&P500 and the ΔlVOL with correlations of 60.06% at 67.29% respectively. The high correlations can be explained by interdependence between the US and German stock markets. Bonfiglioli and Favero (2005) have found that short-term fluctuations in the US share price spill over to the German share price.[197]

One way of detecting which explanatory variables are highly correlated is to regress each explanatory variable on the remaining explanatory variable. Klein's rule of thumb is adopted which suggests that multicolliniearity can be troublesome if the R^2 computed from the auxiliary regression is higher than the overall R^2 from the final model.[198] The auxiliary regressions for the German variables are found in table 8.5.1-1:

Dependent variable	**Δldebt**	**ΔlMSCI**	**ΔlCPI**	**Δprivate debt**	**Δpolitical**	**ΔCA**	**Δgov bal**
R^2	53%	71%	20%	32%	37%	21%	49%
Dependent variable	**Δliq**	**ΔlS&P500**	**Δr_f**	**ΔlVOL**	**ΔGreece**	**ECT**	
R^2	11%	49%	28%	35%	11%%	20%	

Table 8.5.1-1 Auxiliary regressions Germany

From the auxiliary regressions it becomes clear that there are variables in the model that creates high multicolliniearity where the R^2 from these regressions exceeds the overall R^2 of 35% from the final model.

[194] Gujarati and Porter, 2009 page 338
[195] Dielman, 2005 page 367
[196] Gujarati and Porter, 2009 page 338
[197] Bonfiglioli and Favero, 2005
[198] Gujarati and Porter page 339

The last test for multicolliniearity is investigating the CI and VIF. As a rule of thumb if the CI exceeds 30 severe multicolliniearity is present in the model. If the VIF values are greater than 10 of a given variable, it is said to be highly collinear. [199] The CI of the regression is 4.40672 and the VIF values are displayed in table 8.5.1-2:

Variable	**VIF**
∆ldebt	2.11198
∆lMSCI	3.52924
∆lCPI	1.26042
∆lprivate debt	1.59792
∆political	1.47536
∆CA	1.26904
∆gov bal	1.95778
∆liq	1.13012
∆S&P500	2.42232
∆R_f	1.60262
∆lVOL	1.76998
∆Greece	1.1754
ECT	1.25482

Table 8.5.1-2 VIF values Germany

There are not any troublesome VIF values in the model, and the CI is at a satisfactory level. Based on the high correlations and the auxiliary regressions it becomes apparent that multicolliniearity is a problem in the model indicating that corrections are in order to be able to draw reliable conclusions from the estimated model.

8.5.2 Correcting for high multicolliniearity

Multicolliniearity will always be present in any regression model, but as high multicolliniearity was detected, remedial measures are in order. A common method to deal with the presence of multicolliniearity is dropping variables that are highly correlated.[200] Dropping variables from a model can result in specification bias, meaning that variables that should help to explain the dependent variable are left out of the model. In order to avoid the problem of specification bias each removal will be justified by a restriction test, known as the Wald test.[201] The test is specified as follows:

[199] Gujarati and Porter page 340
[200] Gujarati and porter page 343
[201] Gujarati and Porter page 261

H_0: $b_i = 0$

H_1: $b_i \neq 0$

The null hypothesis of the test states that the variable has no explanatory power in the model and is not significantly different from zero. If the null hypothesis cannot be rejected the variable is removed from the model. The test statistic follows a chi-square distribution, $x^2{}_q$, where q is the number of restrictions under H_0.

The removal ΔlMSCI is tested as the local equity index is highly correlated with the global equity variables, in addition to a high R^2 from the auxiliary regression is found. The variable cannot be removed as the test statistic is greater than the critical value of 3.84 at 5% significance, thus rejecting the null hypothesis. [202] The ΔlS&500 and ΔlVOL are further tested for removal. . The removal is justified by the restriction test and the variables are found to have no explanatory power in the model. The results from the Wald test and the statistics is displayed in table 8.5.2-1.

Wald test statistic			
Test	Statistic	Pr > ChiSq	Test conclusion
ΔlMSCI	0.01	0.9140	Cannot be removed
ΔlS&P500	0.01	0.9140	Removed
ΔlVOL	0.03	0.8517	Removed

Table 8.5.2-1 Wald test statistic

After the removal of the variables a new CI, VIF values and auxiliary regressions have been computed which are now all at satisfactory levels.[203] Multicolliniearity have been reduced to an acceptable level. The same procedure for detecting multicolliniearity has been applied to all the CDS regression models where multicolliniearity have been detected in several models. The results from the detection of multicolliniearity and the removal of variables can be found in appendix 4 tables 10-16. It is found appropriate to model the bond regression model in similar fashion as its respective CDS regression model as the correlations between the explanatory variables are the same. The models have been tested for multicolliniearity where it is found to be at an acceptable level.

8.7 Normality of the error terms

The Gauss-Markov theorem makes no assumption of the probability distribution of the random variable, u_i and thus not of the dependent variable. By adding the assumption of normality of the random variable to the assumption of the CLRM the regression becomes what is known as the classical normal linear regression

[202] Gujarati and Porter, page 887
[203] Appendix 4, table 11

model (CNLRM). By assuming normality of the error terms, the estimation can be generalised from a small sample to the population.[204]

The normality of the error terms will be investigated by obtaining a histogram of the residuals and. An other well known test for normality is the Jargue-Bera (JB) test for normality. The JB test is a large sample test and thus not suitable for the given analysis.[205] The residuals do not appear to be perfectly normally distributed by investigating the histogram of the residuals.[206] It is not expected that the sample period yields normally distributed error terms as the tested period is relatively small including 106 observations. In addition, a crisis period is included in the tested time period where the behaviour of the data is significantly different from the prior crisis period.

A solution to non-normality in a series could be dropping outliers and extreme values.[207] This approach is not found suitable given the purpose of this analysis. Any outlier or extreme values may obtain useful information about the different behaviour of the data in the crisis period compared to the prior crisis period. It can be assumed that the error terms are asymptotically normally distributed. Under the Gauss-Markov assumption it can be shown that the OLS estimators are asymptotically normally distributed and thus the analysis is carried forward without any further adjustments. [208]

[204] Gujarat and Porter page 97-99
[205] Gujarati and Porter page 130-131
[206] Appendix 4, table 17
[207] Gujarati and Porter 2009, page 497
[208] Gujarati and Porter 2009, page 544

9 Empirical results

9.1 Interpreting the empirical results

The assumptions of the CLRM have now been assessed and remedial measures have been implemented. Statistical interference can now be drawn from the regression model and final estimation the CDS regression model and equation and the bond regression model will proceed. The logged variables in the model create a lin-log relationship with the dependent variable where the regressand is linear and the regressor is logarithmic. It gives an absolute change in Y of the coefficient/100, for a percentage change in X. A logarithmic variable in first difference is approximately equal to the percentage change, such that the ΔlCPI is the inflation rate and ΔlMSCI is the return on equity and so on. [209]

Discussion of the results will proceed by an interpretation of the CDS spread for the whole period, the prior crisis period and crisis period, lastly an interpretation of the bond analysis will be carried out. Interpretation of the long-term relationship between the CDS and bond market will be done in the last section for a more intuitive representation. Due to space constraints the level effect and significance level will not be pointed out for every regression but is presented in a summary the table.

9.1.1 The whole period CDS regression model

The dependent variable is the ΔCDS spreads for the given country. Data on the Italian spread is only available up until July 2010 resulting in limited information about the behaviour of the spread during the debt crisis relative to the other countries. Table 9.1-1 presents the results for the whole period from March 2003 until January 2012.

[209] Gujarati and Porter, page 164

	France	Germany	Greece	Italy	Portugal	Spain
Intercept	2.038*	0.337	12.750**	-0.014	14.037**	-2.0762
Δldebt	-120.951	63.491	43.400	2310.912*	503.330**	-42.159
ΔlMSCI	-75.745***	-47.823***	-226.164***	-47.508**	-169.670**	-303.753***
ΔlCPI	-118.638	64.068	-1653.6	2382.482*	-1568.27	1123.161
Δlprivate	25.106	0.354	-278.968		-2241.32**	410.761
Δpolitical	-5.997	-4.791	125.633***		125.2***	
Δca	1.854	0.826	0.751	-44.473*	4.832	4.284
Δgov bal	0.085	0.483	-0.678		-1.518	-2.640
Δliq	-1.731***	-0.194	0.306	-30.153*	3.300*	-2.661*
Δrating	n/a	n/a	-76.810***	-27.788	-25.479***	-3.005
ΔlS&P500				-161.344	138.806	199.406*
Δr_f	-6.493*	0.521	-28.176	-8.635	3.552	-4.116
Δlvol			12.021	-58.325	80.473*	20.379*
ΔGreece	-0.813	-1.769		-24.819	-18.778***	-7.512*
ECT_{CDS}	0.019	-0.186***	n/a	n/a	n/a	n/a
R^2	41.95%	34.92%	48.68%	38.20%	45.51%	53.84%
Adj. R^2	35.16%	27.31%	41.96%	30.18%	37.81%	46.92%

Table 9.1.1-1 results CDS whole period
****1%,**5%,*10% significance level*
A blanc cells means the variable have been removed due to multicolliniearity
N/A means the variable is not applicable

Both the R^2 and the adjusted R^2 are presented. The adjusted R^2 penalises adding extra regressors, while R^2 will always increase by adding extra variables into the model. [210] The explanatory power given by the variables in the model differ slightly across countries, where the largest explanatory power is found in Spain, followed by Greece and Portugal.

Equity market indicators

The major influential factor of sovereign risk is the equity return, which is significantly negative for all the countries over the period. The value of -75,745 for ΔlMSCI for the French regression model means that a percentage point increase in the local equity market return decreases the monthly change in CDS spread by 0.75745 basis points. The equity market is a good indicator of the overall wealth of country's economy and subsequently it can predict the economic activity in a country. Analysing the evolution of the equity market

[210] Gujarati and Porter, page 493

can be a good predictor of the direction of the credit risk in a country. The level effect is greatest in Greece, Portugal and Spain.

The local equity return is highly correlated with the global equity variables, ΔlS&P500 and ΔlVOL. The high correlations between the local and global equity variables indicate co-movements across the two markets. The global equity indicators have been removed for a group of countries due to high correlations.

Where still present, the global equity indicators significantly affect the CDS spread for a number of the Eurozone counties. Changes in the volatility index increase the spread in Spain and Portugal. Global risk aversion is significantly affecting sovereign risk. Return on the US equity index, Δ*lS&P500*, has a positive effect on the spread in Spain, indicating that developments in the US economy increases the CDS spread. The S&P500 index fell considerably at the end of 2007 following the financial crisis. From 2009 and until 2012 the index increased reaching nearly pre-crisis levels. At the same time sovereign risk for a number of Eurozone countries increased considerably, denoted by the increased CDS spread. The US economy has gradually strengthened since mid-2009 only to experience minor shocks to the system. The US economy, indicated by the S&P500 index, and the Eurozone economy diverged during over the period. The significant positive effect is not expected during more stable periods.

The relationship between the equity market and the CDS market is subject to a wide range of studies and the results are in line with previous studies where the equity market is the major determinant of CDS spread. Longstaff et.al (2010) finds similar results of a significant MSCI index. The local equity index significantly affects the CDS spread for a number of countries in their analysis on emerging market economies. The countries affected by the local stock market return are the more developed countries in the sample, such as Japan, China, Russia and Turkey.[211] The results suggest that there is a link between the local equity market and advanced economies.

Country-specific variables

The significance of the Δldebt is approximately non-existing being significant only in Portugal at the 5% level and in Italy at the 10% level. The results are of great importance as it amount to saying that debt levels does not have an effect on the pricing on CDS, i.e. it does not affect the country's default probability. The results are contradicting with the ground-breaking structural model introduced by Merton for pricing credit risk, where the level of debt is a major input variable into the pricing of credit risk. It is apparent that other measures are of higher importance when assessing a country's probability of default.

The local variables such as CPI, private debt, current account and government balances are not significant for a number of countries. The inflation rate has a positive and significant effect on the Italian spread.

[211] Longstaff, et.al, 2011

Increased inflation levels cause the country's default risk to increase. The private debt variable is significant for Portugal at the 5% level with a negative sign. Higher private debt reduced the CDS spread. This is in line with the idea that increased private debt causes optimism about future economic growth. In general, the results are in line with Fontana and Scheicher (2010), Longstaff et.al (2010) and Pan and Singleton (2008) who finds local macroeconomic and fiscal variables not determine the probability of default.[212]

The liquidity variable is significant for several of the countries. In France, Italy and Spain there is a liquidity premium, in which increased liquidity (denoted by reduced bid-ask spread) causes an increase in credit spread. Higher liquidity increases the demand for a country's CDS contracts, as high liquidity is a desirable attribute when exposed to credit risk. Prior to the crisis, Italy issued amongst the most liquid CDS contracts, consequently creating a flight to liquidity. The bid-ask spread prior to the crisis was minor. During the crisis there was an increased illiquidity denoted by an increased bid-ask-spread. [213] The dominating factor influencing the French CDS spread is changes in liquidity. The French CDS spread seems to be highly driven by liquidity changes and not affected by increases in default probability measures. The Portuguese spread is significantly affected by reduced liquidity, where illiquidity increases the credit risk. Identifying the effect from liquidity is important from a policy making perspective.

The political risk variable is significant for Greece and Portugal with a positive sign meaning that a more stable political system causes a higher spread. Investigating the political risk indicator in Greece shows an immediate decrease in the political stability in mid- September 2007 and until mid-2009 followed by an increase at the end of 2009. The index of economic freedom increased the political rating for Greece in 2009 increasing the business and monetary freedom as well as increasing freedom from corruption.[214] The increased political stability occurred similarly as the CDS spread increased further. The similar pattern is observed in the Portuguese political risk variable. An explanation of the results from the political risk variable could be that the created variable does not represent the political situation in the Eurozone. The political risk variable is created based a study based on emerging economies and deeply troubled countries and thus the similar risk factors might not be suitable for measuring the political risk in more stable developed economies. Creating a political risk variable more directly related to Eurozone's political situation could yield a more significant effect.

Credit ratings

[212] Fontana and Scheicher 2010, Longstaff et.al 2011, Pan and Singleton 2008
[213] International Monetary Fund, 2013
[214] Heritage foundation economic freedom index, hwww.heritage.org

Contagion effects are found in the analysis as the Greek credit rating is significantly affecting the cds spread in Spain and Portugal. Downgrade of the Greek credit rating results in spillover effect to the neighbouring countries increasing the sovereign risk in these counties. The French and German spread is not affected by changes in the Greek credit rating. The result can be explained by the fact that the major concern for the Eurozone is the Spanish economy and as the fourth largest economy in Europe it is too big to bailout. The Greek, on the other hand, economy is small enough to be saved. [215]

The Portuguese spread is affected by changes in its own credit rating, but this is not the case in Spain. Sovereign risk in Spain is not affected by its own credit rating. Over the course of the period Spain maintained a high credit rating compared to the other PIIGS countries. In 2004 S&P upgraded the country's credit rating from AA to an A+. The upgrade was based on good macroeconomic performance.[216] In January 2012, the Spanish credit rating was downgraded form AA- to A by S&P still maintaining a high credit quality measure.

Concluding remark

The main results from the analysis are the significance of the equity market variables, where country-specific variables lack explanatory power, with the exception of significant effects in certain countries. Portugal, Greece, Italy and Spain share similarities with respect to explaining the CDS spread. The pricing of the Portuguese spread is highly explained by the variables in the model. A liquidity premium dominated changes in the French spread. The German spread appears to be somewhat unaffected by the variables in the model, with the exception of the local stock market. The results from the whole period analysis is an indicator of the overall behaviour of the CDS spread over a time span of 8 years. Dividing into a prior crisis and crisis period allows for investigation of how the pricing of sovereign risk changed during a debt crisis compared to a more stable period proceeds.

9.1.2 The prior crisis CDS regression model

The prior crisis period is set from March 2003 and until September 2008. Table 9.1.2 displays the results from the regression model.

[215] Trading economics, www.tradingeconomics.com
[216] Afonso et.al, 2007

	France	Germany	Greece	Italy	Portugal	Spain
Intercept	0.113	0.245	0.725	0.306	-0.713	-0.31485
Δldebt	80.362*	31.433	-49.642	493.597	74.902	
ΔlMSCI	-16.038***	-4.440*	-23.210	-30.546***	-13.3	-34.348***
ΔlCPI	42.539	-14.587	199.317	100.840	94.293	285.809
Δlprivate debt	41.765	-64.965			305.283	104.042
Δpolitical risk	-3.204	-7.401***			-1.986	5.712
ΔCA	2.421***	-0.232	1.443*	-8.144	0.095	0.615
ΔGovbal	0.289	-0.588	0.222		0.278	-0.387
ΔLiq	0.464	0.907***	1.291	-5.033	1.651	3.355**
ΔRating	n/a	n/a	0.159	6.573		
ΔlS&P500				117.903	-8.822	-41.810**
ΔR_f	0.719	1.382**	-4.603	-20.466**	-7.070	-4.170
ΔlVOL	.		0.953	1.218	0.440	
ΔGreece	-0.001	0.2384		-2.544	1.074	
ECT_{CDS}	0.197*	-0.224***	-0.03	n/a	n/a	-0.06
R^2	52.16%	79.37%	27.85%	43.69%	37.84%	61.18%
Adjusted R^2	42.21%	74.31%	14.73%	32.45%	23.77%	51.94%

Table 9.1.2-1 Results CDS prior crisis period

****1%,**5%,*10% significance level*

R^2 differs significantly across countries where Germany is superior to the other countries with an adjusted R^2 of 74.13%. The explanatory power in the Greek model is only 14.73%. There appears to be pronounced differences in what explain the various CDS spreads over the period.

Equity market indicators

The major determinants in the period is the local stock market return. The ΔlMSCI is highly correlated with the ΔlS&P500 and the ΔlVOL for a number of countries and similar interpretation holds as for the whole period. Equity return has the largest negative level effect in Spain and Italy, followed by France and Germany.

The local equity return is not significance in Portugal and Greece. The MSCI equity index upgraded the classification of the Portuguese and Greek equity market from emerging to developed market around the new century. As of 2008, neither had received the classification as an advanced economy, being severely less developed that the various other nations. An upgrade can have a significant effect on the country's ability to participate in larger equity investments worldwide.[217] This can explain the insignificance of the local equity return given the less developed equity markets in these countries.

ΔlS&P500 is significantly negative for the Spanish CDS spread. An increase in the equity return of the S&P500 index results in a decrease in the change in spread of 0.41 basis points. Neither Portugal nor Italy are affected by the global equity variables. The volatility measure, ΔlVOL, to indicate risk aversion is not significant for any countries. The VIX index remained relatively stable over the period, and so the risk appetite for investors did not change considerably.

Country-specific measure

There are distinct differences during the period of the effect from country-specific measures on the CDS spreads The Δldebt is significantly positive for France where a percentage increase in the debt levels causes an increase in the change in the spread of 0.80 basis points. However, it is only significant at the 10% level. The insignificance of the various debt variables indicates that the level of debt does not have a crucial effect on sovereign default. The results are similar to the whole period regression.

The current account balance is significantly positive for France where an increase in the change of the current account by 1 point causes the change in spread to increase by 2.421 basis points. This is contradicting with the expected sign but as previously stated a negative current account can indicate probabilities for future economic growth and thus reduce the probability of default. Increased illiquidity increases the CDS spread in Spain. With the expectation of minor effect in selective counties, the various other country-specific measures seems to have no severe effect on CDS spread.

A positive current account effect is found in Greece, indicating expectations about further economic growth. Greece's membership into the EMU helped to stimulate growth as EMU countries are considered financially and politically stable. It becomes apparent that Greece was not worried about the future.

The German spread is affected by other determinants than the rest of the European countries, with several significant variables. The political risk variable is significantly negative in Germany. A more stable political system reduced the probability of default. Over the period political risk is reduced significantly. During the period, Germany increased their political stability score by reducing corruption, increasing business,

[217] Gadot- Perex, 2009

financial and trade freedom as well as increased justice.[218] Decreased liquidity increases the German CDS spread.

Risk- free rate

Increases in the risk-free rate are significantly reducing the Italian spread. The risk- free rate significantly affects the probability of default as suggested by the structural model. Contrary, the German spread is positively related to the risk- free rate. The German credit market is generally considered a good proxy for the risk-free rate.[219] Market participants may view increases in the risk-free rate as an increase in the German default risk, subsequently resulting in an increase in the CDS spread.

Credit rating

Neither a country's credit rating nor the Greek rating have any effect in the period. Contagion effects are not detected. It appears that the European countries were at the time not concerned about the Greek economy. The increasing debt levels in Greece and fiscal deficits did not receive specific attention by the Greek government or the EMU and so there was no reason for the rest of Europe to fear the Greek credibility. A country's own rating remained relatively stable over the period and thus no effect on default risk is detected.

Concluding remarks

The CDS spread is not significantly affected by measures that in theory should affect the probability of default. The equity market has the most significant effect, where investors' risk appetite remains relatively constant over the period without any impact on the credit spread. The overall lack of explanatory power in the Greek regression model can indicate that the economy was not worried about the unstable fiscal policies, increased government deficits and debt. The Greek CDS spread is left relatively unexplained in the period. The following section may give a more informative explanation to what determines the Greek spread as the crisis period is investigated next.

9.1.3 The crisis period CDS regression model

Italian spread is not present in the regression model, as only observations up until July 2010 have been provided. Table 9.1.3-1 displays the results from the crisis period from October 2008 – January 2012.

[218] Heritage foundation economic freedom index , www.heritage.org, World competitiveness online, www.worldcompetitiveness.com
[219] Cesare et.al, 2012

	France	Germany	Greece	Ireland	Portugal	Spain
Intercept	-0.3178	1.346	54.339**	7.591	12.326	-14.740
Δldebt	-28.808	124.077**	-2881.23	0.379	2277.55**	744.236
ΔlMSCI	-111.465***	-90.660***	-350.046**	-320.924***	-545.84***	-484.844***
ΔlCPI	1058.226	1150	-6319.25*	2393.334	-6287.08*	1564.197
Δlprivate debt	-441.135	-152.436		-1867.53	-2968.78	
Δpolitical risk	-46.833	-3.914			154.465*	
ΔCA	-3.607	-0.187	-3.811		14.097	-.0338
ΔGovbal	-4.430		5.292	0.686		4.291
ΔLiq	-1.528***	-0.187	5.291	3.686	7.818*	-2.016
ΔRating	n/a	n/a	-90.620***	-17.95**	-35.695***	-0.241
ΔlS&P500					402.172*	265.589**
ΔR_f	-26.550**	-3.091	-111.573	69.710**	58.948	-6.674
ΔlVOL			55.348	62.240	191.207**	
ΔGreece	-1.177	-0.994		-23.951***	6.514	-8.450
ECT_{CDS}	n/a	n/a	n/a	n/a	n/a	n/a
R^2	56.18%	42.01%	62.04%	48.73%	64.45%	64.89%
Adjusted R^2	40.53%	26.54%	44.06%	27.36%	48.04%	52.35%

Table 9.1.3-1 results CDS crisis period
****1%,**5%,*10% significance level*

Both R^2 and adjusted R^2 are considerably higher for a number of the regressions indicating that the period during the crisis is better explained by the variables in the model, with the exception of Germany. There has been a significant re- pricing of default risk following the sovereign debt crisis.

Equity market indicators

The local equity return is significant for all the countries. The variable remains a significant influential variable in assessing sovereign risk. A significant effect is observed in Greece and Portugal compared to period prior to the crisis. The equity index in these countries increased continuously prior to the crisis following the new classification and increasing the size of the local equity market. The market reached a peak in 2008 followed by a rapid decrease, which resulted in increased credit risk.

The US equity index return has been removed due to high correlation with the local equity return for four of the countries. The US equity index is significantly positive in Spain and Portugal, where a similar interpretation as for the whole period holds. The volatility index to proxy global risk aversion is significant only for the Portuguese spread and not in Greece and Ireland. The results indicates that the Portuguese spread is more affected by the risk appetite of the world economy.

<u>Country specific variables</u>

Country-specific variables do not have a significant effect on the spread with the exception of in Portugal and Greece, where increased inflation reduced the credit risk. The negative effect is contradicting with the expected effect, where higher inflation levels are a sign of macroeconomic instability increasing the spread. The negative effect can be explained by the fact that increased inflation rate can create stable inflation levels above zero. Zero or negative inflation levels are not desirable. Inflation levels above zero create an adjustment mechanism for the central bank involving downward adjustments in inflation to mitigate recessions. In addition increased inflation levels have a positive effect for debtors as it reduced the real level of debt. Debtors can pay of their debt with money that is less valuable. The negative inflation effect in Greece and Portugal can be explained by the ease of debtors in the two highly indebted countries to pay back debt as inflation increases.

$\Delta ldebt$ is significant in Germany and Portugal. The Portuguese debt increased from 70% to approximately 120% of GDP over the period yielding the greatest debt increase for the Eurozone together with Ireland.

The insignificance of the Greek debt levels on CDS spread can be linked to the fact that Greek debt levels were already extremely high at the beginning of the period amounting to 120% of GDP, increasing to 160% of GDP at the end of the 2011. The credit spread on the other hand increased considerably, from less than 200 basis points to 1000 basis points in the same period. It becomes evident that the rapid increase in CDS spread was related to other variables than increased debt levels.

Δliq has a significant negative effect on the spread in France. A flight to liquidity occurred during the crisis period where a significant liquidity premium can be detected. While in Portugal liquidity has the expected sign, where an increase in liquidity (denoted by a tighter spread) causes the spread to decrease. There has been a distinct decrease in liquidity during the period, signifying that the Portuguese market has been drying up. The German spread is not affected by the liquidity variable. There has not been a flight to liquidity to the German CDS market during the debt crisis as might be expected. The increased spread in Germany can rather be explained by a flight to quality. These results are in line with Santis (2010) and Mody (2009) who suggests that during the debt crisis the German credit market benefited from a safe haven status.[220]

[220] Santis, 2012; Mody, 2009

The political risk variable is significantly positive in Portugal, where the other CDS spreads seems unaffected by the evolution of the political instability in the country. The same interpretation as for the whole period holds.

Credit rating

Contagion effects are only present in Ireland with an effect larger than the effect from its own credit rating of -17.95 compared to -23.951 from Greek rating changes. The results are similar to that found by Santis (2012) who finds decreased credit ratings on Greek bond to lead to a noticeable increase in sovereign bond spread in Ireland.[221] No contagion effects are found for the rest of the Eurozone. The results can be explained by the fact that the Irish and the Greek economy are economically small compared to the other countries included. The French and German economies are more exposed to the development of the major economics in Europe.

The Irish, Portuguese and Greek rating is significantly negative. The probability of default in Spain is not affected by downgrade in its credit rating. Over the course of the period Spain maintained a high credit rating compared to the other PIIGS countries.

Risk- free rate

The risk- free rate has a significant negative effect in France. The negative risk- free rate in France is in line with economic intuition and Merton's structural model. The risk- free rate has a large positive effect on the Irish CDS spread, where an increase in the risk- free rate increases the credit spread. Positive effects between risk- free rate and credit spreads have been investigated by Mody (2009). A higher risk-free rate can imply a more adverse global environment, and thus the rise in the risk- free rate would be associated with larger spreads on risky assets.[222]

Concluding remarks

The main results from the period are the increased explanatory power in the PIIGS countries while a reduction is observed in France and Germany. It appears that the Eurozone members are not affected uniformly by the factors, where there are distinctions across groups of countries. The equity market remains the main determinant while fiscal local indicators are lacking explanatory power. The increased explanatory power of the indebted countries is derived from contagion effects and country credit rating. The French credit premium is affected by a liquidity premium, while the German model lacks explanatory power.

9.1.4 Bond spread regression

The interpretation from the bond will be based on a comparison of the CDS regression and determine to what extent sovereign risk is incorporated into the bond spread. The analysis will be restricted to a summary of the

[221].Santis, 2012
[222] Mody, 2009

results where the effect form each variable on the bond spread will not be explained in detail. The results from the whole period is found in table 9.1.4-1

	France	Germany	Greece	Italy	Portugal	Spain
Intercept	0.025	0.129	18.062***	1.067	-2.213	-3.261
Δldebt	-103.098	133.628	561.820	-103.193	1135.872	6.984
ΔlMSCI	15.601	27.331*	-176.288***	2.000	-161.575*	-295.981***
ΔlCPI	476.990	-863.589**	-3301.68	-36.890	1822.789	1034.75
Δlprivate	-172.582	-141.308	-648.712		1365.07	-515.923
ΔPolitical	22.946	-5.193	139.39***		42.369	
ΔCA	1.597	-0.001	-3.530	-0.371	-6.245	9.119**
ΔGov bal	-1.829	-2.71523**	1.545		2.622	1.085
ΔLiq	-0.506	-0.127		-11.774**	2.600***	49.370
ΔRating	n/a	n/a	-92.291***	6.5837**	-44.710***	16.976***
ΔlS&P500				-46.360	80.844	289.944**
Δlvol			0.062	16.87	-5.216	27.298*
ΔGreece	-0.240	-0.299		-4.020**	-12.049	-11.027*
ECT_{BOND}	0.093	-0.065	n/a	n/a	n/a	n/a
Adjusted R^2	-0.17%		29.37%	10.82%	65.92%	30.40%
R^2	9.37%		36.06%	20.05%	69.82%	20.94%

Table 9.1.4-1 results bond whole period
****1%,**5%,*10% significance level*

The explanatory power of the regression models have changed significantly compared to the CDS regression model. R^2 in Germany and France is extremely low. No significant effect from the model is found on the French bond spread. The inflation rate has a significant effect in Germany. In addition, the local equity market has a minor positive effect on the spread and the government balance has a negative effect. For the stable Eurozone countries, it becomes evident that the two credit spreads are not affected by the same determinants, where the pricing of sovereign risk differ.

The equity index does not have the same effect. In Greece, Spain and Portugal a negative effect is found with a similar level value as for the CDS spread. The model explains the variation in the Greek bond spread similarly as for the CDS spread where only level effects are detected. Similar comparison can be draw for the Portuguese and Spanish regression model to their respective CDS spread models. The credit rating variable is the major determinant during the period.

In becomes apparent that the global and local probability of default measures found to be highly determinant in the CDS spread does differ in significance for the various bond spreads. The results are in line with the PCA analysis carried out in chapter 9, which revealed that the German and French bond spread did not co-move with the rest of the countries. Table 9.1.4-2 displays the results from the prior crisis period.

	France	Germany	Greece	Italy	Portugal	Spain
Intercept	6.336***	-3.524*	2.462*	0.742	-0.597	-1.969
Δldebt	-70.181	491.802**	-10.085	-52.626	-147.097	
ΔlMSCI	34.510	23.900	-22.135	-6.788**	-28.516	15.470
ΔlCPI	261.227	-899.689**	-712.424	-220.962*	680.304*	627.089
Δlprivate	-717.664	-583.475			-108.161	93.910
Δpolitical	32.060*	10.993			1.986	24.606
ΔCA	-11.237*	1.665	-0.398	-2.490	1.623	-0.676
Δgov bal	1.024	8.495*	-0.255		0.031	-1.913
ΔLIQ	-18.363*	-4.521		-18.893***	-1.376	3.141
Δrating	n/a	n/a	-3.990	9.795***		
ΔlS&P500				3.669	28.510	2.090
ΔlVOL			-0.882	-3.668	-0.961	
ΔGreece	-2.847*	-1.399		11.129	-1.665	
ECT_{BOND}	0.333***	-0.229**	0.099	n/a	n/a	-0.283*
Adjusted R^2	12.53%	8.82%	-1.20%	26.27%	-4.33%	-1.22%
R^2	25.98%	22.64%	11.26%	36.48%	13.32%	16.30%

Table 9.1.4-2 Results prior crisis period bond
****1%,**5%,*10% significance level*

The explanatory power in the model is low. Minor effects are observed from country-specific variables on the French spread. The negative current account effect on the bond spread differs from the positive effect which is detected in the CDS regression model. A liquidity premium is additionally observed in France. The French bond benefited from a flight to liquidity prior to the crisis, while for the CDS market a liquidity premium is detected in the crisis period. In addition contagion effects are found. Overall, the French bond and CDS spreads appears to be affected by different determinants.

The German bond spread is affected by country-specific variable, such as debt levels, inflation rate and government balance. Similar effects are not found in the CDS regression.

The model does not reveal any effect from the explanatory variables on the Greek and Spanish bond spread. Similarly, no severe effects are detected in the Portuguese spread, with the exception of a minor effect from the inflation variable.

Several of the variables included affect the Italian bond spread. The equity index is significant, but the level effect is smaller than for the CDS spread. A minor negative effect from inflation level is observed where increased inflation reduced the credit spread. In addition a liquidity premium is found as the inflation rate is significantly negative. A similar effect is found for the CDS spread over the whole period.

The results from the crisis period are displayed in table 9.1.4-3.

	France	Germany	Greece	Portugal	Spain
Intercept	4.322	1.823	32.497	-13.040	-2.212
Δldebt	-318.238	-51.125	-408.351	1926.632*	1135.872
ΔlMSCI	14.699	30.868	-258.51*	-336.568	-161.575*
ΔlCPI	956.682	-964.202	-8436.92*	3239.94	1822.789
Δlprivate	-766.565	-254.467		-3680.68	-1365.07
Δpolitical	80.599	-116.208		1.117	42.369
ΔCA	1.110	-2.638	-11.000	0.578	-6.245
Δgov bal	-4.974		13.527*		2.622
ΔLIQ	-45.331	1.029		250.406***	2.597***
Δrating	n/a	n/a	-113.382**	-44.544**	-44.708***
ΔlS&P500				149.674	80.844
ΔlVOL			-0.896	-28.705	-5.216
ΔGreece	-0.319	0.842		-10.561	-12.049
ECT_{BOND}	n/a	n/a	n/a	n/a	n/a
Adjusted R^2	-16.61%	-15.75%	18.25%	57.44%	65.92%
R^2	11.00%	8.61%	38.69%	69.76%	69.82%

Table 9.1.4-3 Results crisis period bond
****1%,**5%,*10% significance level*

The model is still lacking explanatory power for the French and German bond spread. For the fiscally troubled countries, the explanatory power has increased. The major influential factor is the country's credit rating with a severally higher effect than in the CDS spread. Contagion effects are not present.

The model has a high explanatory power in Portugal and Spain. Reduced liquidity increases the bond spread in Portugal in similar fashion as the CDS spread. In addition, increased debt levels increases the bond spread, but where the level effects differ from the CDS spread. Increased liquidity reduces the bond spread in Spain, a similar effect is not found in the CDS spread.

Concluding remarks

The overall results from the bond spread analysis are the lack of explanatory power from the local and global variables. The effect from the variables differs greatly from the effect on the CDS spread and between groups of countries. The equity market does not have the same effect, whereas a country's credit rating is the most significant variable. Similarities in explaining the credit pricing in the bond and CDS market are found in Italy prior to the crisis and for Greece, Spain and Portugal during the crisis period, where the prior crisis is lacking explanatory prior. For France and Germany, the pricing of credit risk differs in the bond and CDS market. It becomes apparent that the CDS spread and bond spread are not affected by the same determinants. As a conclusion, from the studying the underlying bond spread, the CDS spread can be regarded as a more appropriate measure of a country's probability of default. The R^2 is generally higher in the CDS regression model indicating that the CDS spread is determined by variables that should affect default risk to a higher extent that the underlying bond spreads.

9.2 The lead-lag relationship

9.2.1 Interpreting the ECT

This section will investigate the price discovery process between the bond and the CDS market. Where a cointegrated relationship was found the ECT describes the deviations of the CDS and bond spread from their no-arbitrate equilibrium relation. A reminder of the construction of the ECT term is in place:

$ECT_{CDS} = CDS_{t-1} - \alpha_0 – \alpha_1 Bond_{t-1}$

$ECT_{BOND} = CDS_{t-1} - \alpha_0 – \alpha_1 Bond_{t-1}$

A negative and statistically significant ECT_{CDS} term means the bond market is contributing significantly to price discovery in the CDS market. The CDS market plays an important role in the price discovery in the bond market if the ECT_{BOND} variable is positive and statistically significant. The existence of a cointegrated relationship between the two markets would imply that at least one of the markets contributes to price discovery while the other adjust.[223]

The size of the ECT term implies the speed of adjustment in the case of disequilibrium where a proportion of the imbalance is corrected for in each period.[224] In an equilibrium state the value of the ECT is zero. A larger

[223] Fontana and Scheicher, 2010
[224] Engel and Granger, 1987

value implies that equilibrium is restored more quickly if an out of equilibrium state occurred. Table 9.4.1 displays the ECT_{CDS} and ECT_{BOND} for the counties where a cointegrated relationship was found.

Dependent variable	**France**	**Germany**	**Greece**	**Spain**
ECT_{CDS}				
Whole period	0.019	-0.186***	n/a	n/a
Prior crisis period	0.197*	-0.224***	-0.03	-0.067
Crisis period	n/a	n/a	n/a	n/a
ECT_{BOND}				
Whole period	0.093***	-0.065	n/a	n/a
Prior crisis period	0.333***	-0.229**	0.098	-0.268**
Crisis period	n/a	n/a	n/a	n/a

Table 9.2.1-1 lead-lag relationship

For the whole period a cointegrated relationship is only found in France and Germany. Given the shift in the behaviour of the CDS and bond spread in mid-2008 a long run co-moving behaviour between the two markets over the whole period is not expected for the countries highly affected by the debt crisis.

In the German market, significant price discovery takes place from the bond market to the CDS market with a negative ECT term of -0.188 over the whole period. The CDS spread makes adjustments to incorporate the information provided by the bond market. If the previous month CDS spread is too high it should start falling in the short-run to restore equilibrium. When the CDS market is above or below the long-run equilibrium level, the bond market makes a gradual adjustment of the CDS value in each period until equilibrium level has been restored. A stronger price discovery takes place during the prior crisis period of -0.224. No price discovery is detected in the opposite direction, as the ECT_{BOND} is statistically significant with a negative effect.

In France a cointegrated relationship is found. In the prior crisis period both coefficient are significant and positive indicating that the CDS market significantly contributes to price discovery in the bond market. The ECT_{BOND} term is positive and substantially large at 0.333. Similar, over the whole period price discovery takes place from the CDS market to the bond market, however with a minor adjustment value in each period.

In the prior crisis period of the Spanish market the bond market acts as a driving force in the market, as the ECT_{BOND} term has a negative and significant sign. The CDS market does not contribute to price adjustments in the bond market. The cointegrated relationship between the Greek CDS and bond market is weak. In the prior crisis, the ECT_{BOND} is significant at the 20% level with a small value of 0.098. In an out of equilibrium state the CDS market corrects the bond market to restore equilibrium.

Concluding remarks from the cointegration testing suggest that short-run deviations exist between the two markets such that imperfections in the no-arbitrage relationship between the two markets exist. The CDS market dominates the price discovery process in France and Greece, where the bond market adapts to new information by following the pricing of the CDS market. The bond market incorporates the pricing changes in the CDS market. In Germany and Spain, the bond market leads the CDS market.

Recent research on euro area CDS and bond spreads find clear evidence that the CDS and bond market diverge substantially in the short run.[225] Pallidin and Portes (2011) states the reasons behind the divergence to be related to differences in response to new information available in the short run where one market tends to react more slowly to new information. [226]

9.2.2 Granger-Causality test

When a cointegrated relationship is not found a Granger-Causality test is carried out. A Granger-Causality relationship is a simpler concept that a cointegrated relationship. It does not suggest long-term co-movements between the variable but rather indicates the causality between the two markets. It investigates whether past values of a variable can help to explain present values of another variable. Granger causality does not provide true causality, meaning that past values of the dependent variable will also help predict the current price.[227] If the bond yield spread granger cause the CDS spread, then past values of the bond spread contains information that helps to determine the current CDS spread beyond the information provided by the past values of cds spread.[228]

The null hypothesis of the test states that the bond (CDS) market does not Granger Cause the CDS (bond) market. The alternative hypothesis states that past values of the bond (CDS) spread affect the current CDS (bond) spread. The test statistics follows a chi-square distribution with corresponding critical values.[229] Table 9.2.2-1 – 9.2.2-3 presents the test statistics from the causality testing.

	Greece	**Italy**	**Portugal**	**Spain**
Bond→ CDS	6.02	12.37***	58.54***	0.88
CDS→bond	9.40*	39.39***	3.38	7.42**

Table 9.2.2-1 Granger causality whole period

[225] Fontana and Scheicher, 2010,; Pallidin and Portes, 2011.
[226] Pallidin and Portes, 2011
[227] Gujarati and Porter, 2008, page 750
[228] Pallidini and Portes, 2011
[229] Appendix 5, table 19 for test statistics

In Greece, the CDS market has a dominant role in price discovery, which is similar to what is found in the cointegrated relationship. Significant causality occurs between both markets in Italy, where the CDS and bond spread is affected by each other. In Portugal the bond market granger causes the CDS market. The derivatives market does not contribute to the pricing of bond. The causality goes from the CDS market to the bond market is Spain.

	Portugal	**Italy**
Bond → CDS	5.09	9.38**
CDS→Bond	2.29	5.30

Table 9.4.2-2 Granger causality prior crisis period

	France	**Germany**	**Greece**	**Portugal**	**Spain**
Bond → CDS	2.00	8.67***	0.65	20.33***	0.46
CDS → Bond	7.16***	0.63	1.29	0.83	0.28

Table 9.4.2-3 Granger causality crisis period

During the prior crisis period no severe causality between the two markets is observed in Portugal, while during the crisis the CDS market significantly affect the bond market. In Italy, bond market is not affected by the pricing of the CDS market, where the causality goes in the opposite direction. In France, the price discovery mechanism during the crisis period is similar to the results found from the ECT. Similarly to the cointegration relationship in Germany, the bond market is unaffected by the CDS pricing. In Spain and Greece, no significant causality is detected during the crisis period.

The overall results from the lead-lag relationship indicate that the leading market varies for the respective countries. The study is not able to find a general price discovery rule as to which market leads the other. However, the CDS market has become more active indicated by a leading role for several countries. In France, Greece and Spain the derivatives market is the leading bond market. In the period before the financial crisis, a cointegrated relationship is found suggesting a trending behaviour between the two markets over time. In Germany, Italy and Portugal the bond market is the significant driver, where the CDS market adjusts to new information about the bond market. Prior to the crisis, the two markets trended together in Germany forming an equilibrium relationship.

10 Reflections

10.1 Criticism

Data limitations have restricted the thesis in terms providing a thorough investigation of the behaviour of the CDS spread prior to the crisis and during the crisis for a number of the included nations. The empirical analysis could have been carried out in weekly numbers in order to increase the number of observations. That would require interpolation from quarterly to weekly numbers creating only minor fluctuations in the macroeconomic variables as quarterly data would be employed to explain weekly figures and the accuracy of the analysis would be reduced. Another alternative would have been to express the data in US dollars. However, this would have restricted the quality of the fiscal balances and other local variables as they were found to be expressed in a higher frequency in euros than in US dollars. In addition, exchange rate risk should have been accounted for.

Minor significance from the political risk variable is observed, in addition the sign effect is contradicting with what is expected based on economic intuition. The political risk variable created is based on a study where political risk has a pronounced effect on emerging markets credit risk. Developing a political risk variable more appropriate for the European economy in terms of including risk components more applicable to represent the European system would be desirable.

An additional analysis could have been carried out using the CDS spread with 10-year maturity for a robustness test of the empirical results.

10.2 Conclusion

To summarize the results the problem statement from the introduction is revisited.

"What are the determinants of the spread on sovereign credit default swap in Eurozone countries?"

The study of the pricing of CDS contracts over the period from 2003 and until 2012 finds there to be significant co-movements between the Eurozone spreads, where high correlations between the various CDS spreads are found. Fluctuations of global financial variables, local stock market return, liquidity and country's credit rating dominate in explaining pricing change. The country-specific variables, such as government debt, current account and fiscal balances are lacking explanatory power. However, there are significant variations in terms of the effect of the evolution of local variables on credit risk. The thesis has provided evidence of the suggested reprising of credit risk during the sovereign debt crisis. Prior to the crisis the CDS spreads for the indebted countries were mainly affected by local stock market return. The debt crisis has created a significant pricing change for the distressed countries, where the model helps to explain variations in the CDS spreads to a satisfactory level. The pricing change is mainly related to increased contagion effects and the evolution of a country's own credit rating. The French and German CDS spreads are primarily affected by local stock market return in both periods, where no spillover effects are found.

Studying the underlying bond reveals significant pricing differences of sovereign risk between the two markets. The bond spread in Germany and France remains relatively unexplained by the variables in the model, while in the distressed counties the country's own credit rating dominate the pricing of government debt. The study finds the CDS spread to be a better proxy for measuring a country's default probability than the spread on the underlying bond.

A cointegration relationship is found for a number of the nations in the period prior to the debt crisis, where the CDS market dominates pricing discoveries in half of the tested sample. During the crisis period no long-run relationship between the two markets is detected. However, the debt crisis has not significantly changed the relationship between the two markets in terms of assessing the causality as the causality direction is similar to that found in the prior crisis period.

The analysis suggests that the traditional measures of sovereign default risk are not sufficient to measure the relative default risk of a country. The ground-breaking structural mode introduced by Merton in 1974 is no longer sufficient for pricing sovereign default risk, as other measures has proven influential in explaining credit risk spreads. Following a booming globalization of the financial market, country border are no longer an obstacle for the financial market opening up for an endless security market. Increased global financial markets have introduced exposers to new risk measures. Contagion risk, global risk aversion and equity market return have become increasingly important determinants in assessing the sovereign risk of a country.

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Appendix 1 Data description

Seasonality adjustments

X11 method seasonally adjusts monthly or quarterly data. The procedure makes additive or multiplicative adjustments and creates an output data set containing the adjusted time series and intermediate calculations.[230] It is obtainable using SAS. For robustness check of the seasonality procedure the seasonally adjusted variable is compared to a yearly seasonally adjusted variable and the similar behaviour is satisfactory.

Political risk variable

The data from Heritage foundation economic freedom index is presented in a scale from 0-100, while the world competiveness online provides data in a scale from 0-10. The data are standardized to give the same unit of measure. Standardized variables are obtain from the following formula:

$$Y_i = \frac{Y_i - \bar{Y}}{S_Y}$$

Where $\bar{Y}$=sample mean of Y, S_Y= sample standard deviation of Y.[231] The new unit of measure lies between -2,5 and +2,5 where a higher a score indicate a lower political risk in the country. The various index measures are available on a yearly basis. The interpolation method is applied. The procedure for compressing the data is carried out using a specified code in SAS.

[230] SAS/ETS (R) 9.2 User's guide. Getting Started: X11 Procedure.
[231] Gujarati and Porter, 2009

Table 1 Credit ratings

Credit rating by S&P from March 2003- January 2012

Country	Date	Rating	Country	Date	Rating
Germany			Italy		
	17.08.1983	AAA		13.01.2012	BBB+
France				12.05.2011	A
	13.01.2012	AA+		19.09.2011	A
	25.06.1975	AAA		20.05.2011	A+
Greece				19.10.2006	A+
	13.01.2012	CC		11.01.2005	AA-
	27.07.2011	CC		08.08.2005	AA-
	13.06.2011	CCC		07.07.2004	AA-
	05.09.2011	B		15.01.2003	AA
	29.03.2011	BB-		05.06.1998	AA
	12.02.2010	BB+		05.03.1996	AAA
	27.04.2010	BB+	Portugal		
	16.03.2010	BBB+		13.01.2012	BB
	16.12.2009	BBB+		12.05.2011	BBB-
	12.07.2009	A-		29.03.2011	BBB-
	14.01.2009	A-		24.03.2011	BBB
	01.09.2009	A		30.11.2010	A-
	11.01.2005	A		27.04.2010	A-
	17.11.2004	A		12.07.2009	A+
	13.09.2004	A+		21.01.2009	A+
	06.10.2003	A+		13.01.2009	AA-
	13.03.2001	A		11.01.2005	AA-
Ireland				27.06.2005	AA-
04.01.2011	13.01.2012	BBB+		29.10.2004	AA
	12.05.2011	BBB+		15.12.1998	AA
	04.01.2011	BBB+	Spain		
	02.02.2011	A-		13.01.2012	A
	23.11.2010	A		12.05.2011	AA-
	24.08.2010	AA-		13.10.2011	AA-
	06.08.2009	AA		28.04.2011	AA
	30.03.2009	AA+		12.09.2009	AA+
	01.09.2009	AAA		19.01.2009	AA+
	11.01.2005	AAA		01.12.2009	AAA
	10.03.2001	AAA		11.01.2005	AAA
	10.03.2000	AA+		13.12.2004	AAA
				30.07.2003	AA+
				31.03.1999	AA+

Appendix 2 Stationarity testing

Table 2 Breusch-Godfrey test

The results from the Breusch Godfrey test where the LM-value at four autoregressive lags are reported, LM value < AR(4) are found to be smaller than the critical value. The critical value at AR(4) at 5% significance level is 9.48773.

(1) The number of lags necessary to remove autocorrelation such that AR(4) > critical
(2) Reports the LM-test value at AR(4)

	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Variable	**Italy**		**Portugal**		**Spain**		**Greece**	
CDS	1	9.0639	1	1.1592	1	9.2495	0	5.9312
Bond	0	6.3926	9	9.6169*	1	9.0278	0	4.5905
ldebt	6	5.3508	7	7.7729	7	7.7729	7	2.3312
lMSCI	5	1.7770	4	5.6482	4	5.6482	1	7.7367
lCPI	0	7.8832	0	2.7037	0	2.7038	5	3.1242
lprivatedebt	7	2.8055	7	3.8830	7	3.8830	6	5.8533
Politicalrisk	3	7,8959	7	9.48275	7		2	7.7880
CA	7	9.0942	8		9	5.2546	7	7.0517
Gov bal	7	4.4202	7	5.6501	7	5.6501	5	7.0928
Liq	0	3.1412	1	0.8852	0	4.8098	0	0.4976
Credit rating	0	0.2172	0	4.0191	0	1.0687	0	6.4661
	France		**Germany**		**Ireland**			
CDS	0	2.5241	0	0.2786	0	3.5067		
Bond	1	7.6400	0	4.0152				
ldebt	7	3.9914	7	2.1530	4	5.3544		
lMSCI	5	8.7057	2	9.0481	0	3.2513		
lCPI	1	9.6958	1	10.4272	2	10.6807**		
lprivate debt	7	5.3608	7	0.4769	7	8.3302		
Political risk	7	10.2148**	3	12.2516**	9	13.0857**		
CA	7	4.8974	0	6.5031	5	8.6550		
Gov bal	7	8.1814	9	8.8385	4	10.0694**		
Liq	2	4.4700	0	5.6193	0	3.8913		
Credit rating					0	1.6438		
lVOL	0	1.8742						
lS&P500	0	7.5112						
R_f	1	8.6740						

**significant at 1%

Table 3 Augmented dickey fuller unit root test statistic

The tau statistic with the correct lag length is reported for the variables in level form.

(1) reports the variable tested for stationary
(2) reports the type, either zero mean, single mean or trend
(3) The Tau statistic of interest following lags necessary to remove autocorrelation found in table 1 and type reported in (2)
(4) Critical value at 5% significance level following type denoted in (2)
(5) Test conclusion

(1)	(2)	(3) Italy	(3) Portugal	(3) Spain	(3) Greece	(3) France	(3) Germany	(3) Ireland	(4)	(5)
CDS	Single mean	0.03	4.54**	0.06	1.09	0.25	1.34	0.36	2.89	Nonstationary
Bond	Single mean	1.75	6.06**	0.79	1.05	2.70	1.61		2.89	Nonstationary
ldebt/gdp	Singe mean	1.48	0.84	0.84	2.34	0.2	0.04	2.96	2.89	Nonstationary
lMSCI	Single mean	1.44	1.95	1.95	0.97	2	2.45	2.49	2.89	Nonstationary
lCPI	Single mean	1.07	0.38	1.52	0.22	0.6	0.09	1.52	2.89	Nonstationary
lprivate debt	Single mean	1.40	0.91	0.91	2.21	1.45	1.68	2.04	2,89	Nonstationary
Political risk	Single mean	1.13	2.33	2.23	0.26	2.40	1.94	0.93	2.89	Nonstationary
CA	Single mean	1.21	0.79		1.53	0.36	3.40	1.45	2,89	Nonstationary*
Gov bal	Single mean	1.72	1.58	1.58	1.43	1.42	2.56	1.11	2,89	Nonstationary
Credit rating	Single mean	1.56	1.75	1.48	2.75		3.40	1.15	2.89	Nonstationary
Liquidity	Single mean	1.58	3.23	3.34	2.53	2.67	7.23	5.92	2.89	Nonstationary
lVOL	Single mean	3.04							2.89	Nonstationary
lS&P500	Single mean	1.49							2.89	Nonstationary*
R_f	Single mean	0.99							2.89	Nonstationary

**stationary

Table 4 Augmented dickey fuller unit root test statistics

The tau statistic with the correct lag length is reported for the variables in differenced form.

(1)	(2)	(3) Italy	(3) Portugal	(3) Spain	(3) Greece	(3) France	(3) Germany	(3) Ireland	(4)	(5)
ΔCDS	Zero mean	8.25	10.67	11.59	11.84	10.18	10.49	10.60	1.95	Stationary
Δbond	Zero mean	9.73	10.90	13.06	11.84	13.96	12.54		1.95	Stationary
Δldebt	Single mean	1.80* (zero mean)	3.28	2.29*	2.86	1.86*	3.02	8.53	2.89	Stationary
ΔlMSCI	Zero mean	2.80	2.89	2.89	8.03	3.42	9.12	5.88	1.95	Stationarity
ΔlCPI	Single mean	7.75	9.07	9.07	3.30	3.93	8.13	3.96	2.89	Stationary
Δlprivate	Single mean	3.16	1.80*	1.80*	2.89	3.36	3.06	2.99	2.89	Stationary
ΔPolitical risk	Zero mean	5.63	2.20	2.20	7.38	4.09	3.24	1.99	1.95	Stationary
ΔCA	Zero mean	4.43	2.78	2.78	3.03	2.38	6.82	3.00	1.95	Stationary
ΔGov bal	Zero mean	4.91	5.24	5.24	4.33	3.56	2.11	6.31	1.95	Stationary
ΔLiq	Zero mean	9.76	10.07	12.76	10.21	11.79	16.53	8.36	1.95	Stationary
Δrating	Zero mean	9.27	6.35	6.75	7.32	3.57		5.74	1.95	Stationary
ΔlVOL	Zero mean	10.18							1.95	Stationary
ΔlS&P500	Zero mean	8.81							1.95	Stationary
ΔR_f	Zero mean	8.02							1.95	Stationary

*Result based on the ACF/PACF graph

Appendix 3 Cointegration testing

Table 5 ADF test prior crisis and crisis period.

Tau > critical value, series is stationary and not tested for cointegration.

	Tau CDS	**Tau Bond**	**Critical value**
France			
Prior crisis	0.79	1.11	2.89
Crisis	1.82	2.27	2.89
Germany			
Prior crisis	2.12	0.81	2.89
Crisis	2.21	1.51	2.89
Greece			
Prior crisis	0.62	3.27*	2.89
Crisis	0.07	0.29	2.89
Italy			
Prior crisis	0.16	3.50	2.89
Portugal			
Prior crisis	0.89	2.36	2.89
Crisis	1.74	3.50**	2.89
Spain			
Prior crisis	1.05	2.16	2.89
Crisis	0.90	1.30	2.89

*borderline nonstationary
**stationary

Table 6 Johansen cointegration test

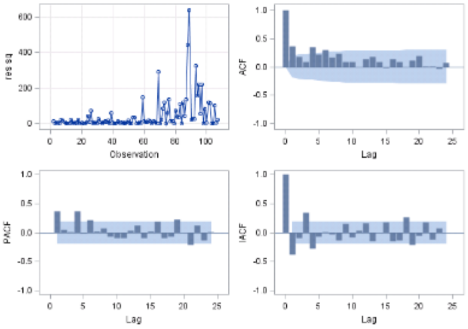
	H_0: rank =r	H_1: rank > r	Trace	5% critical value	Conclusion
France					
	0	0	27.3062	19.99	Reject H_0
	1	1	1.3682	9.13	Cannot reject H_0
Prior crisis	0	0	28.5075	19.99	Reject H_0
	1	1	0.9147	19.13	Cannot reject H_0
Crisis period	0	0	16.6883	19.99	Cannot reject H_0
	1	1	2.1296	9.13	
Germany					
	0	0	26.6099	19.99	Reject H_0
	1	1	2.4210	9.13	Cannot reject H_0
Prior crisis	0	0	32.7464	19.99	Reject H_0
	1	1	2.6237	19.13	Cannot reject H_0
Crisis period	0	0	17.4232	19.99	Cannot reject H_0
	1	1	3.2457	9.13	
Greece					
	0	0		19.99	Cannot reject H_0
	1	1		9.13	
Prior crisis	0	0	22.0133	19.99	Reject H_0
	1	1	1.4226	19.13	Cannot reject H_0
Crisis period	0	0	16.85	19.99	Cannot reject H_0
	1	1	2.37	9.13	
Italy					
	0	0	18.5083	19.99	Cannot reject H_0
	1	1	2.26556	9.13	
Prior crisis	0	0	21.6182	19.99	Reject H_0
	1	1	1.6743	19.13	Cannot reject H_0
Portugal *					
Prior crisis	0	0	14.1440	19.99	Cannot reject H_0
	1	1	1.9598	9.13	
Spain					
	0	0	14.4500	19.99	Cannot reject H_0
	1	1	1.9737	9.13	
Prior crisis	0	0	23.3406	19.99	Reject H_0
	1	1	1.9561	19.13	Cannot reject H_0
Crisis period	0	0	11.7655	19.99	Cannot reject H_0
	1	1	2.7372	9.13	

*no cointegration test is carried out for Portugal whole period and Portugal crisis period, as the series does not contain a unit root.

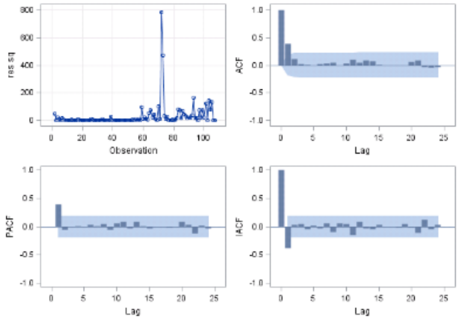
Appendix 4 Classical linear regression model

Figure 7 PACF correlogram of squared residuals

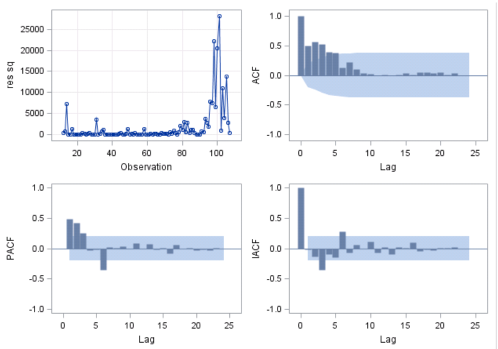
France



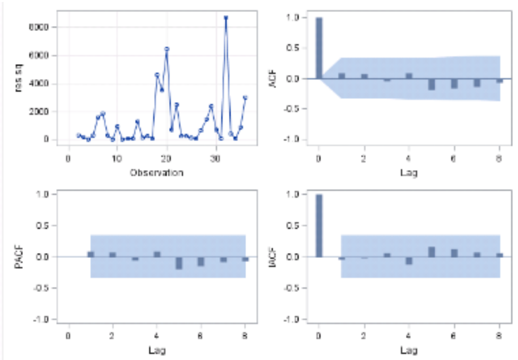
Germany



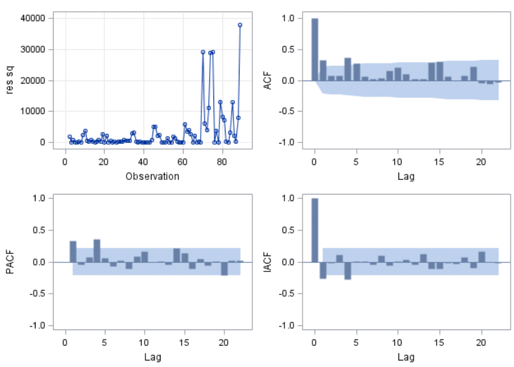
Greece



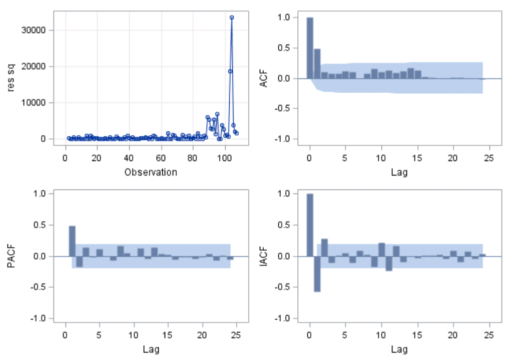
Ireland



Italy



Portugal



Spain

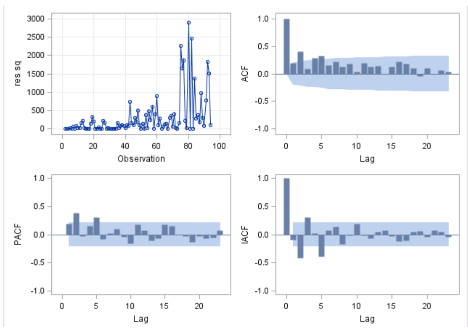


Table 8 Engel's ARCH test-statistics

Heteroscedasticity present if LM test value is greater than critical value.

France

Tests for ARCH Disturbances Based on OLS Residuals				
Order	Q	Pr > Q	LM	Pr > LM
1	15.0396	0.0001	14.7195	0.0001
2	18.6480	<.0001	14.9737	0.0006
3	19.5052	0.0002	14.9802	0.0018
4	33.8546	<.0001	27.6786	<.0001
5	39.5636	<.0001	27.7148	<.0001
6	49.9089	<.0001	31.4778	<.0001
7	53.2672	<.0001	31.5239	<.0001
8	59.8777	<.0001	31.8604	<.0001
9	60.7732	<.0001	32.1581	0.0002
10	61.6041	<.0001	32.8131	0.0003
11	61.6136	<.0001	33.5247	0.0004
12	63.9664	<.0001	33.7911	0.0007

Germany

Tests for ARCH Disturbances Based on OLS Residuals				
Order	Q	Pr > Q	LM	Pr > LM
1	17.1255	<.0001	16.5943	<.0001
2	18.4215	<.0001	16.8799	0.0002
3	18.4804	0.0004	16.8801	0.0007
4	18.4952	0.0010	16.8907	0.0020
5	18.4953	0.0024	16.8981	0.0047
6	18.5425	0.0050	16.9869	0.0093
7	18.6393	0.0094	17.0025	0.0174
8	18.9715	0.0150	17.2034	0.0281
9	18.9751	0.0254	17.4455	0.0422
10	19.1299	0.0386	17.9587	0.0557
11	20.3440	0.0408	18.5021	0.0706
12	20.6732	0.0554	18.5344	0.1004

Greece

Tests for ARCH Disturbances Based on OLS Residuals				
Order	Q	Pr > Q	LM	Pr > LM
1	23.8496	<.0001	23.2191	<.0001
2	54.9110	<.0001	35.8980	<.0001
3	82.8712	<.0001	40.1572	<.0001
4	98.9240	<.0001	40.2259	<.0001
5	114.0039	<.0001	40.2274	<.0001
6	115.5881	<.0001	49.8145	<.0001
7	120.5286	<.0001	56.3711	<.0001
8	121.5053	<.0001	57.2987	<.0001
9	121.6217	<.0001	57.3064	<.0001
10	121.6534	<.0001	57.3195	<.0001
11	121.6538	<.0001	57.3224	<.0001
12	121.6749	<.0001	57.6669	<.0001

Italy

Tests for ARCH Disturbances Based on OLS Residuals				
Order	Q	Pr > Q	LM	Pr > LM
1	0.2528	0.6151	0.2909	0.5897
2	0.4657	0.7923	0.5382	0.7641
3	0.5448	0.9089	0.5749	0.9021
4	0.8351	0.9337	1.0577	0.9009
5	2.3695	0.7960	3.0336	0.6948
6	3.4910	0.7452	3.5053	0.7433
7	4.3242	0.7418	3.5270	0.8324
8	4.5537	0.8040	3.5456	0.8956
9	4.7101	0.8588	3.5669	0.9375
10	4.9397	0.8952	5.2153	0.8763
11	5.2572	0.9181	6.0612	0.8693
12	9.6365	0.6478	17.3347	0.1374

Italy

Tests for ARCH Disturbances Based on OLS Residuals				
Order	Q	Pr > Q	LM	Pr > LM
1	10.0006	0.0016	13.9057	0.0002
2	10.4934	0.0053	14.4695	0.0007
3	11.0159	0.0116	15.0322	0.0018
4	23.4864	0.0001	29.9865	<.0001
5	30.8164	<.0001	30.0226	<.0001
6	31.1708	<.0001	31.4842	<.0001
7	31.2155	<.0001	31.9853	<.0001
8	31.3211	0.0001	33.5802	<.0001
9	33.8465	<.0001	34.1616	<.0001
10	37.9806	<.0001	37.9676	<.0001
11	39.0649	<.0001	37.9860	<.0001
12	39.0957	0.0001	38.0227	0.0002

Portugal

Tests for ARCH Disturbances Based on OLS Residuals				
Order	Q	Pr > Q	LM	Pr > LM
1	32.5829	<.0001	31.8344	<.0001
2	34.1263	<.0001	36.8016	<.0001
3	35.2384	<.0001	41.4785	<.0001
4	36.3780	<.0001	41.5795	<.0001
5	38.3890	<.0001	51.8791	<.0001
6	40.0871	<.0001	51.9766	<.0001
7	40.0914	<.0001	59.0894	<.0001
8	40.9241	<.0001	68.8765	<.0001
9	42.7312	<.0001	69.1010	<.0001
10	44.0484	<.0001	70.0657	<.0001
11	45.8048	<.0001	72.2721	<.0001
12	46.9905	<.0001	72.2820	<.0001

Spain

Tests for ARCH Disturbances Based on OLS Residuals				
Order	Q	Pr > Q	LM	Pr > LM
1	3.4673	0.0626	3.4681	0.0626
2	19.1871	<.0001	17.3325	0.0002
3	20.0511	0.0002	17.3331	0.0006
4	28.0775	<.0001	19.2958	0.0007
5	38.4717	<.0001	28.0016	<.0001
6	40.8842	<.0001	28.2561	<.0001
7	46.1263	<.0001	28.2564	0.0002
8	47.9589	<.0001	29.0176	0.0003
9	51.1515	<.0001	29.0732	0.0006
10	51.2763	<.0001	31.8781	0.0004
11	55.2143	<.0001	34.0914	0.0003
12	56.9759	<.0001	35.5076	0.0004

Table 9 Breusch-Godfrey test statistic

Autocorrelation is present if LM> critical value. Critical value at 5% significance AR(1)= 3.84146, AR(2)= 5.99147, AR(3) = 7.81473, AR(4)= 9.48773[232]

France

Godfrey's Serial Correlation Test		
Alternative	LM	Pr > LM
AR(1)	4.2233	0.0399
AR(2)	4.4348	0.1089
AR(3)	4.7927	0.1876
AR(4)	10.1429	0.0381

Germany

Godfrey's Serial Correlation Test		
Alternative	LM	Pr > LM
AR(1)	6.5407	0.0105
AR(2)	9.3216	0.0095
AR(3)	9.3868	0.0246
AR(4)	10.9430	0.0272

Greece

Godfrey's Serial Correlation Test		
Alternative	LM	Pr > LM
AR(1)	26.7283	<.0001
AR(2)	28.1155	<.0001
AR(3)	35.9779	<.0001
AR(4)	36.0807	<.0001

Ireland

Godfrey's Serial Correlation Test		
Alternative	LM	Pr > LM
AR(1)	1.3977	0.2371
AR(2)	1.6757	0.4327
AR(3)	1.9359	0.5858
AR(4)	2.0397	0.7285

Italy

Godfrey's Serial Correlation Test		
Alternative	LM	Pr > LM
AR(1)	5.8656	0.0154
AR(2)	6.4981	0.0388
AR(3)	8.2192	0.0417
AR(4)	11.6279	0.0203

Portugal

Godfrey's Serial Correlation Test		
Alternative	LM	Pr > LM
AR(1)	18.9403	<.0001
AR(2)	18.9421	<.0001
AR(3)	18.9869	0.0003
AR(4)	21.3420	0.0003

Spain

Godfrey's Serial Correlation Test		
Alternative	LM	Pr > LM
AR(1)	35.3758	<.0001
AR(2)	36.5488	<.0001
AR(3)	36.5531	<.0001
AR(4)	39.3249	<.0001

Multicolliniearity table 10-16

(1) Dependent variable
(2) Reports the Variance of inflation values
(3) Reports the R^2 from the auxiliary regression with dependent variable denoted in (1)
(4) Reports the variance of inflation values after removal of variables
(5) Reports the R^2 from auxiliary regression after removal of variables
(6) Reports the Condition Index
(7) Reports the Condition index after removal
(8) Period to be tested for variables removal
(9) The tested variable for removal which is based on VIF, CI, Auxiliary regressions and correlation matrixes
(10) Wald test statistic
(11) Significance value, Pr<0.05, reject H_0
(12) Test conclusion, H_0: variable is not significantly different from zero, H_A: Variable is significantly different from zero.

[232] Gujarat and Porter, 2008, page 887

Table 10 France

(1)	(2)	(3)	(4)	(5)		(6)	(7)
Variable	VIF	Auxiliary regression	VIF	Auxiliary regression		**CI**	**CI removal**
R^2		35%					
Δdebt	1.50597	33%	1.46092	31%	Whole period	4.2666	4.22757
ΔlMSCI	4.31594	76%	1.55015	35%	Prior crisis	5.16865	5.03601
ΔlCPI	1.37293	27%	1.35642	26%	crisis	4.42666	4.22757
Δlprivate debt	1.47102	32%	1.46249	31%			
Δpolitical	1.42929	30%	1.41654	29%			
Δca	1.29082	22%	1.28766	22%			
Δgov bal	1.37713	27%	1.35669	26%			
Δliq	1.13700	12%	1.08882	8%			
ΔlS&P500	2.37242	57%		%			
Δr_f	1.54870	35%	1.54749	35%			
Δlvol	2.22575	55%		%			
ΔGreece	1.13498	12%	1.11416	10%			
ECT	1.43777	30%	1.31743	24%			
Prior crisis							
R^2		53.67%					
Δdebt	1.60604	37%	1.54979	35%			
ΔlMSCI	4.35813	77%	1.66343	39%			
ΔlCPI	1.63731	39%	1.47260	32%			
Δlprivate debt	1.59923	37%	1.55952	35%			
Δpolitical	1.80315	44%	1.72547	42%			
Δca	1.30811	23%	1.30501	23%			
Δgov bal	1.21777	18%	1.20067	16%			
Δliq	1.17875	15%	1.14825	12%			
ΔlS&P500	3.75903	73%					
Δr_f	1.36823	27%	1.35920	26%			
Δlvol	2.18303	54%					
ΔGreece	1.2864	11%	1.04954	4%			
ECT	1.54586	35%	1.54455	35%			
Crisis period							
R^2		**60.33%**					
Δdebt	1.50597	61%	1.46092	46%			
ΔlMSCI	4.31594	82%	1.55015	38%			
ΔlCPI	1.37293	72%	1.35642	47%			
Δlprivate debt	1.47102	47%	1.46249	40%			
Δpolitical	1.42929	39%	1.41654	28%			
Δca	1.29082	48%	1.28766	40%			
Δgov bal	1.37713	58%	1.35669	48%			
Δliq	1.13700	51%	1.08882	27%			
ΔlS&P500	2.37242	76%					
Δr_f	1.54870	59%	1.54749	50%			
Δlvol	2.22575	66%					
ΔGreece	1.13498	30%	1.11416	20%			

(8) Wald test statistic	(9) Test	(10) Statistic	(11) Pr>ChiSq	(12) Test conclusion
Whole period	ΔlVOL	0.85	0.3577	Removed
	ΔlS&P500	5.93	0.0149	Cannot be removed *removed due to high multicolliniearity
Prior crisis period	ΔlS&P500	0.46	0.4982	Removed
	ΔlVOL	0.90	0.3439	removed
Crisis period	ΔlVOL	0.85	0.3577	Removed
	ΔlS&P500	5.93	0.0149	Cannot be removed *removed due to high correlation

Table 11 Germany

(1) **Variable**	(2) VIF	(3) Auxiliary regression	(4) VIF	(5) Auxiliary regression		(6) **CI**	(7) **CI removal**
R^2		35%					
Δdebt	2.11198	53%	2.08485	18%	Whole period	4.40672	4.15757
ΔlMSCI	3.52924	71%	1.61725	37%	Prior crisis	5.98595	5.49430
ΔlCPI	1.26042	20%	1.23978	16%	Crisis period	4.40672	3.9802
Δlprivate debt	1.59792	32%	1.57588	32%			
Δpolitical	1.47536	37%	1.44706	27%			
Δca	1.26904	21%	1.25968	16%			
Δgov bal	1.95778	49%	1.88909	49%			
Δliq	1.13012	11%	1.06098	6%			
ΔlS&P500	2.42232	58%					
Δr_f	1.60262	37%	1.57950	36%			
Δlvol	1.76998	43%					
ΔGreece	1.1754	11%	1.16413	7%			
ECT	1.25482	20%	1.21281	16%			
Prior crisis							
R^2		80%					
Δdebt	1.49909	35%	1.49830	33%			
ΔlMSCI	3.55052	72%	2.39062	58%			
ΔlCPI	1.31938	24%	1.28291	22%			
Δlprivate debt	1.72366	42%	1.71500	42%			
Δpolitical	1.74768	42%	1.74614	42%			
Δca	1.67338	42%	1.66865	40%			
Δgov bal	1.46413	33%	1.43186	30%			
Δliq	1.26645	31%	1.25387	20%			
ΔlS&P500	2.80194	64%	.	%			
Δr_f	1.53834	39%	1.53737	35%			
Δlvol	2.02910	81%	1.91718	47%			
ΔGreece	1.17425	75%	1.15646	13%			
ECT	1.60228	38%	1.60114	37%			
Crisis period							
R^2		**45.44%**					
Δdebt	2.91068	65%	1.22121	18%			
ΔlMSCI	3.52859	72%	1.52181	34%			
ΔlCPI	1.48971	32%	1.34138	19%			

Δlprivate debt	2.94104	66%	1.36544	42%
Δpolitical	2.47167	60%		
Δca	1.61041	37%	1.15669	42%
Δgov bal	2.81088	64%		
Δliq	1.16678	14%	1.04669	13%
ΔlS&P500	2.46158	60%		
Δr_f	2.08526	52%	1.8710	48%
Δlvol	2.32255	60%		
ΔGreece	1.35239	26%	1.08405	10%

(8) Wald test statistic	**(9) Test**	**(10) Statistic**	**(11) Pr>ChiSq**	**(12) Test conclusion**
Whole period	ΔlMSCI	4.69	0.0302	Cannot be removed
	ΔlS&P500	0.01	0.9140	Remove
	ΔLVOL	0.03	0.8517	Removed
Prior crisis period	ΔlS&P500	0.99	0.3241	Removed
	ΔlVOL	5.93	0.0149	Cannot be removed *removed due to high correlation
Crisis period	ΔlS&P500	1.22	0.2702	Removed
	ΔlVOL	0.12	0.7525	Removed
	Δgovbal	0.07	0.7934	Removed
	Δpolitical	0.14	0.7116	Removed

Table 12 Greece

(1) Variable	**(2)** VIF	**(3)** Auxiliary regression	**(4)** VIF	**(5)** Auxiliary regression		(6) **CI**	(7) **CI removal**
R^2		50%					
Δdebt	1.2928	22%	1.27048	21%	Whole period	4.43301	4.3301
ΔlMSCI	1.9801	49%	1.63870	38%	Prior crisis	8.67799	2.98824
ΔlCPI	1.1848	16%	1.18347	16%	Crisis period	9.78592	6.60428
Δlprivate debt	1.3951	28%	1.39008	26%			
Δpolitical	1.3769	27%	1.28117	21%			
Δca	1.3999	27%	1.32874	24%			
Δgov bal	1.15167	14%	1.08324	7%			
Δliq	1.17001	14%	1.14002	12%			
Δrating	1.09856	8%	1.09420	8%			
ΔlS&P500	1.95752	49%					
Δr_f	1.36876	26%	1.33031	24%			
Δlvol	1.53990	35%	1.42466	29%			
Prior crisis							
R^2		38.87%					
Δdebt	3.26821	73%	1.28981	22%			
ΔlMSCI	3.02990	67%	1.89212	47%			
ΔlCPI	1.18235	15%	1.11946	10%			
Δlprivate debt	3.50871	75%					
Δpolitical	3.54946	71%					

Δca	1.89976	52%	1.17856	15%
Δgov bal	2.25506	60%	1.35304	26%
Δliq	1.15930	14%	1.13257	11%
Δrating		30%	1.15552	13%
ΔlS&P500	2.73187	64%		
Δr_f	1.25913	21%	1.25044	20%
Δlvol	1.87921	42%	1.63778	38%
ECT	3.33238	50%	1.35304	11%%
Crisis period				
		62.52%		
Δdebt	4.14373	75%	1.20790	17%
ΔlMSCI	2.09013	52%	1.58793	37%
ΔlCPI	2.13129	53%	1.37778	27%
Δlprivate debt	4.33194	76%		
Δpolitical	6.36687	85%		
Δca	3.38209	70%	1.15066	13%
Δgov bal	1.54760	35%	1.15990	13%
Δliq	2.50526	60%	1.19714	16%
Δrating	1.35729	26%	1.25741	20%
ΔlS&P500	2.42497	58%		
Δr_f	1.98307	49%	1.46257	31%
Δlvol	1.62741	38%	1.37676	27%

(8)	**(9)**	**(10)**	**(11)**	**(12)**
Wald test statistic	Test	Statistic	Pr>ChiSq	Test conclusion
Whole period	ΔS&P500 = 0	1.45	0.2280	Remove
Prior crisis	ΔlogS&P500 = 0	2.07	0.1502	Remove
	Δlogprivate = 0	0.00	0.9773	Remove
	Δlogpolitical = 0	8.13	0.0044	Cannot be removed, necessary to remove due to high correlation
Crisis period	Δlogpolitical = 0	0.66	0.4152	Remove
	Δlogprivate = 0	0.04	0.8372	Remove
	ΔlogS&P50 = 0	0.07	0.7892	Remove

Table 13 Ireland

(1) **Variable**	**(2)** VIF	**(3)** Auxiliary regression	**(4)** VIF	**(5)** Auxiliary regression	(6) **CI**	(7) **CI removal**
R^2		55.38%				
Δldebt	2.61631	61%	1.55535	35%	7.21894	3.99648
ΔlMSCI	3.17564	68%	1.67337	40%		
ΔlCPI	3.04213	67%	1.96891	49%		
Δlprivate debt	2.02312	50%	1.84936	45%		
Δpolitical	2.62546	61%				
Δca	3.03269	67%				
Δgov bal	1.80305	44%	1.47669	32%		
Δliq	2.22820	55%	1.81515	44%		

Δrating	1.68952	40%	1.36831	26%
ΔlS&P500	3.19467	68%		
Δr_f	1.90888	47%	1.27993	21%
Δlvol	2.67477	62%	2.22713	55%
ΔGreece	1.99171	49%	1.73311	42%

Wald test statistic	**(10)**	**(11)**	**(12)**
(9)	Statistic	Pr>ChiSq	Test conclusion
ΔlS&P500	3.03	0.0817	Removed
Δpolitical	0.54	0.4614	Removed
ΔCA	0.25	0.6151	Removed

Table 14 **Italy**

(1)	**(2)**	**(3)**	**(4)**	**(5)**		(6)	(7)
Variable	VIF	Auxiliary regression	VIF	Auxiliary regression		**CI**	**CI removal**
R^2		41.20%					
Δdebt	19.48748	94%	1.26617	21%	Whole period	12.50302	2.20483
ΔlMSCI	1.34053	25%	1.31018	23%	Prior crisis	18.27536	2.91993
Δlprivate debt	3.96061	75%					
Δpolitical	3.40447	71%					
Δca	4.36337	77%	1.24271	19%			
Δgov bal	20.25035	95%					
Δliq	1.23667	19%	1.22394	9%			
Δrating	1.12236	10%	1.09908	12%			
ΔlS&P500	1.53359	35%	1.45325	31%			
Δr_f	1.38418	27%	1.32499	24%			
Δlvol	1.47996	32%	1.38717	27%			
ΔGreece	1.15306	13%	1.09908	9%			
Prior crisis							
R^2		44.89%					
Δdebt	33.27838	97%	2.14824	54%			
ΔlMSCI	1.42786.	30%	1.41699	29%			
ΔlCPI	1.34028.	25%	1.29123	22%			
Δlprivate debt	5.52242	82%					
Δpolitical	4.65754	78%					
Δca	6.77985	85%	1.82656	46%			
Δgov bal	39.52544	97%					
Δliq	1.924224	30%	1.49935	34%			
Δrating	1.21812	18%	1.16592	15%			
ΔlS&P500	1.96796	49%	1.83400	46%			
Δr_f	1.24167	19%	1.17494	15%			
Δlvol	1.94224	48%	1.81685	44%			
ΔGreece	1.43187	13%	1.3032	24%			

Table 15 Portugal

(8) Wald test statistic	(9) Test	(10) Statistic	(11) Pr>ChiSq	(12) Test conclusion
Whole period	Δgov bal	1.73	0.1889	Removed
	Δpolitical	1.28	0.2576	Removed
	Δlprivate	0.16	0.6854	Removed
Prior crisis period				
	Δgov bal	0.44	0.5048	Removed
	Δpolitical	1.54	0.2152	Removed
	Δlprivate	0.00	0.9539	Removed

(1) Variable	(2) VIF	(3) Auxiliary regression	(4) VIF	(5) Auxiliary regression		(6) CI	(7) CI removal
R^2		**47.19%**					
Δdebt	1.51865	35%			Whole period	4.16596	
ΔlMSCI	1.53546	37%			Prior crisis	4.41444	4.36627
ΔlCPI	1.22698	20%			Crisis period	5.33696	5.27711
Δlprivate debt	1.29755	31%					
Δpolitical	1.13372	11%					
Δca	1.38643	27%					
Δgov bal	1.61374	38%					
Δliq	1.13399	11%					
Δrating	1.51214	33%					
ΔlS&P500	1.64124	39%					
ΔR_f	1.32135	24%					
Δlvol	1.62316	38%					
ΔGreece	1.55131	35%					
Prior crisis							
R^2		38.50%					
Δdebt	1.42839	29%	1.31960	24%			
ΔlMSCI	1.50470	33%	1.49502	33%			
ΔlCPI	1.10863	9%	1.10624	9%			
Δlprivate debt	1.39437	28%	1.39430	28%			
Δpolitical	1.25052	20%	1.22266	18%			
Δca	1.16762	14%	1.16639	14%			
Δgov bal	1.44574	30%	1.41791	29%			
Δliq	1.22188	18%	1.21722	17%			
Δrating	1.14491	12					
ΔlS&P500	2.25242	55%	2.24755	55%			
ΔR_f	1.34313	25%	1.29893	23%			
Δlvol	1.95174	48%	1.91714	47%			
ΔGreece	1.33376	25%	1.32007	24%			
Crisis period							
R^2		**62.50%**					
Δdebt	2.00522	50%	1.87390	46%			
ΔlMSCI	2.08491	52%	1.84446	51%			
ΔlCPI	1.85519	46%	2.07305	45%			
Δlprivate debt	1.70539	41%	1.57389	36%			
Δpolitical	1.64862	39%	1.59607	37%			

Δca	3.63031	72%	1.68283	40%
Δgov bal	3.60892	72%	.	
Δliq	1.45501	31%	1.44063	30%
Δrating	1.91064	47%	1.90025	47%
ΔlS&P500	1.89969	47%	1.89862	46%
ΔR_f	1.77785	43%	1.60706	37%
Δlvol	2.14895	54%	2.12425	52%
ΔGreece	1.97572	49%	1.97126	49%

(8) Wald test statistic	(9) Test	(10) Statistic	(11) Pr>ChiSq	(12) Test conclusion
Prior crisis period	Δrating			Removed due to approximately no variation
Crisis period	Δgovbal = 0	1.78	0.1805	Remove

Table 16 Spain

(1) Variable	(2) VIF	(3) Auxiliary regression	(4) VIF	(5) Auxiliary regression		(6) CI	(7) CI removal
R^2		**53.87%**					
Δdebt	1.65594	39%	1.65502	39%	Whole period	4.75919	3.93720
ΔlMSCI	2.03849	50%	2.00443	50%	Prior crisis period	8.9801	7.64647
ΔlCPI	1.40501	28%	1.35492	26%	Crisis period	9.80134	2.83363
Δlprivate debt	2.86948	65%	1.74475	42%			
Δpolitical	2.22384	55%		%			
Δca	1.18413	15%	1.17668	15%			
Δgov bal	1.33034	24%	1.32941	24%			
Δliq	1.26169	14%	1.25089	20%			
Δrating	1.19052	16%	1.17556	36%			
ΔlS&P500	1.59575	37%	1.58656	23%			
ΔR_f	1.31990	24%	1.30918	44%			
Δlvol	1.82969	45%	1.79492	28%			
ΔGreece	1.40235	28%	1.39873	15%			
Prior crisis							
R^2		63.84%					
Δdebt	2.62602	61%	1.91327	54%			
ΔlMSCI	2.39001	58%	2.23670	55%			
ΔlCPI	1.31247	24%	1.19835	20%			
Δlprivate debt	2.11852	52%	1.87537	52%			
Δpolitical	2.13433	54%	1.91702	47%			
Δca	1.65505	37%	1.15572	32%			
Δgov bal	2.23466	55%	.				
Δliq	1.28559	22%	1.17069	14%			
Δrating	1.29331	14%	.				
ΔlS&P500	2.81709	64%	2.10910	52%			

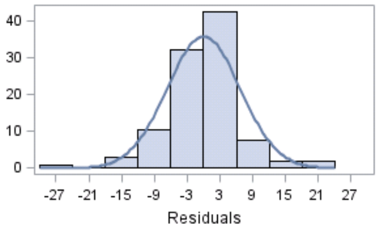
ΔR_f	1.40358	28%	1.29387	22%
Δlvol	2.31073	56%	.	
ΔGreece	1.16378	22%	.	
ECT	2.26852	55%	1.96281	49%
Crisis period				
R^2		**66.75%**		
Δdebt	3.29737	70%		
ΔlMSCI	2.79073	64%	1.62660	38%
ΔlCPI	1.93571	48%	1.61894	38%
Δlprivate debt	2.82137	64%	1.18884	15%
Δpolitical	2.48127	59%	1.10043	
Δca	1.33959	25%		9%
Δgov bal	1.7279	42%	1.50041	33%
Δliq	1.75635	42%	1.55412	36%
Δrating	1.27103	21%	1.24099	19%
ΔlS&P500	1.50028	33%	1.39830	28%
ΔR_f	1.77877	43%	1.44430	30%
Δlvol	2.37555	57%		
ΔGreece	1.52578	34%	1.37860	27%

(8)	**(9)**	**(10)**	**(11)**	**(12)**
Wald test statistic	**Test**	**Statistic**	**Pr>ChiSq**	**Test conclusion**
Whole period	Δpolitical= 0	0.06	0.8073	Remove
Prior crisis	ΔlVOL= 0	0.05	0.8225	Remove
	Δldebt = 0	5.40	0.0253	Cannot remove *remove due to high correlation
Crisis period	ΔlVOL= 0	0.94	0.3419	Removed
	Δldebt = 0	0.55	0.4632	Removed
	Δpolitical = 0	0.10	0.7490	Removed

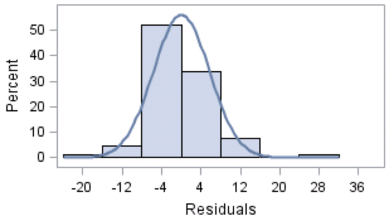
Table 17 Normality

<u>CDS</u>

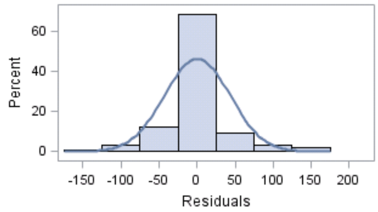
France



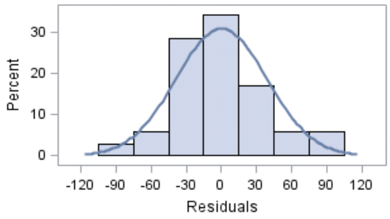
Germany



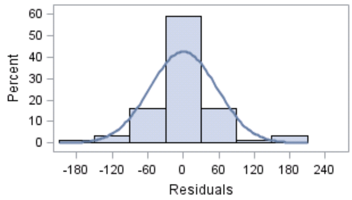
Greece



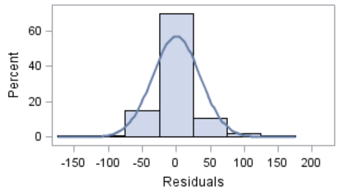
Ireland



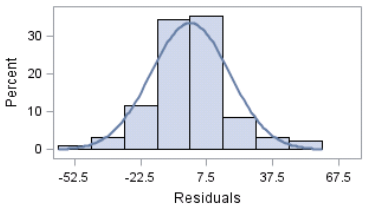
Italy



Portugal



Spain



Appendix 5 Final results

Table 18 Final results

b1=Δdebt
b2=ΔlMSCI
b3=ΔlCPI
b4=Δlprivate debt
b5=Δpolitical
b6=Δca
b7=Δgov bal
b8=Δliq
b14=Δrating
b10=ΔlS&P500
b11=ΔR_f
b12=Δlvol
b9=ΔGreece
b13=ECT

For each country the whole period model is presented first, followed by the prior crisis model and the crisis model.

CDS

France

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	12	94	5258.6	49.6097	7.0434	0.4195	0.3516

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	2.038047	0.9638	2.11	0.0371
b1	-120.951	159.0	-0.76	0.4487
b2	-75.7455	20.4740	-3.70	0.0004
b3	-118.638	287.7	-0.41	0.6810
b4	25.10647	238.8	0.11	0.9165
b5	-5.9971	13.3027	-0.45	0.6532
b6	1.853773	4.0501	0.46	0.6482
b7	0.085195	2.3204	0.04	0.9708
b8	-1.73053	0.4416	-3.92	0.0002
b9	-0.81347	1.5143	-0.54	0.5924
b11	-6.49292	3.8850	-1.67	0.0980
b13	0.018674	0.0242	0.77	0.4419

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	12	54	59.8885	0.9074	0.9526	0.5216	0.4241

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	0.113024	0.2050	0.55	0.5837
b1	80.36236	41.0443	1.96	0.0554
b2	-16.0381	5.2787	-3.04	0.0037
b3	42.5386	58.3203	0.73	0.4689
b4	41.76472	47.1704	0.89	0.3799
b5	-3.20386	3.1547	-1.02	0.3143
b6	2.420755	0.8715	2.78	0.0075
b7	0.289098	0.2306	1.25	0.2154
b8	0.464432	0.3252	1.43	0.1590
b9	-0.00079	0.2161	-0.00	0.9971
b11	0.71957	0.6205	1.16	0.2513
b13	-0.19696	0.1190	-1.66	0.1036

BOND

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	11	95	9284.0	87.5848	9.3587	0.0937	-0.0017

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	0.025136	1.2734	0.02	0.9843
b1	-103.098	146.7	-0.70	0.4839
b2	15.60068	26.2872	0.59	0.5543
b3	476.9894	422.3	1.13	0.2616
b4	-172.582	306.9	-0.56	0.5752
b5	22.94556	13.2559	1.73	0.0867
b6	1.5973	4.1292	0.39	0.6997
b7	-1.82959	2.7968	-0.65	0.5146
b8	-0.50654	0.5399	-0.94	0.3505
b9	-0.23863	1.1354	-0.21	0.8340
b13	0.093446	0.0232	4.03	0.0001

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	11	55	3246.6	49.1909	7.0136	0.2598	0.1253

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	6.335763	2.2106	2.87	0.0059
b1	-70.1809	170.7	-0.41	0.6826
b2	34.50974	27.1101	1.27	0.2084
b3	261.2268	424.1	0.62	0.5404
b4	-717.664	522.6	-1.37	0.1753
b5	32.05927	18.1591	1.77	0.0830
b6	-11.2366	5.9281	-1.90	0.0633
b7	1.024031	2.9359	0.35	0.7286
b8	-18.3629	10.1626	-1.81	0.0762
b9	-2.84675	1.1466	-2.48	0.0161
b13	0.332711	0.0749	4.44	<.0001

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	11	28	3680.1	94.3614	9.7140	0.5618	0.4053

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	-0.31718	3.1663	-0.10	0.9209
b1	-28.8088	334.8	-0.09	0.9320
b2	-111.465	37.1382	-3.00	0.0056
b3	1058.226	701.4	1.51	0.1426
b4	-441.135	588.8	-0.75	0.4600
b5	-46.833	36.3220	-1.29	0.2078
b6	-3.60756	5.6417	-0.64	0.5277
b7	-4.42973	3.8776	-1.14	0.2630
b8	-1.52843	0.4167	-3.67	0.0010
b9	-1.1774	1.2596	-0.93	0.3579
b11	-26.5506	10.4408	-2.54	0.0168

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	10	29	4914.7	126.0	11.2258	0.1100	-0.1661

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	4.32237	3.4425	1.26	0.2193
b1	-318.238	337.2	-0.94	0.3530
b2	14.69937	44.7592	0.33	0.7450
b3	956.6825	1136.9	0.84	0.4069
b4	-766.565	608.5	-1.26	0.2178
b5	80.59918	36.8504	2.19	0.0369
b6	1.11024	6.1761	0.18	0.8586
b7	-4.97363	6.2362	-0.80	0.4316
b8	-45.3316	57.4066	-0.79	0.4361
b9	-0.31927	1.5466	-0.21	0.8379

Germany

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	12	94	3401.2	32.0869	5.6645	0.3492	0.2731

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	0.337031	0.8794	0.38	0.7024
b1	63.49064	64.3270	0.99	0.3262
b2	-47.823	17.5922	-2.72	0.0078
b3	64.06837	297.7	0.22	0.8300
b4	0.354454	236.5	0.00	0.9988
b5	-4.79093	16.0797	-0.30	0.7664
b6	0.82598	1.5639	0.53	0.5986
b7	0.482849	0.6770	0.71	0.4775
b8	-0.19396	0.3769	-0.51	0.6080
b9	-1.76859	1.3422	-1.32	0.1908
b11	0.521044	2.6849	0.19	0.8465
b13	-0.18602	0.0573	-3.25	0.0016

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	11	95	8319.7	78.4880	8.8593	0.1088	0.0149

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	0.129833	1.0506	0.12	0.9019
b1	133.6287	122.6	1.09	0.2785
b2	27.33109	15.5362	1.76	0.0818
b3	-863.589	350.8	-2.46	0.0156
b4	-141.308	414.9	-0.34	0.7342
b5	-5.19309	22.5686	-0.23	0.8185
b6	-0.00821	2.0962	-0.00	0.9969
b7	-2.71523	1.0415	-2.61	0.0106
b8	-0.12765	5.1178	-0.02	0.9802
b9	-0.29988	2.0858	-0.14	0.8860
b13	-0.06486	0.0578	-1.12	0.2648

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	12	54	33.1114	0.5017	0.7083	0.7866	0.7431

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	0.245098	0.1758	1.39	0.1690
b1	31.43317	28.1146	1.12	0.2685
b2	-4.44009	2.6100	-1.70	0.0947
b3	-14.5872	48.1648	-0.30	0.7632
b4	-64.9655	49.0705	-1.32	0.1911
b5	-7.40131	2.5617	-2.89	0.0055
b6	-0.23214	0.2182	-1.06	0.2921
b7	-0.58819	0.5155	-1.14	0.2589
b8	0.907534	0.1150	7.89	<.0001
b9	0.238463	0.3342	0.71	0.4786
b11	1.382053	0.6397	2.16	0.0352
b13	-0.22414	0.0489	-4.59	<.0001

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	11	55	2883.4	43.6880	6.6097	0.2284	0.0882

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	-3.52409	1.9391	-1.82	0.0746
b1	491.8015	197.7	2.49	0.0159
b2	23.8997	21.2541	1.12	0.2657
b3	-899.689	354.0	-2.54	0.0139
b4	-583.475	517.8	-1.13	0.2647
b5	10.99273	19.8831	0.55	0.5826
b6	1.665266	2.4421	0.68	0.4982
b7	8.495032	5.0283	1.69	0.0968
b8	-4.52071	4.5354	-1.00	0.3232
b9	-1.39909	2.1649	-0.65	0.5208
b13	-0.22947	0.1009	-2.27	0.0269

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	9	30	2743.2	70.3382	8.3868	0.4201	0.2654

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	-1.34529	1.9586	-0.69	0.4974
b1	124.0767	60.3618	2.06	0.0486
b2	-90.6591	24.8232	-3.65	0.0010
b3	1150	1016.4	1.13	0.2668
b4	-152.436	296.3	-0.51	0.6106
b6	-3.91413	3.8691	-1.01	0.3198
b8	-0.18678	0.5977	-0.31	0.7568
b9	-0.99409	1.7474	-0.57	0.5737
b11	-3.09054	7.1445	-0.43	0.6684

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	9	30	4955.1	127.1	11.2719	0.0861	-0.1575

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	1.822678	2.2471	0.81	0.4237
b1	-51.1254	134.9	-0.38	0.7074
b2	30.86832	23.1262	1.33	0.1920
b3	-964.202	983.5	-0.98	0.3347
b4	-254.467	571.9	-0.44	0.6596
b5	-116.208	104.9	-1.11	0.2765
b6	-2.63809	4.4092	-0.60	0.5541
b8	1.02912	8.0734	0.13	0.8994
b9	0.842459	1.9379	0.43	0.6669

Greece

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	12	84	179804	1873.0	43.2777	0.4868	0.4196

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	12.74957	4.9047	2.60	0.0110
b1	43.39295	410.7	0.11	0.9161
b2	-226.164	65.6181	-3.45	0.0009
b3	-1653.6	1408.4	-1.17	0.2437
b4	-278.968	516.8	-0.54	0.5908
b5	125.6332	37.4818	3.35	0.0012
b6	0.75097	3.9020	0.19	0.8478
b7	-0.67767	2.9240	-0.23	0.8173
b8	0.305938	3.6854	0.08	0.9340
b9	-76.8075	18.6770	-4.11	<.0001
b11	-28.1758	24.5331	-1.15	0.2540
b12	12.02072	32.5562	0.37	0.7129

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	10	86	329785	3435.3	58.6111	0.3606	0.2937

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	18.06166	7.1497	2.53	0.0134
b1	561.8203	438.9	1.28	0.2040
b2	-176.288	66.7119	-2.64	0.0098
b3	-3301.68	2110.8	-1.56	0.1214
b4	-648.712	820.2	-0.79	0.4312
b5	139.3914	52.1762	2.67	0.0090
b6	-3.53012	7.6513	-0.46	0.6457
b7	1.544812	3.6517	0.42	0.6733
b9	-92.2909	37.4501	-2.46	0.0157
b12	0.062256	33.9813	0.00	0.9985

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	11	55	1279.6	19.3881	4.4032	0.2785	0.1473

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	0.725159	0.7312	0.99	0.3257
b1	-49.6423	43.1064	-1.15	0.2545
b2	-23.2092	18.5303	-1.25	0.2157
b3	199.3165	134.4	1.48	0.1437
b6	1.443139	0.8527	1.69	0.0962
b7	0.22204	0.7833	0.28	0.7779
b8	1.291022	0.9623	1.34	0.1852
b9	0.158763	1.0819	0.15	0.8839
b11	-4.60292	4.2757	-1.08	0.2864
b12	0.953132	3.5221	0.27	0.7877
b13	-0.03012	0.0790	-0.38	0.7044

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	9	57	3789.5	57.4170	7.5774	0.1126	-0.0119

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	2.462697	1.2697	1.94	0.0574
b1	-10.0855	58.0892	-0.17	0.8628
b2	-22.1353	23.1825	-0.95	0.3437
b3	-712.424	443.7	-1.61	0.1139
b6	-0.39768	0.9502	-0.42	0.6771
b7	-0.25468	1.0264	-0.25	0.8049
b9	-3.9904	3.3483	-1.19	0.2383
b12	-0.88216	4.7318	-0.19	0.8528
b13	0.098457	0.0653	1.51	0.1372

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	10	19	124402	4289.7	65.4959	0.6204	0.4406

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	54.33865	20.3610	2.67	0.0152
b1	-2881.23	1808.8	-1.59	0.1277
b2	-350.046	140.7	-2.49	0.0223
b3	-6319.25	3080.7	-2.05	0.0543
b6	-3.81054	8.8212	-0.43	0.6706
b7	8.145691	5.2363	1.56	0.1363
b8	5.291422	7.9926	0.66	0.5159
b9	-90.6198	16.1669	-5.61	<.0001
b11	-111.573	88.5972	-1.26	0.2232
b12	55.34824	69.1738	0.80	0.4335

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	8	21	294038	10139.2	100.7	0.3869	0.1825

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	32.49737	23.1792	1.40	0.1755
b1	-408.351	1478.4	-0.28	0.7851
b2	-258.51	133.4	-1.94	0.0662
b3	-8436.92	4687.2	-1.80	0.0862
b6	-10.9998	14.4812	-0.76	0.4559
b7	13.52786	7.7981	1.73	0.0974
b9	-113.824	46.8078	-2.43	0.0241
b12	-0.89623	111.7	-0.01	0.9937

Ireland

Ordinary Least Squares Estimates			
SSE	50916.9587	DFE	24
MSE	2122	Root MSE	46.06018
SBC	393.32564	AIC	376.216811
MAE	28.1140055	AICC	387.695072
MAPE	212.036309	HQC	382.122777
Durbin-Watson	2.1209	Regress R-Square	0.4873
		Total R-Square	0.4873

Durbin-Watson Statistics	
Order	DW
1	2.1209

Parameter Estimates					
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	7.5907	14.3920	0.53	0.6027
difldebt	1	0.3791	440.1272	0.00	0.9993
diflmsci	1	-320.9237	144.4629	-2.22	0.0360
diflcpi	1	2393	4672	0.51	0.6132
diflprivatedebt	1	-1868	1481	-1.26	0.2195
difgovbal	1	0.6860	1.6041	0.43	0.6727
difliq	1	3.6861	4.7309	0.78	0.4435
difvol	1	62.3298	54.0656	1.15	0.2603
difeuroswaprate	1	69.7089	48.3403	1.44	0.1622
difcredit	1	-17.9501	14.6099	-1.23	0.2311
difgreece	1	-23.9505	11.8529	-2.02	0.0546

Italy

Nonlinear GMM Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	11	77	289945	3294.8	57.4006	0.3820	0.3018

Nonlinear GMM Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	-0.01419	3.8540	-0.00	0.9971
b1	2310.912	1169.0	1.98	0.0516
b2	-47.5083	20.7785	-2.29	0.0250
b3	2382.482	1217.9	1.96	0.0541
b6	-44.4734	21.7682	-2.04	0.0445
b8	-30.1527	13.7471	-2.19	0.0313
b9	-24.8189	15.9929	-1.55	0.1248
b10	-161.344	270.0	-0.60	0.5518
b11	-8.63428	21.7701	-0.40	0.6928
b12	-58.3251	59.0839	-0.99	0.3267
b14	-27.7886	30.3697	-0.92	0.3630

Nonlinear GMM Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	10	78	11688.3	132.8	11.5248	0.2005	0.1082

Nonlinear GMM Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	1.066709	1.0822	0.99	0.3273
b1	-103.193	422.7	-0.24	0.8078
b2	1.999331	4.7591	0.42	0.6756
b3	-36.8903	108.8	-0.34	0.7354
b6	-0.37139	8.2934	-0.04	0.9644
b8	-11.7747	5.8563	-2.01	0.0478
b9	-4.0197	1.7609	-2.28	0.0252
b10	-46.3604	51.1877	-0.91	0.3679
b12	16.87	10.3020	1.64	0.1055
b14	6.583711	2.9284	2.25	0.0274

Nonlinear GMM Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	11	55	9381.7	142.1	11.9225	0.4369	0.3345

Nonlinear GMM Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	0.305615	0.9301	0.33	0.7437
b1	493.5977	391.0	1.26	0.2121
b2	-30.5466	9.5152	-3.21	0.0022
b3	100.8393	210.8	0.48	0.6343
b6	-8.14418	6.7199	-1.21	0.2307
b8	-5.03301	3.8511	-1.31	0.1967
b9	-2.54339	3.2791	-0.78	0.4413
b10	117.903	72.4824	1.63	0.1095
b11	-20.4666	9.4198	-2.17	0.0341
b12	1.217847	10.9143	0.11	0.9116
b14	6.572661	4.5461	1.45	0.1539

Nonlinear GMM Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	10	56	2534.0	38.3940	6.1963	0.3648	0.2627

Nonlinear GMM Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	0.741747	0.5631	1.32	0.1931
b1	-52.6265	287.9	-0.18	0.8556
b2	-6.78785	3.1634	-2.15	0.0362
b3	-220.962	116.9	-1.89	0.0638
b6	-2.49044	3.7363	-0.67	0.5078
b8	-18.8931	4.5137	-4.19	0.0001
b9	11.12896	7.3078	1.52	0.1334
b10	3.66879	28.3525	0.13	0.8975
b12	-5.47697	4.6440	-1.18	0.2432
b14	9.794735	2.0286	4.83	<.0001

Portugal

Nonlinear GMM Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	14	92	129115	1218.1	34.9008	0.4551	0.3781

Nonlinear GMM Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	14.03671	5.6494	2.48	0.0148
b1	503.3292	418.4	1.20	0.2320
b2	-169.669	81.8216	-2.07	0.0409
b3	-1568.27	1312.6	-1.19	0.2352
b4	-2241.32	1043.7	-2.15	0.0344
b5	125.2	46.8821	2.67	0.0090
b6	4.831694	6.1408	0.79	0.4334
b7	-1.51755	1.3383	-1.13	0.2598
b8	3.300446	1.7460	1.89	0.0619
b9	-18.778	6.8486	-2.74	0.0073
b10	138.8065	90.4064	1.54	0.1281
b11	3.552222	16.9508	0.21	0.8345
b12	80.47341	42.3313	1.90	0.0604
b14	-25.4788	9.0964	-2.80	0.0062

Nonlinear GMM Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	13	93	251321	2371.0	48.6924	0.6982	0.6592

Nonlinear GMM Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	-2.21285	8.3524	-0.26	0.7916
b1	1135.872	809.2	1.40	0.1638
b2	-161.575	97.3378	-1.66	0.1003
b3	1822.789	2392.6	0.76	0.4481
b4	-1365.07	1038.7	-1.31	0.1920
b5	42.36944	74.2948	0.57	0.5699
b6	-6.24537	10.7046	-0.58	0.5610
b7	2.622356	1.8450	1.42	0.1586
b8	2.597726	0.2520	10.31	<.0001
b9	-12.049	10.1761	-1.18	0.2394
b10	80.84447	133.7	0.60	0.5469
b12	-5.21625	23.3360	-0.22	0.8236
b14	-44.7083	12.6433	-3.54	0.0006

Nonlinear GMM Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	13	53	612.7	9.2829	3.0468	0.3784	0.2377

Nonlinear GMM Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	-0.71271	0.4834	-1.47	0.1463
b1	74.90162	63.1449	1.19	0.2408
b2	-13.3	16.2027	-0.82	0.4154
b3	94.29377	131.4	0.72	0.4760
b4	305.283	123.9	2.46	0.0170
b5	-1.98612	5.7070	-0.35	0.7292
b6	-0.09537	0.6264	-0.15	0.8796
b7	0.278164	0.1735	1.60	0.1149
b8	1.650538	1.5200	1.09	0.2825
b9	1.074455	1.2719	0.84	0.4021
b10	-8.82247	15.2352	-0.58	0.5650
b11	-7.07028	3.9445	-1.79	0.0788
b12	0.43932	3.4149	0.13	0.8981

Nonlinear GMM Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	12	54	3161.5	47.9014	6.9211	0.1332	-0.0433

Nonlinear GMM Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	-0.59743	1.3042	-0.46	0.6487
b1	-147.097	118.1	-1.25	0.2184
b2	-28.5162	17.9706	-1.59	0.1184
b3	680.3045	373.6	1.82	0.0741
b4	-108.161	151.3	-0.72	0.4776
b5	1.986449	17.0400	0.12	0.9076
b6	1.623137	1.8227	0.89	0.3771
b7	0.030519	0.4813	0.06	0.9497
b8	-1.37633	1.7095	-0.81	0.4243
b9	-1.66557	3.8431	-0.43	0.6665
b10	28.50935	33.8514	0.84	0.4034
b12	-0.96123	5.4388	-0.18	0.8604

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	13	26	77053.7	1975.7	44.4492	0.6445	0.4804

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	12.32569	10.4302	1.18	0.2480
b1	2277.55	955.5	2.38	0.0247
b2	-545.84	168.1	-3.25	0.0032
b3	-6287.08	3119.5	-2.02	0.0543
b4	-2968.78	2150.4	-1.38	0.1792
b5	154.4651	90.3361	1.71	0.0992
b6	14.09761	8.4408	1.67	0.1069
b8	7.817617	3.9903	1.96	0.0609
b9	6.51383	13.4277	0.49	0.6317
b10	402.1721	220.6	1.82	0.0798
b11	58.9486	47.8068	1.23	0.2286
b12	191.2076	80.4122	2.38	0.0251
b14	-35.6955	12.6638	-2.82	0.0091

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	12	27	232928	5972.5	77.2820	0.6976	0.5744

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	-13.0402	23.4608	-0.56	0.5829
b1	1926.632	1068.6	1.80	0.0826
b2	-336.568	319.0	-1.06	0.3007
b3	3239.94	7536.2	0.43	0.6707
b4	-3680.68	2362.6	-1.56	0.1309
b5	1.11779	238.6	0.00	0.9963
b6	0.577894	15.7637	0.04	0.9710
b8	250.406	33.2208	7.54	<.0001
b9	-10.5609	18.7449	-0.56	0.5778
b10	149.6744	266.2	0.56	0.5785
b12	-28.7052	50.4181	-0.57	0.5738
b14	-44.5435	16.5770	-2.69	0.0122

Spain

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	13	80	29153.7	313.5	17.7054	0.5384	0.4692

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	-2.07621	3.6433	-0.57	0.5704
b1	-42.1594	150.6	-0.28	0.7803
b2	-303.753	91.3299	-3.33	0.0013
b3	1123.161	801.1	1.40	0.1648
b4	410.7613	362.8	1.13	0.2610
b6	4.283896	2.9700	1.44	0.1531
b7	2.635867	3.1259	0.84	0.4016
b8	-2.66072	1.4252	-1.87	0.0656
b9	-7.51208	4.1837	-1.80	0.0763
b10	199.4058	93.0816	2.14	0.0352
b11	-4.11569	12.9468	-0.32	0.7514
b12	20.37906	11.1252	1.83	0.0707
b14	-3.00542	4.9110	-0.61	0.5423

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	12	81	70658.6	759.8	27.5639	0.3292	0.2381

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	-3.26137	4.5682	-0.71	0.4773
b1	6.984893	162.1	0.04	0.9657
b2	-295.981	102.2	-2.90	0.0048
b3	1034.758	975.6	1.06	0.2920
b4	515.9229	459.7	1.12	0.2650
b6	9.119804	3.9270	2.32	0.0227
b7	1.084549	4.2638	0.25	0.7999
b8	49.36967	35.6707	1.38	0.1701
b9	-11.0276	5.3330	-2.07	0.0418
b10	289.944	137.3	2.11	0.0378
b12	27.29866	16.2824	1.68	0.0975
b14	16.97564	4.5313	3.75	0.0003

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	11	42	368.8	6.9581	2.6378	0.6118	0.5194

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	-0.31485	0.9487	-0.33	0.7416
b2	-34.3487	10.6600	-3.22	0.0025
b3	285.8092	198.7	1.44	0.1577
b4	104.0418	88.5149	1.18	0.2464
b5	5.712622	6.4872	0.88	0.3835
b6	0.614681	0.4898	1.26	0.2164
b7	-0.38629	0.4730	-0.82	0.4187
b8	3.355481	1.5102	2.22	0.0317
b10	-41.8019	19.5291	-2.14	0.0382
b11	-4.16977	2.6110	-1.60	0.1178
b13	-0.06552	0.0707	-0.93	0.3591

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	10	43	2405.8	45.3927	6.7374	0.1630	-0.0122

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	-1.96906	2.6442	-0.74	0.4605
b2	15.46966	31.8407	0.49	0.6295
b3	627.0891	521.9	1.20	0.2361
b4	93.90696	255.7	0.37	0.7153
b5	24.60556	17.1241	1.44	0.1580
b6	-0.67693	1.4902	-0.45	0.6519
b7	-1.9132	1.8809	-1.02	0.3147
b8	3.140912	2.9625	1.06	0.2950
b10	2.089601	25.6974	0.08	0.9356
b13	-0.28314	0.1542	-1.84	0.0732

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difcds	11	28	21399.1	548.7	23.4243	0.6489	0.5235

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	-14.7395	9.5832	-1.54	0.1353
b1	744.2363	541.5	1.37	0.1802
b2	-484.844	85.7322	-5.66	<.0001
b3	1546.197	1133.4	1.36	0.1834
b6	-0.33762	5.1464	-0.07	0.9482
b7	4.290506	6.7881	0.63	0.5325
b8	-2.01666	2.8000	-0.72	0.4773
b9	-8.44994	5.7227	-1.48	0.1510
b10	265.5888	97.0120	2.74	0.0106
b11	-6.67386	32.7966	-0.20	0.8402
b14	-0.24117	4.5355	-0.05	0.9580

Nonlinear GMM Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
difbond	13	93	251321	2371.0	48.6924	0.6982	0.6592

Nonlinear GMM Parameter Estimates				
Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
b0	-2.21285	8.3524	-0.26	0.7916
b1	1135.872	809.2	1.40	0.1638
b2	-161.575	97.3378	-1.66	0.1003
b3	1822.789	2392.6	0.76	0.4481
b4	-1365.07	1038.7	-1.31	0.1920
b5	42.36944	74.2948	0.57	0.5699
b6	-6.24537	10.7046	-0.58	0.5610
b7	2.622356	1.8450	1.42	0.1586
b8	2.597726	0.2520	10.31	<.0001
b9	-12.049	10.1761	-1.18	0.2394
b10	80.84447	133.7	0.60	0.5469
b12	-5.21625	23.3360	-0.22	0.8236
b14	-44.7083	12.6433	-3.54	0.0006

Table 19 Granger Causality

Test 1: Group 1 Variables:cds
Group 2 Variables:bond

Test 2: Group 1 Variables:bond
Group 2 Variables:cds

H_0: group 1 variable is affected only by itself, it is weakly exogenous

H_A: group 1 variable is affected by group 2 variable

Whole period | Prior crisis | Crisis period

France

Prior crisis:

Granger-Causality Wald Test			
Test	DF	Chi-Square	Pr > ChiSq
1	1	10.15	0.0014
2	1	3.62	0.0571

Crisis period:

Granger-Causality Wald Test			
Test	DF	Chi-Square	Pr > ChiSq
1	1	2.00	0.1574
2	1	7.16	0.0074

Germany

Prior crisis:

Granger-Causality Wald Test			
Test	DF	Chi-Square	Pr > ChiSq
1	4	41.64	<.0001
2	4	22.65	0.0001

Crisis period:

Granger-Causality Wald Test			
Test	DF	Chi-Square	Pr > ChiSq
1	1	8.67	0.0032
2	1	0.63	0.4258

Greece

Whole period:

Granger-Causality Wald Test			
Test	DF	Chi-Square	Pr > ChiSq
1	4	6.02	0.1980
2	4	9.40	0.0518

Crisis period:

Granger-Causality Wald Test			
Test	DF	Chi-Square	Pr > ChiSq
1	2	0.65	0.7223
2	2	1.29	0.5250

Italy

Prior crisis:

Granger-Causality Wald Test			
Test	DF	Chi-Square	Pr > ChiSq
1	3	9.38	0.0246
2	3	5.30	0.1511

Portugal

Whole period:

Granger-Causality Wald Test			
Test	DF	Chi-Square	Pr > ChiSq
1	3	58.54	<.0001
2	3	3.38	0.3370

Prior crisis:

Granger-Causality Wald Test			
Test	DF	Chi-Square	Pr > ChiSq
1	4	5.09	0.2781
2	4	2.29	0.6818

Crisis period:

Granger-Causality Wald Test			
Test	DF	Chi-Square	Pr > ChiSq
1	2	20.33	<.0001
2	2	0.83	0.6594

Spain

Whole period:

Granger-Causality Wald Test			
Test	DF	Chi-Square	Pr > ChiSq
1	2	0.88	0.6443
2	2	7.42	0.0245

Crisis period:

Granger-Causality Wald Test			
Test	DF	Chi-Square	Pr > ChiSq
1	1	0.46	0.4977
2	1	0.28	0.5960