Insights into the Credit default swaps and Bond markets

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Samuel Kwabena Ofori

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Graduate School of Systems and Information Engineering

University of Tsukuba

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Samuel Kwabena Ofori

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CHAPTER 1

INTRODUCTION

A credit default swap (hereafter CDS) is an Over -the -counter derivative instrument. The contract arrangement is such that a buyer of a protection makes series of regular premium payments to the seller of the protection and in the case of an occurrence of an event, receives compensation based on the settlement terms in the contract. The series of periodic payments or premiums that the protection buyer pays to the protection seller is what is referred to as the spreads. A Credit default swap payout/ compensation is triggered when a credit event occurs.

What constitutes a credit event is dependent on the International Swaps and Derivatives Association (ISDA) Determinations Committee overseeing that particular region or block. In total, five ISDA determination committees (DCs) oversee the Americas, Asia excluding Japan, Australia-New Zealand, EMEA (Europe), and Japan. For Western European sovereigns, Failure to pay; Repudiation / Moratorium and Restructuring are typical credit events that would trigger a CDS payout (ISDA, 2012). Credit default swap as a financial product is not traded on an exchange but an over the counter (OTC) arrangement between two parties. Until recently, due to the lack of transparency in the market, there are those who argue that CDS played a significant role in the 2007-2010 global financial crisis[1].

Comparably, Credit default swaps are more or less like an insurance product with only a minor difference. For Insurance, take for example, a simple insurance contract written on a property. The buyer of the protection pays premiums periodically with the assurance that in the case of an event occurring, compensation will be received. On the other hand, the insurance company which receives the payments provides the assurance that in the occurrence of an event, certain amounts of payments are made.

In contrast to the insurance market, in a credit default swap contract, the buyer of the protection need not own the underlying asset or bonds that protection is been bought on. These arrangement provide a mechanism for speculators to bet on the default of a sovereign or corporate entity in the CDS market.

[1] See the testimony of Michael Greenberger, University of Maryland, at the Financial Crisis Commission Hearing at Washington DC 2010.

For example, an investor may buy protection on government or corporate bonds without actually owning it or having any exposure to it, in what is referred to as Naked credit default swaps. However, by its nature, Credit default swaps also allows investors to hedge their risk or transfer the risk associated with an asset, say bonds, issued by a corporate entity or a sovereign country to a third party. In a simple case, the bondholder (the protection buyer) makes periodic payments to another party, say Company B (the protection seller) with the assurance that in the event that Company C (referred to as the reference entity) does not honor its obligations, the protection seller will then make a payoff or compensation.

Credit default swaps, even though, provide a mechanism for bondholders to mitigate their risk; it also provides a channel for speculation. Investors are increasingly buying protection or speculating on the default of government debts. Table 1.1, presents the Gross Notional and the Net Notional amounts bought or sold on selected Government debts.

Table 1.1 Gross and Net Notional of Sovereign CDS spread

Reference Entity	Gross Notional (USD EQ)	Net Notional(USD EQ)
Germany	87,582,219,716	11,180,060,367
Brazil	129,824,926,706	12,716,426,877
Ireland	32,344,774,157	804,024,908
Japan	50,866,823,346	7,071,198,657
Spain	122,452,615,053	1,013,184,875
South Korea	74,632,653,931	7,767,435,543
South Africa	59,807,786,330	4,271,129,239
Italy	367,043,613,434	16,742,938,09

Source: Data obtained from DTTC August, 20, 2015

Sovereign credit default swap spreads have come to be accepted, somewhat, as a direct quantifier of the risk associated with sovereign government debts. Data shows that since the start of the global financial crisis through to the current European sovereign crisis, spreads have been fluctuating. Figure 1.1 provides a glimpse of the 5 year Sovereign credit default swap spreads for some selected countries. Research into the sovereign CDS spreads is of importance in understanding the market and the possibility thereof in managing sovereign risk.

This research seeks to increase our understanding of the Credit default swap market and the corresponding Bond market. The research covers three chapters.

In chapter 2, we look into one of the important but under studied market, Japan sovereign credit default swap market. Research has shown that the Japanese government bonds are to a large proportion owned by Japanese investors. Therefore in a real setting, these investors should have been buying Credit default swaps to hedge their risk. However, only a small percentage of Japanese Government bond holders have bought protection, in that, the majority of participants in the CDS market are foreign investors (Shino (2010)).

From table 1.1, The Gross notional value bought on Japanese Sovereign debts is equivalent to $50,866,823,346 and its spread is correspondingly increasing. It is of academic interest to try and understand what factors drive the fluctuations in the spread. Research into the determinants in other markets has established that both global and country specific factors play a significant role in the pricing of Sovereign CDS spreads. In this study, we examine both global and country factors in a Markov regime switching framework to ascertain its role in the determination of the Japanese sovereign CDS spreads.

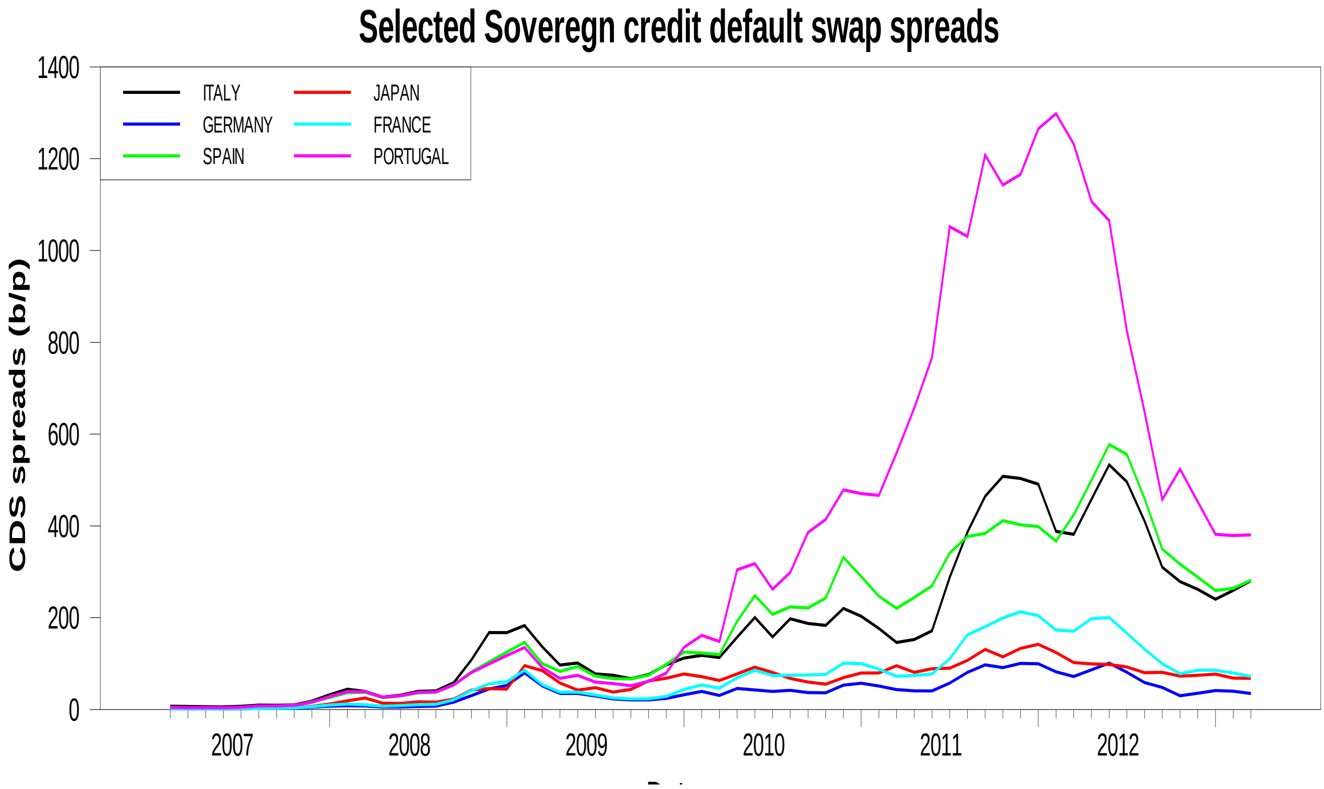

Figure1.1. Plot of selected 5 year Sovereign CDS spreads

Extending the analysis to Chapter 3, we examine the corresponding rise in the Sovereign CDS spreads for select countries in the Eurozone during the recent European sovereign crisis and the possible transmission of default risk to other countries. The research seeks to reveal if there have been spillover effects and or contagion from the Greek instigated crisis to other countries as distant as Japan. What may be the underlying cause of the contagion? Employing a VAR (p) framework whiles controlling for the common trends in the sovereign CDS market, we examine the possible contagion. Impulse response functions and Variance Decomposition analysis help us to reveal the dynamics.

In Chapter 4, the corresponding corporate bond market is analyzed. It has been established in literature, from a theoretical perspective, that a no- arbitrage relation should hold between a corporate credit spread and the corresponding CDS spread for any given reference entity. Results from earlier research are mixed and a section of this chapter tries to examine this parity condition both in the short and long run.

More so, since credit spreads are associated with default risk, analyzing the corporate credit spreads in Japan provides a unique opportunity to reveal how the credit event, the credit rating downgrade, in 2011 for Tokyo Electric Power Company had on the three mega banks that were highly exposed to its credit situation. In a reduced form framework and appealing to a Risk neutral valuation, the effect of the TEPCO credit crisis on the default probabilities of the banks would be captured.

Chapter 2

Regime switching determinants of the Japanese sovereign credit default swaps spreads

2.1 INTRODUCTION

Credit default swaps continue to receive considerable research attention. Earlier studies on Credit default swaps (Benkkert (2004); Breitenfellner and Wagner (2012); Cesare and Guazzarotti (2010); Ericsson, Jacobs and Oviedo (2009); Doshi, Ericsson, Jacobs and Turnbull (2013); Hull, Predescu and White (2004); Skinner ,Timothy and Townend (2002)) focused on the Corporate credit default swap spreads or Credit default swap indices while exploring either its determinants, valuation or the No -arbitrage relationship between Corporate credit default swaps and bond markets.

Nevertheless, the recent budget deficits in some Euro area countries and the resulting sovereign crisis have reignited the debate on the risk exposures on government bonds and the corresponding sovereign credit default swap market. The increasing perceived risk and dramatic jumps in the sovereign spreads during the crisis has necessitated the rapid research into the factors that drive those fluctuations. Several authors including (Fontana and Scheicher (2010; Zinna (2013)) have focused on understanding the Sovereign CDS market.

Despite this increasing shift to the Sovereign market, most of the literature is focused on the dynamics in the European area market and some emerging markets. The aim of this paper is to shift the discussion to the Japanese sovereign credit default swap market and to analyze its determinants in a Markov regime switching framework. Understanding the drivers of CDS spreads is both useful for policy purposes in understanding the dynamics and the inherent risks it pose to Japan.

This study is related to Pan and Singleton (2006), who identify three important factors that are significant in explaining Japanese Sovereign Credit default Swap spreads in an Ordinary Least Square regression. However, this study differs, in that, we include other global and local variables in a Markov regime switching setting using monthly CDS spreads data over the period, January 2004 to March, 2014. Specifically, what are the main drivers of Japanese CDS spreads and are these determinants regime dependent? The paper makes a number of significant contributions to existing literature .This is the first paper, to the best of our knowledge, which examines the Japanese Sovereign CDS Spreads in a Regime switching framework. Secondly, our sample period (2004-2014) is far longer than earlier studies. Also, we identify and use other local variables that have not been used in earlier studies on the determinants of Japanese Sovereign CDS. Lastly, we provide further insights into the Japanese CDS market where existing literature is scant.

The main results indicate that determinants are indeed regime specific. Specifically, the global factors: the Implied Volatility on the CBOE and the 10year US Treasury yields remain highly significant in both the normal and volatile regimes while the U.S default risk factor assume significance only in the normal regime .Also, the country specific factors; the Nikkei225 Total Return Index, Leading index of the Composite Index, the 10 year Japanese Government bond yields have more impact on the CDS spreads in the volatile regime than the normal regime with the exception of the Terms of Trade variable which remains insignificant in both regimes.

The rest of the paper is structured as follows: Section 2 discusses the data and methodology, Section 3 covers the results and discussion and concludes under Section 4.

2. 2 LITERATURE REVIEW

Several models employed on the studies into the determinants of Credit default swap spreads have focused on corporate CDS spreads in an Ordinary least square (OLS) regression framework. Only until recently, have researchers tried to explore the sovereign market, albeit a handful, in a regime dependent framework following the work of Hamilton (1989).

Fender, Hayo and Neuenkirch (2012) analyze the determinants of sovereign credit default swap spreads for emerging countries from April 2002 to December 2011.They study twelve emerging economies over two time periods i.e. during “normal times “and “turbulence period”. By assembling both country specific and international factors in a GARCH modelling framework, their results indicate that emerging countries are more affected by international and regional factors than country specific factors. The importance of country specific factors diminishes during turbulent periods in comparison to international factors.

Dieckmann and Plank (2012) study the determinants of eighteen (18) developed economies including eleven European Monetary Union (EMU) countries and seven euro area countries in a weekly setting over the period, January 2007 to April 2010.They test for the importance of the state of a country’s financial system and the effects of global factors on the sampled sovereign credit default swap spreads. Analyzing the data in a two period framework, pre and post Lehman brother’s crisis, they conclude that both local and global financial shocks influence sovereign credit default swap spreads. Also, the state of a country’s financial system before a crisis play an important role in the behavior of credit default swap spreads.

In studying the determinants and the price discovery of sovereign credit default swap spreads and stock price movements in China, Eyssell, Fung and Zhang (2013), analyze data from January 2001 to December 2010.Both domestic and global variables are employed in studying the sovereign CDS in both levels and changes. Results indicate that both the domestic and global variables better explain the behavior of the Chinese CDS spreads in level analysis than when the spreads are differenced. However, the Chinese domestic variables are more important in explaining CDS spreads before February 2007 than the global factors. The global factors assume more importance during the global crisis (i.e after February 2007).Chinese CDS spreads turn out to lead the stock market in the price discovery process in China.

Kliber and Będowska-Sójka (2013) investigate the determinants of Polish sovereign credit default swap spreads by employing data that represent the economic situation in Poland and various international macroeconomic news variables. The authors employ a VAR-DCC methodology in their empirical analysis. For the domestic variables, they assemble bond spreads, exchange rate, stock-exchange index and trading volume of the index. They aggregate the announcements from industrial production, retail sales, consumer confidence, durable goods order, unemployment rate, producer price index, new home sales and purchasing manager index from the American market into an indicator variable to analyze its impact on Polish CDS spreads. Their findings indicate that domestic factors are relevant to Polish CDS pricing. However, macroeconomic news from the American economy does not play any important role in Polish CDS pricing.

Alper, Forni and Gerard (2012) study the credit default swap (CDS) and the Relative asset swap (RAS) spreads. Among other things, they analyze the determinants of both the CDS and RAS spreads. Country specific factors and global variables are employed in the analysis over the period, January 2008 to October 2010, for twenty one countries. Results indicate that credit default swap spreads decreases when : expectations on primary deficit is revised downward; expected domestic growth goes up; the global risk aversion falls and there is large scale purchases of long term government bonds by the federal reserve.

Focusing on Emerging economies, Ismailescu and Kazemi (2010) analyze the reaction of sovereign credit default swap spreads to sovereign credit rating change announcements and possible spillover effects to other countries. The research uses daily data from twenty two countries from January 2001 to April 2009.Their results suggest credit default swap spreads are immediately impacted by positive credit ratings but negative credit ratings have no impact on it.

Pan and Singleton (2006), find evidence that the Option Implied volatility Index for US equities (VIX), Zero Interest rate policy (ZIRP) and the Implied Volatility on the Nikkei Index Option (Nikkei IV) together explain about 65% of the changes in Japanese Sovereign CDS spreads. They observe a positive relation for all variables with the spreads.

In a Markov switching framework, Guo and Newton (2013) explore the impact of several factors, especially Liquidity on credit default swap spreads. They conclude that leverage ratio, volatility, the risk free rate and liquidity are all important factors in explaining CDS spread changes and the effect of liquidity is more pronounced in the crisis period than during the normal period.

Also, applying a linear regression and a Markov switching model to iTraxx Europe Indices, Alexander and Kaeck (2008), find that the impact of the determinants is regime specific. Specifically, the impact of implied volatility is more sensitive to spread changes during volatile periods whereas stock returns are more sensitive to spread changes during normal periods. Also, the explanatory power of the model is more pronounced during the volatile period than the tranquil period.

Furthermore, Huang and Hu (2012) apply a Smooth transition auto regressive model (STAR) to analyze the regime switching behavior of corporate credit default spreads. Based on threshold estimates, they are able to identify precise dates of regime change. Their results indicate that the determinants of CDS spreads are indeed regime specific.

Focusing on the Euro-zone, Oliveira, Curto and Nunes (2012) study the determinants of sovereign credit changes. They assemble the spreads relative to the German yield curves for seven countries in the Eurozone. By employing both financial and economic variables over a 10 year period whiles analyzing the before crisis and crisis effects, the results provide interesting results. The stock returns and interest rate sensitive variables are the most important drivers during the “before crisis” period. Whiles finding insignificant results for the liquidity factor in both periods, both international volatility and macroeconomic variables have a significant impact during the crisis period.

Beirne and Fratzscher (2013) study the determinants of sovereign risk. They use government bond yield spreads, Sovereign CDS spreads and S&P sovereign ratings as the three main measures of sovereign risk for thirty one emerging and advanced countries over the period 1999 to 2011. They employ the debt to GDP ratio, fiscal balance to GDP ratio, real GDP growth, current account balance and the VIX Index as possible fundamental factors. Their results show that higher public debt, lower growth rate and a worsening of the fiscal balance and the current account are all possible drivers of sovereign risk.

Ismailescu & Phillips (2015), study among other things, the determinants of CDS trading initiation for sovereign entities. In total, they study what factors determine the initiation for the 63 countries in their sample over the period: January 2001 to September 2010.They assemble both local and global factors in their analysis. The aggregate local stock market return, local stock market volatility, exchange rates, foreign currency reserves, sovereign credit rating, Gross domestic product, Global Index return, equity risk premium, volatility risk premium, default spread, the turnover variable, and external debt to obtain a regional and global CDS indexes. Their results show that the volatility of the local equity index, global and regional CDS indexes are the most dominant factors explaining CDS initiation.

Also, employing a Markov Switching Model, Chan and Marsden (2014), use a set of firm level, economy wide and theoretical determinants on North American investment grade and high yield credit default swap indices, make a number of important findings. First, during both volatile and tranquil periods, spreads have a positive relationship with the market wide default premium, VIX and Treasury bond yield. The underlying stock market returns and the Fama-French's High-Minus-Low factor loading are all negatively related to the spreads. Also, they find that the determinants of CDS spreads are regime dependent.

Gibson, Hall and Taylas (2012) focus exclusively on understanding the credit spreads in Greece. Their paper focuses on understanding the yield spread of ten year Greek bonds over a comparative German bond and to what extent economic factors determine the rising yields. Using credit ratings, they analyze its contribution to risk premia. To analyze the determinants of the spreads, the potential factors they employ are the measures of fiscal situation, trade and current account variables, rate of change of monthly coincident indicator and external factors such as the price of oil. The results indicate the fiscal and oil price variables are small but significant and the trade and current account variables are insignificant in explaining the credit spread.

Appealing to Regime switching analysis, Chun, Dionne and Francois (2014) study the determinants of credit spreads by differentiating among regimes and compare it with a single regime model to better understand the differences in significance of the factors across regimes. They specify the following regime specifications: Economic regime, monetary regime, supply credit regime and the endogenous credit regime. Their results indicate that the significance of the determinants of credit spreads is different across the different regime classifications and that regime based models outperform the single regime model.

Calice, Mio, Sterba and Vasicek (2015) focus on the determinants of the sovereign CDS term premium. They derive the term premium as the difference between the 10 year and 5 year CDS spreads. By adopting a Markov switching unobserved model, they decompose the CDS term premium into two components: a stationary component corresponding to a theoretical CDS term premium and an unpredictable component of the term premium. The research assembles a set of possible economic and financial market variables as possible determinants of sovereign spreads over a daily basis. The results indicate among other things, that for the five countries in their sample, the dominant factor driving the CDS term premium is the domestic CDS market liquidity. Also countries in the EMU are sensitive to the global risk aversion variable whiles other countries in the sample show no significant response to global risk.

On the comparable long term government bond yields, Ichiue and Shimizu (2015) study the determinants of bonds yields for ten advanced countries including Japan. The authors use yearly data covering the period 1990 to 2010.The authors use the long term forward interest rates as a proxy for the long term government bond yields in a panel data framework. Various variables related to fiscal conditions, foreign borrowing, labor productivity, demographics and labor productivity are employed. The result from the analysis of the Japanese government bond yields shows that an increasing gross government debt to GDP ratio increases the long term interest rates. Also, the large foreign assets of the Japanese government, the rapid aging of the population and global factors causes interest rates to fall.

2.3 METHODOLOGY

For a considerable period of time, linear models continued to be the major models used in studying financial theories. There are those who question the ability of these models to effectively analyze the non-linear and dynamic patterns of various financial assets. A closer look at Credit default swap spreads provides evidence on how it fluctuates at higher levels while remaining persistent during financial crisis and its ability to remain stable during "normal" periods.

Modelling such time series requires the use of non-linear models such as the Markov regime switching methodology. Regime switching models facilitates the identification of the values and at what points a variable switches from one regime to the other, providing an opportunity to analyze its behavior or pattern in a given state.

This study employs the Markov regime switching methodology in analyzing the monthly first differenced 5 year Japanese Sovereign CDS Spreads (JCDS).

The corresponding model is given as;

$$\Delta CDS_t = \beta_{i,0} + \beta_{i,1}\,\Delta CompIndex_t + \beta_{i,2}\,\Delta NikkeiReturns_t + \beta_{i,3}\,\Delta JGBY_t + \beta_{i,4}\,\Delta TOT_t + \beta_{i,5}\,\Delta VIX + \beta_{i,6}\,\Delta IntRate_t + \beta_{i,7}\,\Delta DefRisk_t + \varepsilon_{i,t} \qquad (1)$$

Where $i \in \{1, 2\}$; CompIndex is the leading index of the composite Index of Japan; Nikkei Returns is the Nikkei 225 Total Return Index, JGBY is the 10 year Japanese Government bond yields, TOT is the terms of trade variable; VIX is the Implied Volatility Index on the S&P 500, IntRate is the 10 year US treasury Rates and the DefRisk is the difference between Moody's Corporate Baa and Aaa Bond yields.

2.4 DATA

The sample starts from January 2004 to March 2014 using monthly Japanese sovereign credit default swap (JCDS) data obtained from Markit Limited. This sample period covers and extends beyond the global financial crisis and the recent Euro sovereign crisis which facilitate our empirical work on examining the regime switching behavior of the determinants. Figure 2.1, shows a plot of the monthly 5year Sovereign CDS spreads for Japan.

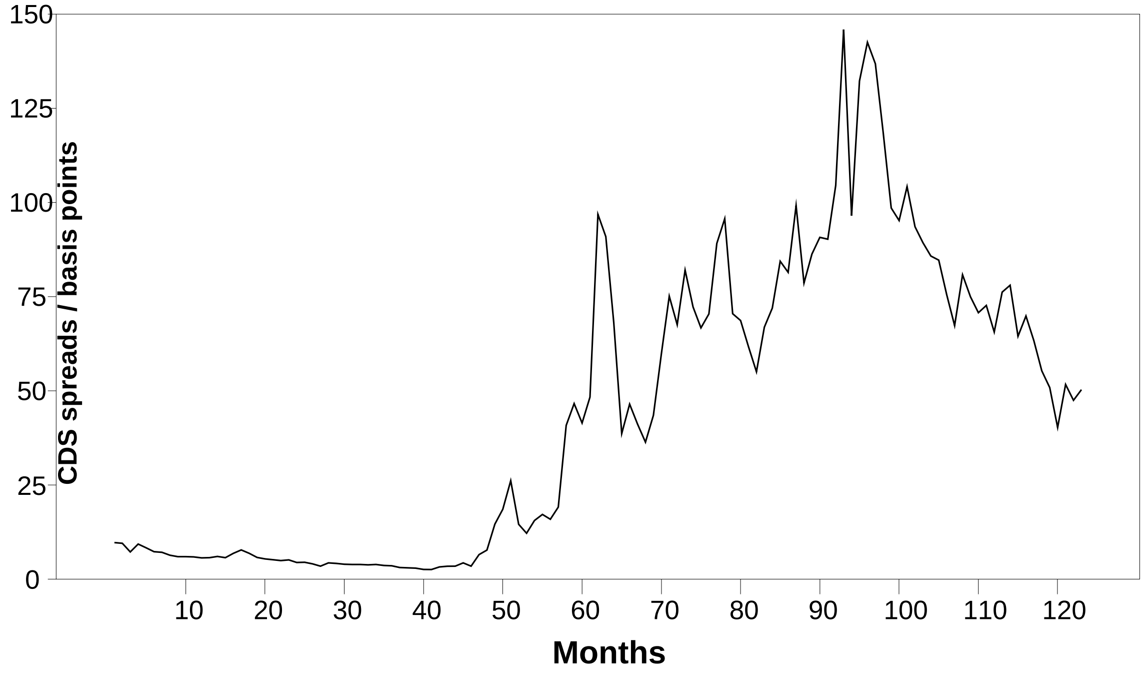

Figure 2.1 Plot of 5 year Japanese sovereign CDS spreads (2004 – 2014)

It could be observed that the CDS spreads shows sporadic increase during the time of the global financial crisis (2007-2009) and further peaks during the Great East Japan Earthquake through to the European sovereign Crisis.

Table 2.1 reports the descriptive statistics for the data. From the table, it could be noted that the mean of the CDS spreads is around 44 bps with a standard deviation of 39.The minimum CDS spread was about 3 basis points in the less volatile period to a maximum of about 146 basis points in the volatile period. This indication of the fluctuations in the Japanese sovereign CDS market requires a modelling methodology that captures this dynamics. The Composite Index variable takes on a mean of around 106.The Implied volatility variable has a mean of 20 with fluctuations ranging from a minimum of 10 to a maximum of 60.

Table 2.1 Descriptive Statistics

Series	*Obs*	*Mean*	*Std Error*	*Minimum*	*Maximum*
JCDS	123	44.063	39.074	2.643	145.930
CompIndex	123	105.941	8.741	78.4	116.4
TOT	123	1.043	0.159	0.831	1.420
JapGBY	123	1.266	0.358	0.492	1.956
NIKKEIReturns	123	15353.56	3541.741	9510.01	22284.61
IntRates	123	3.488	1.016	1.53	5.11
DefRISK	123	2.6762	0.9378	1.55	6.01
CBOE	123	20.0828	9.1060	10.42	59.89

JCDS is the 5year Japanese Sovereign CDS; CompIndex is the leading index of the Composite Index of Japan; Nikkei Returns is the Nikkei 225 Total Return Index; JapGBY is the yield on the 10year Japanese Government Bonds; TOT is the Terms of Trade; CBOE is the Implied Volatility on the CBOE; IntRate is the 10 year US Treasury rate; DefRisk is the difference between Moody's Corporate Baa and Aaa Bond yields.

Other descriptive statistics for the other seven variables are evident in the table. We extract monthly data from daily data by taking the values of the last trading day of the month. We follow existing literature by using 5year CDS spreads which have been shown to be the most liquid among the various maturities in the CDS market. In total, 123 observations for each of the variables are used in the regression.

Testing for the stationarity of our CDS spreads, the results indicate that the Japanese CDS spreads are non-stationary. To account for the unit root in our data, the first difference of the logarithm of all the variables are used in our analysis. A Stationarity test on the first differenced data confirms that our data is stationary.

This analysis employs several country specific and global factors in analyzing the spreads. First, we assemble several global factors that have already been employed in earlier studies on sovereign CDS spreads. Our inclusion of global factors stem from the fact that the Japanese Sovereign CDS market is dominated by foreign investors (Shino and Takahashi, 2010) and also these variables have been established through earlier studies to have significant impact on CDS markets worldwide.

The variables include, Chicago Board Options Volatility Index (VIX data), an Implied volatility index, which has been established to be a global event risk factor (investor risk appetite) is downloaded from the Chicago Board of Exchange (CBOE) website, the 10year US Treasury rates is used as a proxy for World Interest rates and the difference between the Corporate bonds with Moody's rating of Baa and Aaa yields is used to proxy for US default spread. The latter two variables are downloaded from FRED Series and are in percentage points.

The analysis would be incomplete without the inclusion of country specific factors. Even though earlier results from Pan and Singleton (2006) show that the Implied Volatility on the Nikkei Index has a potential impact on Japanese CDS spreads, we exclude it from our analysis due to its high correlation with the Implied Volatility on the CBOE.

To cover for the state of the Japanese economy, we include the Nikkei 225 Total Return Index. The argument follows that a positive and expanding economy is an indicator of the ability of a country to repay its debt and should reflect in a lower default risk and a corresponding lower CDS spreads for the country. Therefore, we expect a negative relationship between the Nikkei 225 Total Return Index and the CDS Spreads.

This paper includes the Leading Index of the Composite Index (LCI) obtained from the website of Cabinet Office of Japan. These data provided on a monthly basis corresponds to the results of several surveys conducted on the overall business conditions in Japan. The leading Index anticipates changes in the direction of the economy. According to the website, the Composite Index provides a quantitative measure of economic strength in Japan. The expectations of a positive signal in the economic strength of

Japan should result in a reduction in the credit spreads .The argument follows that positive expectations in the economic strength of a country would result in a reduction in CDS spreads.

The yields on the Japanese Government 10 year Bonds are included in the analysis. The expectation is that an increase in yields should result in decrease in credit spreads.

As argued in Hilscher and Nosbusch (2010), an increase in a country's terms of trade (TOT) is an indicator of an increase in exports over imports. With Japan been an export driven country, a positive terms of trade is both favorable to the local economy as well as sending a positive signal of the country's ability to repay its debt. Thus, an increase in the TOT variable should reduce the default risk of Japan leading to a reduction in CDS spreads.

2.5 RESULTS

We run equation (1), allowing for the coefficient estimates for all the explanatory variables to vary. Table 2.2 and 2.3 presents the regression estimates and its significance levels. There is strong evidence that the global variables have a strong impact on the Japanese Sovereign CDS spreads. The Implied Volatility on the CBOE Index (VIX) exerts strong positive significance on Japanese Sovereign CDS spreads in both regimes. In the volatile regime, a percentage point increase in the VIX results in ,on average, a 1.09bps increase in the spreads of the Japanese sovereign CDS.

These are consistent with earlier findings (as in Chan and Marsden (2014); Alexander and Kaeck (2008)) who find a positive relationship between VIX and CDS Indexes. Though the VIX show a positive impact on CDS spreads in the less volatile regime, the significance reduces to a 1% level and magnitude of the coefficient reduces as compared to the volatile regime. In effect, a percentage point increase in the VIX would lead to a 0.23bps increase in CDS spreads. This reaffirms existing findings of the importance of the VIX as a global factor that gauges investor risk.

Existing research show mixed results on the expected sign for the Interest rate variable. The 10 year US Treasury yield shows a positive sign which is consistent with those found by Arora and Cerisola (2001) ; Dailami et al. (2005); Hilscher and Nosbusch (2010). In the volatile regime, a percentage point increase in the Interest rate will result in, on average, a corresponding 1.67 bps increase in CDS spreads. The magnitude of the coefficient is larger in the volatile period than in the less volatile regime. In that, in the normal regime, a percentage point increase in interest rate would result in, on average, a 0.40 bps increase in credit spreads in the normal regime.

A possible interpretation of the positive sign could be that, an increase in Interest yields signals a positive economic outlook in the USA and encourages capital flights from other countries into the U.S. For countries with high public debt, like Japan, any further purchases of U.S government bond will move capital from Japan to U.S and would send a signal to CDS investors (dominated by foreign investors) on the possibility of the Japanese government not honoring its obligations. Since, the dominant players in the Japanese CDS market do not own the underlying government bonds. In other words, they speculate on the default of Japan. Therefore, any increase in interest rates in the US, would cause capital flight out of Japan, resulting in an increase in demand for Japanese CDS. Such an increase in demand would cause the CDS spreads or prices to rise. This may explain the positive relation between U.S interest rates and Japanese CDS spreads.

Similarly, when U.S default risk increases, we expect credit spreads to widen. Results show that in the normal regime, the default risk variable has a positive and highly significant impact on the Japanese Sovereign CDS spreads. On the other hand, in the volatile regime, despite showing a weak 10% significance, a percentage point increase in the default risk of the US would on average result in a 0.60 bps increase in spreads. In contrast to the other global variables; the size of the coefficient reduces. Specifically, a percentage point increase would result in a 0.98bps increase in CDS spreads.

Table 2.2

Results for Regime 1

Results from the Regime Switching Markov Switching Model			
Regime 1			
	Estimate	***Std. Error***	***P-values***
(Intercept)	***-0.0060***	***0.0110***	***0.5854***
	(-0.5455)		
CompIndex	***-1.0182***	***0.5223***	***0.0512***
	(-1.9495)		
NikkeiReturns	***-0.5687****	***0.2549***	***0.0256***
	(-2.2311)		
JGBY	***0.1555***	***0.1251***	***0.2138***
	(1.2430)		
TOT	***-0.0061***	***0.9037***	***0.9945***
	(-0.0068)		
VIX	***0.2250 *****	***0.0715***	***0.0016***
	(3.1469)		
IntRate	***0.3996 ****	***0.1704***	***0.0190***
	(2.3451)		
DefRisk	***0.9856 *******	***0.2000***	***8.308e-07***
	(4.9280)		
Adj.R2	***0.52***		

This table reports the results Regime 1 with the First differenced 5 year Japanese CDS spreads .The numbers in parenthesis represent the t-statistics. The data period covers for January 2004 to March 2014.The *** , **and * represents the 0.1percent ;1 percent and 5 percent significance levels respectively. Regime 1 and 2 are the normal and volatile periods respectively.

Table 2.3

Results for Regime 2

Results from the Regime Switching Markov Switching Model			
Regime 2			
	Estimate	***Std. Error***	***P-values***
(Intercept)	***0.1398 ******	***0.0267***	***1.641e-07***
	(5.2360)		
CompIndex	***-2.6609 ****	***1.2221***	***0.0294***
	(-2.1773)		
NikkeiReturns	***-2.5476******	***0.5215***	***1.03e-06***
	(-4.8851)		
JGBY	***-1.3657******	***0.3171***	***1.656e-05***
	(-4.3068)		
TOT	***-1.5377***	***1.6003***	***0.3366***
	(-0.9609)		
VIX	***1.0884******	***0.1727***	***2.933e-10***
	(6.3023)		
IntRate	***1.6725******	***0.5080***	***0.0009***
	(3.2923)		
DefRisk	***0.6024***	***0.3586***	***0.0857***
	(1.7182)		
Adj.R2	***0.89***		

This table reports the results of Regime 2 with the First differenced 5 year Japanese CDS spreads .The numbers in parenthesis represent the t-statistics. The data period covers for January 2004 to March 2014.The *** , **and * represents the 0.1percent ;1 percent and 5 percent significance levels respectively. Regime 1 and 2 are the normal and volatile periods respectively.

A possible interpretation would be, in volatile regimes, investors are more concerned with the possible default risk of the country they have invested in, Japan. Thus, they are less concerned with the default indicators in the US market.

The results indicate that the global factors are significant in varying degrees in both regimes, emphasizing the importance of these variables in explaining Japanese Sovereign CDS spreads.

Turning to the results from the local factors, the impact is more pronounced in the volatile regime than the normal regime. Considering the fact that expectations play an important role in investor decisions. The Composite Index, an index constructed from a survey on economic sentiments should have an impact on credit spreads. An improvement in investor economic sentiments would result in a lower credit spreads. Specifically, in the normal period, a one percentage point increase in economic sentiment reduces credit spreads by 1.02bps whereas in the volatile period it results in a 2.66bps decrease and the significance increases to a 1 percent level.

The Nikkei 225 Total Return Index is used to proxy the state of the Japanese economy. It assumes significance in both regimes and like other variables, the size of the coefficient is larger in the volatile regime than the normal regime. In effect, a percentage point increase in expectations of the state of the economy would result in a 0.57bps decrease in sovereign spreads in the normal period. The magnitude of the coefficient increases in the volatile period where a percentage point increase in the Nikkei 225 Total Return Index would result in a 2.55bps reduction in CDS spreads with the significance increasing to a 0.1 percent.

Though, yields on Japanese government bonds historically have remained low, during volatile periods it plays an important role in investor decisions. It remains insignificant in the normal regime .In the volatile regime a rise in the yields results in a reduction in the CDS spreads. Our result is consistent with findings of Fender, Hayo and Neuenkirch (2012) in other markets. The authors find that an increase in the US 3–month treasury yields result in a decrease in CDS spreads. In this research, in the volatile regime, a percentage point increase in the Japanese government yields would result in a 1.36 bps reduction in CDS spreads.

The Terms of Trade variable (TOT) exhibits a negative sign in both regimes. An indication that when the Terms of trade of the country improve, Japanese government would be able to repay its debt which would result in a lower credit spread. However, its impact remains insignificant in both regimes.

2.6 DISCUSSION

Our results are consistent with existing literature that have found strong evidence that the coefficients in the volatile regime tend to be higher than those in the normal regime (as in Guo and Newton (2013); Alexander and Kaeck (2008)).The statistical importance of our model is on average around 89% in the volatile regime as compared to a 52% explanatory power in the normal period.

The important findings in both regimes could be interpreted from the established fact that, the Japanese CDS market is dominated by foreign investors. They therefore have a mix of both local and global factors that influence the premium. Thus, during both periods they tend to access and appraise their risk exposure by looking at the global variables with the exception of the default risk variable which assumes more significance in the normal regime than the volatile regime.

Also, the Implied volatility on the CBOE Index and the World interest rate variable proxied by the 10 year US treasury yields are highly significant. During volatile periods (smoothed probability associated with this regime is shown in Fig.2.3) investor uncertainty sets in.Thus,it is no surprise that more variables become more highly significant in this period as compared to the normal period(smoothed probability associated with this regime is shown in Fig 2.2).

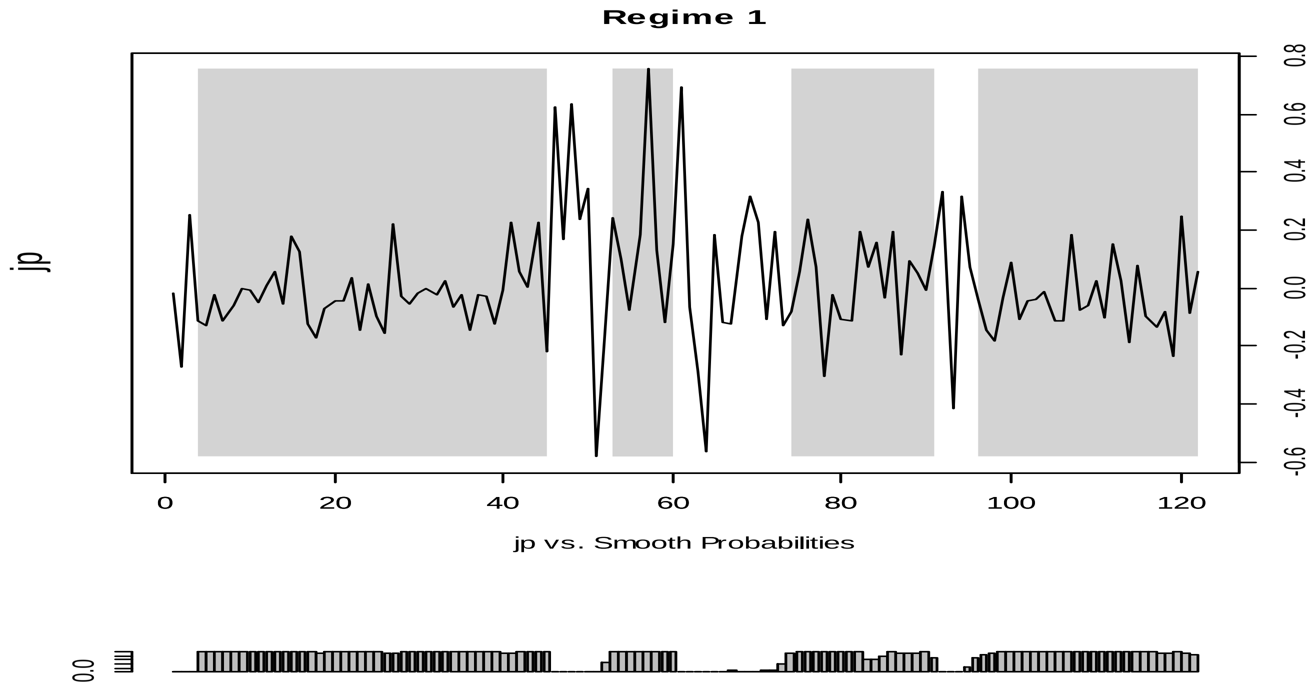

Figure 2.2 Smoothed probabilities of the observations associated with the less volatile regime.

The “jp” is the 5year Sovereign log first differenced CDS spreads

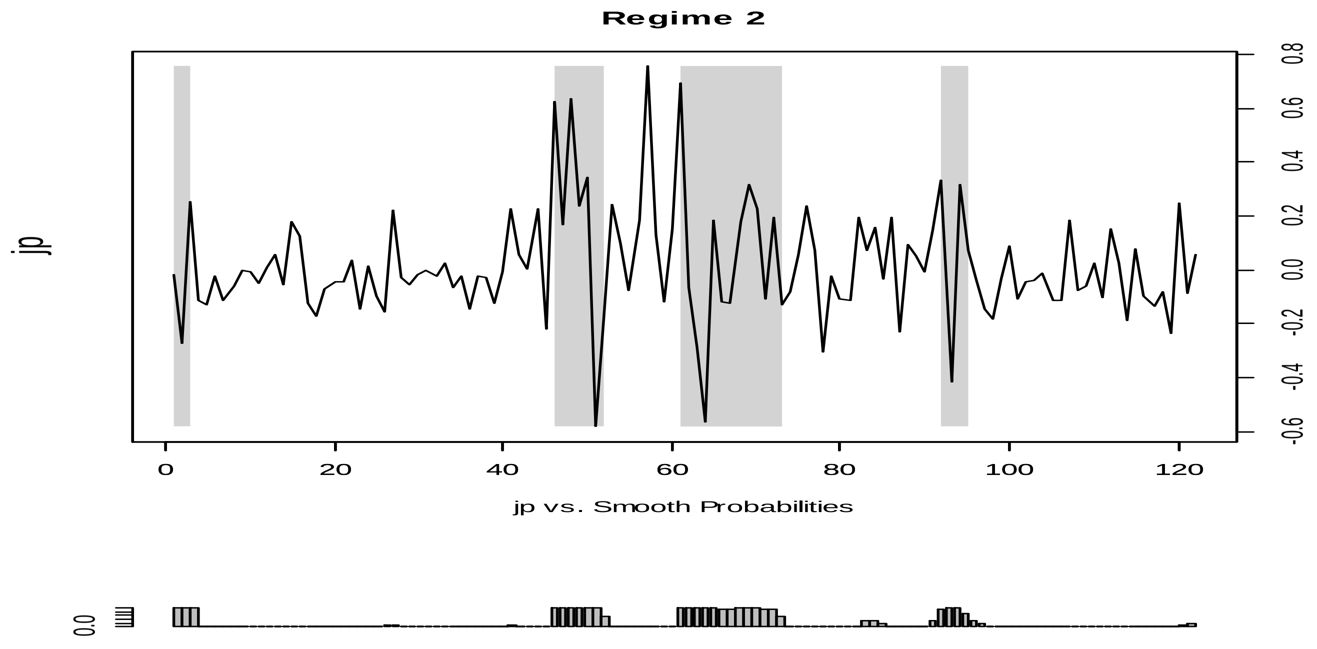

Figure.2.3 Smoothed probabilities of the observations associated with the volatile regime.

The “jp” is the 5year Sovereign log first differenced CDS spreads

2.7 CONCLUSION

Research on sovereign credit default swaps has increased in the last decade, more or less, due to its perceived role in recent crises. Studies on this financial instrument remain limited in comparison with other financial products especially in the Japanese Market. This study aimed to fill this void by analyzing its determinants in a Markov regime switching framework. Appealing to several global factors that have been used in earlier studies and a host of local variables, the following conclusions are drawn:

Firstly, the results suggest that the Japanese Sovereign CDS spreads are more influenced by global variables than country variables. They global determinants assume more significance in both regimes than the local factors. This is in line with established fact that the dominant investors' in the Japanese market are mostly foreigners.

Secondly, the results from the analysis of the local variables indicate that they are more influential in the volatile regime than the normal regime. This may be due to foreign investor uncertainty in the face of extreme markets volatility. Indicating that during volatile regimes, investors access and emphasize the importance of country specific factors in their investment decisions.

Finally, consistent with earlier studies, the impact and size of the variables are more pronounced in the volatile regime than the normal regime. These results not only emphasize the importance of using nonlinear models in finance but also shed light on the factors influencing Japanese credit default swap spreads. The results are useful for researchers' and practitioners alike.

In sum, determinants of the Japanese CDS spreads are regime specific and there should be more emphasis on the use of non-linear models such as Markov switching models in financial modelling.

Chapter 3

Contagion in the Sovereign credit default swaps market

3.1 INTRODUCTION

The Euro area sovereign crisis has generated interest among policy makers and researchers on the linkages and transmission mechanisms among assets. By March 9^{th}, 2012 the International Swaps and Derivatives (ISDA) EMEA Determinations Committee has agreed that a Restructuring credit event has occurred for Greece. The total net exposure bought or sold on the Greek sovereign debt was approximately $3.2 billion as of March, 2012(ISDA, 2012). In the event of such a credit event, protection buyers would have to be settled based on the terms of agreement, in most cases, after the recovery rate has been established. The crisis in Greece has spread out to other countries in the Euro area and existing literature have established Spillover and or Contagion effects among the Euro - area countries.

Though the literature on what constitutes contagion is mixed, there are some generalizations that can be made. Then ECB Vice President, Vitor Constancio (2011) in a keynote address, outlines four main criteria for identifying Contagion as when " (1)the transmission is in excess of what can be explained by economic fundamentals ; (2)the transmission is different from regular adjustments observed in tranquil times; (3) the events constituting contagion are negative extremes and (4) the transmission is sequential for example in a causal sense.

According to Gomez and Rivero (2014), there are two competing theories on contagion. The fundamental based contagion and the pure contagion. The former is when the countries are interconnected through economic fundamentals. Whereas the pure contagion theory argues that contagion could occur due to market imperfection or asymmetric information on the part of international investors.

Shino and Takahashi (2010) argue that even though a significant proportion of Japanese Government bonds (JGBs) are held by Japanese investors, they have not significantly hedged their positions by buying credit default swaps. Their analysis reveals that the majority of Japanese sovereign credit default swaps are held by foreign investors.

The most intriguing part of a CDS is its use for speculative purposes. In what is commonly referred to as "naked CDS", an investor with no exposure to the reference entity takes a position in order to profit in the event of a default. Japanese government high public debt may have signaled an increased default probability and may be the underlying sentiment for the presence of the high foreign investors in the Japanese CDS market.

More so, the IMF Country report (2011)[2] for Japan, establishes that the Japanese CDS market consists mainly of foreign hedge funds and a possible channel for a global spillover could be through its derivatives markets.

These stylized facts about the Japanese sovereign credit default swap market drives us to analyze the possible contagion from the European markets. As noted earlier, there are several transmission mechanisms.

Common Investors with common asset holdings across various countries could be a potential source of spillover of a crisis. In the face of the crisis in the Euro area, that mostly stemmed from public debt imbalance in Greece, investors that have exposures in countries that have similar or higher public debt like Japan will reassess their risk, rebalance their portfolio leading to a possible propagation of contagion.

In this paper, we argue that the mix of investors and a common investor base, for a given asset across countries, is a potential channel of propagation for contagion. Countries with higher foreign investor ratio coupled with common holdings in a given asset class are susceptible to contagion from a crisis in another region. In this study, similar to Alter and Beyer (2014), contagion occurs when there are spillover effects or there are excess interdependencies after the exogenous common factors affecting the credit default swap market both regionally and globally have been controlled for.

[2] IMF COUNTRY REPORT No.11/182 available on http://www.imf.org/external/pubs/ft/scr/2011/cr11182.pdf

The paper assesses contagion in the sovereign credit default swap markets within the so – called "peripheral" Euro area countries and its possible propagation to Japan. We test this hypothesis by analyzing data on sovereign CDS spreads in a Vector autoregressive model (VAR) whiles controlling for exogenous common factors. The interdependencies and spillovers between the sovereign countries are analyzed using an Impulse response function and Variance decomposition analysis after the VAR(p) estimation.

The remainder of the paper is structured as follows. In the next section, we review the existing literature. We follow to discuss the data and our methodology in Section 3 and 4. Results are presented in Section 5 and we finally draw conclusions in section 6.

3.2 LITERATURE REVIEW

The definitions, results and methodologies used in contagion analysis are mixed.

Focusing on nine Euro area countries, Tola and Wälti (2015), research on financial contagion by differentiating among various shocks in a narrative approach. They use the dynamic system of simultaneous equations methodology. They study the transmission of country specific shocks beyond the limits. Their sample covers nine Eurozone countries: Belgium, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain over the period, 2007 to 2014.Their results show that three-quarters of country specific shocks are transmitted across borders beyond what normal interdependence would have permitted. Their conclusion shows evidence of financial contagion during the Euro sovereign crisis.

Kenourgios (2014) focus on volatility contagion across the US and European stock markets. The paper employs five volatility measures: VIX, VCAC, VDAX, VSMI and VFTSE over 2003 to 2013 sample period. Specifically, they study the conditional asymmetric correlation dynamics between two time periods using a multivariate GJR – GARCH model. Their results show an increase in risk aversion during the early face of the global financial crisis. There is also evidence of contagion in cross market volatilities during the last phase of the European sovereign debt crisis.

Also, Beirne and Gieck (2014) investigate the interdependence and contagion among three asset classes: Bonds, Stocks and Currencies across sixty countries using a Global VAR methodology. Their study uses weekly data from July 1998 to June 2011.The authors establish that the equity markets in the emerging countries are more integrated to the foreign equity market when compared to the integration of the Bond market in emerging markets to their foreign counterparts and the currency market to its foreign counterpart.

In another study, Gorea and Radev (2014) analyze two transmission channels: the financial linkages and the real economy interconnections (proxied by bilateral trade flows).By estimating the joint probability of default of Euro area countries, they conclude that financial linkages are an important channel for contagion only in the periphery Euro area countries (GIIPS). However, the real economy interconnections played a more important role in contagion transmission from the periphery countries to the Euro area countries.

Using two endogenous breakoff tests : the Quandt – Andrews (1994) and the Bai and Perron(1998) to identify structural breaks, GomesPuig and Sosvilla-Rivero(2014) apply a Granger causality test to ten year bond yields of eleven EMU countries. They identified that in the crisis period, there was an increase in causal relationships not only within the peripheral countries but also in the causal relationships from the EMU peripheral countries to the EMU central countries. Their findings prove that there is intensification and Granger causality from the peripheral countries to the central countries.

Mink and Hank (2013) using an event study methodology, examine the impact of idiosyncratic news about Greece on forty - eight European banks stock prices and bond prices of highly indebted countries in the Euro area. The results from the study indicates that news on the Greece bailout has an important impact on the bank stock prices and even on banks without any exposure to Greece. Also, the authors argue that news about the Greece economy also led to abnormal returns in Greek bank stock prices only.

Muratori (2015) use a panel spatial regression methodology to study contagion in the government bond market among ten countries in the Euro-area. The authors study the size of the contagion; track it through different phases and compare its magnitude between the periphery and core countries. The results indicate that there was contagion in all phases of the financial crises in both the core and periphery countries.

Zhang and Jorion (2007) using Credit default swap and stock data study the intra industry response to various credit events. They employ data on Chapter 11 bankruptcy, Chapter 7 bankruptcy and jump events to analyze competitive and contagion effects. Their findings indicate that Chapter 11 bankruptcies have contagion effects and Chapter 7 bankruptcies results in competitive effects.

Kazemi and Ismailescu (2010) analyze the reaction of emerging market economies to credit ratings and the possible spillover effects in the credit default swaps market. Specifically, they analyze the spillover effect that changes in the credit rating of a country have on other countries. Their findings show that positive changes in credit rating have the potential to spill over to other countries than negative events. They identify common creditor and competition in trade markets as possible channels of spillover effects.

Beirne and Fratzscher (2013) study the flow of contagion during the European sovereign crisis. They study three channels of contagion: the fundamental channel, the regional contagion and the herding contagion, by using data from thirty one emerging and advanced countries from 1999 to 2011. They assemble a list of country fundamentals such as the debt to GDP ratio, fiscal balance to GDP ratio, real GDP growth, current account balance and the VIX Index and explore their contribution to fundamental contagion across countries. They find evidence of fundamental contagion and herding contagion among the countries. However the impact of the regional contagion is limited and insignificant during the sovereign debt crisis in Europe.

Focusing on analyzing the channels, Groba, Lafuente and Serrano (2013), use the information content in credit default swaps to study transmission mechanisms both in and outside the European sovereign market. By decomposing the credit default swaps into two components: the risk premium and default risk premium, they test the effect of the distressed economies on these two components. They find that the peripheral risk factor is dominant in explaining the CDS default risk across countries. Furthermore, using volatility measures, the authors also test volatility spillovers between the Periphery EMU countries to non-periphery EMU countries. Their results show that there is a unidirectional causal relationship from the periphery to non-periphery EMU countries. The results indicate that risk is transmitted from periphery to non-periphery countries.

Caccioli, Farmer, Foti, & Rockmore (2015) study the counterparty failure risk and overlapping portfolio exposure channels of contagion. They use quarterly data from Austrian banks over a three year period. By assessing the stress tests of the banks in the network, they conclude that the effect of counterparty failure risk is stable. However, when the counterparty failure risk is combined with the overlapping portfolio risk channel, there is an increase in failure than would be observed. The authors also show that interbank exposures highly amplify contagion.

Focusing on the Asian crisis, Chiang, Jeon & Li (2007), investigate contagion in the Asian region by analyzing nine daily stock return data over the period 1990 to 2003.They employ simple correlation analysis and further use the multivariate GARCH model to derive the dynamic conditional correlations to investigate the possible contagion. Their results find evidence in support of contagion during the crisis. Also, sovereign credit rating changes and market participants played an important role in the increase in correlations during the crisis.

In another study, Alter and Beyer (2014) study the spillovers between sovereign CDS markets and banks in the Euro area. They use daily 5 year sovereign CDS data covering the period, October 2009 to July 2012.Employing a VAR (p) and a subsequent Generalized Impulse functions analysis, they assess contagion in sovereign entities and banks. By aggregating the spillover into a contagion Index, their results show varying degrees of contagion. They also find spillover effects from banks to sovereigns and from sovereigns to banks as well.

Baur & Fry (2009) propose a methodology to test the statistical, economic significance and existence of contagion. They use the returns of stock indexes from eleven Asian countries spanning the period 1997 to 2003.Without specifying the crisis period, contagion and the source country are endogenously determined from the model. They find evidence of contagion across the asset classes but the effects were short lived. Also, common volatility arising durinSg crisis is due to interdependencies rather than contagion.

Rodriguez (2007) use daily stock market returns from five East Asian countries during the Asian crisis and four Latin American countries during the Mexican crisis in a copula methodology framework to study contagion. The author argues that in contrast to correlation analysis, Copulas provides information on the dependence between variables. Their findings indicate a changing dependence between the countries during financial turmoil. Further, the result shows that changes in the increase in dependence vary across countries.

Chander, Patro & Yezegel (2009) study the impact of currency crisis in a given country on cross listed and non -cross listed firms in the crisis originating country. Without measuring contagion directly, they appeal to examining the cross differences between cross listed and non -cross listed stocks to measure what they refer to as “Contagious CL effects”. Various currency crises after 1993 are examined by sampling cross listed and non-cross listed firms from fifteen countries. Their results indicate that cross listed firms experienced more positive effects after a crisis compared to non-cross listed firms in their respective countries. More so, the authors argue the evidence for contagious cross effects is limited.

Using a study period from 2005 to 2010, Kalbaska and Gatkowski(2012), analyze contagion in the credit default swap market in the Eurozone. EWMA correlation analysis and Granger causality tests are employed in analyzing nine sovereigns entities. The result from the EWMA analysis confirms that there was an increase in correlations after the global financial crisis. The Granger causality analysis shows an increase in interdependencies in countries after the global financial crisis as compared to the pre-crisis.

Using monthly data, Arghyrou and Kontonikas (2012) study the EMU sovereign debt crisis. The authors among other things analyze contagion in ten European sovereign entities. Using Principal component analysis, their results show that the variance can be explained by two principal components.

The first principal component is interpreted as the sovereign risk whiles the second principal component represent the divergence between the core and periphery countries in the Eurozone. Their findings indicate that contagion occurred in the later period compared to the earlier period of the crisis.

In another study, Markwat, Kole & Dijk (2009) analyze contagion from the perspective of transmission in stock market crashes. Using daily data, they investigate stock markets in US, emerging markets in Asia and Latin America over the period 1996 to 2007.Using an Ordered logit model, they specifically analyze whether stock markets crashes cause domino effect. Their findings show that for any given country in their sample, a stock market crash occurs, when the daily returns lies below the 5% quantile of the empirical return distribution. They find evidence that stock markets crashes have domino effects. Also, there are interdependencies between stock markets and other asset classes.

3.3 DATA

The sample used in our analysis consists of daily 5year Sovereign Credit default swap (CDS) data for Portugal, Italy, Spain and Greece (PIGS) in Europe and Japan. The daily CDS spread data are obtained from Markit Group and starts from September, 2008 through to March 2012. In this study, we split the sample period into two: the periods covering the Lehman crisis and the European sovereign crisis.

Most researchers agree that the Euro-crisis started during the latter part of 2009.In this study, the Euro sovereign crisis period is assumed to start from November 5, 2009, the day the Greek Prime Minister George Papandreou's announced that Greece's budget deficit for 2009 would be 12.5 percent of GDP through to March 8, 2012,[3] the day the European Central Bank (ECB) reactivated Greek bonds as collateral. To fully understand the dynamics of contagion during different time periods, a period to capture the Lehman crisis is included from September 14, 2008 to November 4, 2009.The end date of this Lehman crisis period is just a day before the start of our Euro sovereign crisis period.

[3] This information is available on the ECBs website "https://www.ecb.europa.eu/ecb/html/crisis.en.html"

Table 3.1 and 3.2 presents the descriptive statistics for the data for both periods. It could be observed that the mean for all the country CDS spreads are higher during the Euro sovereign crisis period than the Lehman period. For all the variables used in the research, in total we obtain 583 daily data for our Euro sovereign crisis period and 285 daily data for the Lehman crisis period.

To control for common exogenous factors that affects Sovereign CDS spreads, we include a list of both global and regional factors. These exogenous factors ; the Implied Volatility Indicator (VIXX),TED spread(TEDD) and 10 year Treasury Constant Maturity Rates (TRATES) variables are downloaded from the FRED website and the EURO STOXX Volatility Index (VSTOXX)[4] and Euro Overnight Index Average (EONIA) rates[5] are obtained from their respective websites.

Table 3.1
Descriptive Statistics for the Euro sovereign crisis period

Series	*Obs*	*Mean*	*Std Error*	*Minimum*	*Maximum*
GREECE	583	2467.666	3383.072	145.354	23188.54
ITALY	583	236.9089	135.7683	73.00198	590.6238
GERMANY	583	53.59741	23.85351	20.361	115.6673
SPAIN	583	257.8411	100.6771	72.32706	485.8465
PORTUGAL	583	587.8402	404.188	58.63242	1656.674
JAPAN	583	87.87144	24.44664	52.02634	159.3118
FRANCE	583	100.1061	54.73507	22.78388	247.309
VIX	583	22.83635	6.850388	0	48
TED	583	-1.41759	0.50298	-2.4	0
TRATES	583	1.043299	0.259116	0	1.4
VSTOXX	583	27.93848	7.520347	18.3588	53.5472
EONIA	583	0.616343	0.303301	0.295	1.715

EONIA represents the Euro Overnight Index rates; VSTOXX is the Euro Stoxx Volatility Index; TRATES is the US 10 year treasury constant maturity rates; TED is the TED spread

[4] EURO STOXX 50 data available at http://www.stoxx.com/indices/
[5] EONIA rates available at ECB Statistical warehouse http://sdw.ecb.europa.eu/

Table 3.2
Descriptive statistics for Lehman crisis period

Series	*Obs*	*Mean*	*Std Error*	*Minimum*	*Maximum*
GREECE	285	159.40	59.68	51.26	295.46
ITALY	285	110.61	44.13	41.89	197.78
GERMANY	285	37.38	18.59	8.37	91.37
SPAIN	285	89.74	28.36	39.79	167.86
PORTUGAL	285	79.82	28.29	40.11	158.33
JAPAN	285	51.66	21.40	16.46	120.02
FRANCE	285	42.26	19.77	11.71	97.87
VIXX	285	38.49	14.40	0	80.86
TEDD	283	-0.32	0.93	-1.9	1.5
TRATES	285	1.15	0.20	0	1.4
VSTOXX	285	39.98	12.70	23.84	87.51
EONIA	285	1.43	1.26	0.32	4.60

EONIA represents the Euro Overnight Index rates; VSTOXX is the Euro Stoxx Volatility Index; TRATES is the US 10 year treasury constant maturity rates; TED is the TED spread.

3.4 METHODOLOGY

Vector Auto regressive models is a modelling framework where the dynamic relationships between variables could be studied without laying recourse to exogenous restrictions. In a simple Bi-variate case, the current value of a variable is influenced by both its own past values and those of the other variable in the system. In this paper, we employ a VAR (p) analysis whiles controlling for common factors that influence Credit default swap spreads both regionally and globally.

As in Alter and Beyer (2014), a multivariate VAR (p) model with exogenous common variable is given as;

$$\begin{bmatrix} \Delta y_{1,t} \\ \vdots \\ \Delta y_{n,t} \end{bmatrix} = \begin{bmatrix} \emptyset_{1,0} \\ \vdots \\ \emptyset_{n,0} \end{bmatrix} + \sum_{1=i}^{p} \begin{bmatrix} \gamma_{11,1} & \cdots & \gamma_{n1,i} \\ \vdots & \ddots & \vdots \\ \gamma_{n1,1} & \cdots & \gamma_{nn,i} \end{bmatrix} \begin{bmatrix} \Delta y_{1,t-1} \\ \vdots \\ \Delta y_{n,t-1} \end{bmatrix} + \sum_{j=0}^{q} \begin{bmatrix} \beta_{11j} & \cdots & \beta_{1kj} \\ \vdots & \ddots & \vdots \\ \beta_{n1j} & \cdots & \beta_{njk} \end{bmatrix}$$

$$\begin{bmatrix} EX_{1,t-j,} \\ \vdots \\ EX_{k,t-j,} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \vdots \\ \varepsilon_{n,t} \end{bmatrix} \quad \ldots.(1)$$

Where ε_t is white noise.

Proper analyses that provide correct estimates for VAR (p) analysis is dependent on an appropriate lag choice.VAR(p) model estimation requires the use of an appropriate lag choice. We test for the persistence in our data by minimizing the Akaike Information Criteria (AIC). In order to obtain an optimal length of the lags we set the maximum to 6. Based on results from our AIC, an optimal lag of 2 is obtained for the Euro sovereign crisis period and a lag of 1 for the Lehman crisis period. We test for the unit root in our data using the Dick fuller tests. Results show that all the Credit default swap spreads data for all countries in our sample are non-stationary.

Research has shown that a VAR (p) analysis using non-stationary variables which are cointegrated in the long run results in spurious estimates. In situations where the variables are cointegrated in the long run, a Vector error correction model should be employed. To ascertain if our non-stationary variables are cointegrated in the long run, we employ the Johansen ML cointegration tests. The results show that the variables are not cointegrated in the long run. The existence of no long run cointegration allows us to run a VAR (p) model whiles controlling for our exogenous variables.

However, estimating a VAR (p) model requires that the variables used are stationary. In econometric modelling, one of the possible avenues to have a stationary time series is to use first differencing. The first differences of our logged variables are used to address the non-stationary issue. The unit root test on the first differenced variables shows all the first differenced variables are stationary. Results for the unit root tests on the first differenced variables are shown in Appendices A and B.

As per our adopted definition of contagion, a VAR (p) model is estimated whiles controlling for the following common exogenous factors: Implied Volatility Indicator (VIX), TED spread (TED) to control for perceived risk in the global economy as in (Gerlach et al (2010); Moratori (2015)), ten year Treasury Constant Maturity Rates, the EURO STOXX Volatility Index (VSTOXX) and Euro Overnight Index Average (EONIA) rates.

As in Alter and Beyer (2014), this strategy is useful in controlling both the common global and regional factors that affect Sovereign Credit default swap spreads and the remaining residuals represent the idiosyncratic part. More so, by controlling for the common factors, this research adopts the definition of contagion as the excess interdependence or the transmission that is in excess of what common factors can explain.

One major challenge in our analysis is how to uniquely identify that the effects of a shock to the other variables in the system are not correlated. A correlated shock poses a challenge in our attempt to explain the responses of the variables to shocks in the system. One possible solution in economic literature is to orthogonalize the shocks. One of the corrective methods is the use of Cholesky decomposition. Cholesky decomposition is a recursive causal structure which is highly dependent on how the variables are ordered. In our analysis, the variable ordering stipulates that values of Greece enter into the current level determination of Spain. Then, the current level of both Greece and Spain enters into the current level determination of Italy, then into Portugal followed by Japan.

The methodologies we use to uniquely ascertain possible contagion effects after the VAR(p) analysis, is in part due to the Impulse response functions (IRF) analysis used by Alter and Beyer (2014) in their study of contagion and the Variance decomposition methodology used by Yang, J et al (2006) to study the international transmission of inflation.

Impulse response functions (IRF) analysis provides a medium to analyze the dynamic interactions between endogenous variables, especially, on how the other variables in the system respond to a shock to another variable. IRF analysis enables us to visually present the path that the responses to a shock to a variable follow.

Further, we analyze the contributions of each country sovereign CDS spreads to the forecast error variance of other sovereign credit default swap spreads by employing the Variance decomposition analysis. Variance decomposition allows us to access the CDS spread variations in a country at time $t + k$ that is due to shocks to the countries in our sample at time t. Further, it allows us to decompose the variations in the CDS spreads of a country that is due to the shocks in every country in our sample. Here we borrow from Alter & Beyer (2014), and calculate the bilateral net spillover effect between two pairs of countries. This enables us to analyze the net spillover effect between any two sovereign pairs in our sample. By definition the bilateral net spillover effect is defined as the difference between innovations sent and received from / to another variable.

3.5 RESULTS

This section presents the results from the analysis of shocks to the Sovereign CDS of countries in our data set. A VAR (p) analysis and its subsequent Impulse Response Function (IRF) and Variance Decomposition methodologies help us to analyze the dynamic interrelationship in default risk and the possible contagion across countries in our sample.

In contrast to earlier studies on contagion which appealed to increase in correlation between two time periods as a measure contagion, Impulse response functions and Variance decompositions provide insights into the dynamic relationship between variables in a system without relying on the magnitude of change between two periods. For comparative purposes and academic curiosity, we present the results for the Lehman crisis and Euro sovereign crisis periods.

3.5.1 EURO SOVEREIGN CRISIS PERIOD

3.5.1.1 *Variance decomposition analysis*

Variance decomposition provides an innovative way for us to analyze the percentage changes in a country's CDS spreads that are attributed to unexpected shocks to the CDS spreads of other countries in the system.

Results from our analysis indicate that Greece is the least affected by the unexpected shocks in other countries CDS spreads in contemporaneous time. In earlier time periods, its variance is affected largely by its own innovations. Even though at later time periods the cumulative effect of other countries is around 6%.However the individual country effects are negligible with Spain contributing about 4% out of the 6%.

We narrow the discussion to the contributions of Greece and Spain to the CDS price variations of Italy, Portugal and Japan. From table 3.3, from the results on Italy, it could be observed that, in total, the shocks to the CDS spreads of other countries affect Italy by almost 79%, with shocks in only the Spanish CDS spreads explaining about 69% percent of the variance in the earlier time periods. Consequently, shocks to the Greek CDS spreads explain about 8% in the later time horizons. On the reverse, the contributions of the shocks from Italy to Spain and Greece are about 2.5 percent and almost negligible for Greece respectively. Thus, the bilateral net spillover effect from Spain to Italy is about 66% and that for Greece to Italy, on average, is about 7.5%.

Table 3.3

Forecast error variance decomposition for Euro sovereign crisis

Step	Std Error	GREECE	SPAIN	ITALY	PORTUGAL	JAPAN
Decomposition of Variance for GREECE						
1	**0.07**	**100**	**0**	**0**	**0**	**0**
2	**0.07**	**95.37**	**3.67**	**0.42**	**0.53**	**0.01**
4	**0.07**	**94.36**	**4.19**	**0.43**	**0.57**	**0.45**
6	**0.07**	**94.34**	**4.20**	**0.44**	**0.57**	**0.46**
9	**0.07**	**94.34**	**420**	**0.44**	**0.57**	**0.46**
12	**0.07**	**94.34**	**4.20**	**0.44**	**0.57**	**0.46**
Decomposition of Variance for SPAIN						
1	**0.04**	**10.38**	**89.62**	**0**	**0**	**0**
2	**0.04**	**9.71**	**85.76**	**2.37**	**0.05**	**2.12**
4	**0.04**	**9.54**	**85.32**	**2.44**	**0.10**	**2.61**
6	**0.04**	**9.54**	**85.29**	**2.46**	**0.10**	**2.61**
9	**0.04**	**9.54**	**85.29**	**2.46**	**0.10**	**2.61**
12	**0.04**	**9.54**	**85.29**	**2.46**	**0.10**	**2.61**
Decomposition of Variance for ITALY						
1	**0.04**	**8.98**	**69.17**	**21.85**	**0**	**0**
2	**0.04**	**8.32**	**69.05**	**19.94**	**0.04**	**2.65**
4	**0.04**	**8.21**	**68.42**	**19.69**	**0.63**	**3.04**
6	**0.04**	**8.21**	**68.40**	**19.69**	**0.64**	**3.04**
9	**0.04**	**8.22**	**68.40**	**19.69**	**0.65**	**3.04**
12	**0.04**	**8.22**	**68.40**	**19.69**	**0.65**	**3.04**
Decomposition of Variance for PORTUGAL						
1	**0.04**	**15.20**	**45.07**	**0.10**	**39.64**	**0**
2	**0.05**	**14.36**	**46.11**	**2.36**	**36.45**	**0.70**
4	**0.05**	**14.02**	**45.66**	**2.45**	**36.71**	**1.16**
6	**0.05**	**14.02**	**45.66**	**2.46**	**36.70**	**1.16**
9	**0.05**	**14.01**	**45.66**	**2.46**	**36.70**	**1.16**
12	**0.05**	**14.01**	**45.66**	**2.46**	**36.70**	**1.16**
Decomposition of Variance for JAPAN						
1	**0.03**	**0.69**	**0.05**	**1.65**	**0.18**	**97.43**
2	**0.03**	**1.59**	**6.74**	**1.76**	**0.17**	**89.73**
4	**0.03**	**1.61**	**7.76**	**2.05**	**0.30**	**88.28**
6	**0.03**	**1.61**	**7.78**	**2.05**	**0.30**	**88.26**
9	**0.03**	**1.61**	**7.78**	**2.05**	**0.30**	**88.26**
12	**0.03**	**1.61**	**7.78**	**2.05**	**0.30**	**88.26**

NOTES: Each panel shows how variance in each country's Credit default swap spreads is explained in percentage points by shocks to other countries in our sample.

Extending the analysis to the Portuguese CDS market, the shocks, in total, from the other countries in our sample explain over 61% of the variance in the Portuguese CDS spreads in the earlier period and about 64% in later time horizons. In the first period, in contemporaneous time, around 15% and 46 % of the variance is explained by Greece and Spain respectively. In later time horizons, their contributions remain stable with the shocks in the Italian CDS influencing the Portuguese CDS spreads by about 2% while's shocks to the Japanese CDS spreads contribute just about 1%. On the reverse, analyzing the contributions of the shocks from the Portuguese CDS spread show it has almost a negligible impact on the variations in the Greek and Spanish CDS spreads.

The Japanese CDS spread variations provide interesting insights. At earlier time horizons, its variations are due largely to its own innovations. At later time horizons, the influence of the shocks in Greece and Spain are felt. This lag in transmission of risk to the Japanese market is due to common investor base. In that, information flow or the transmission of default risk moves from the EU market to Japanese CDS market. On average, about 12% of the variations of the Japanese CDS are due to shocks to countries in the European Union during later time horizons. The Spanish CDS spreads play a leading role by contributing about 8% to the Japanese CDS spreads variations. The shocks to the Greek CDS spread influence about 2% of the variance.

Comparably, the shocks to the Spanish CDS spreads play a bigger role than the contribution of the Greek CDS to the Japanese CDS price variations. On the other hand, shocks to the Japanese CDS contribute a negligible impact on Greek CDS spread variations and about 2.6% to the Spanish CDS variance. The bilateral net spillover effect from Spain and Greece to Japan is about 5.2% and about 1% respectively.

It is interesting to note that the variance of the other countries in the PIGS, are by and large, affected by the shocks in Greece and Spain. This is due to the interconnectedness of countries in the Eurozone. From the results, it could be inferred that during the Euro sovereign crisis, in the CDS market, shocks in the Spanish market had a profound influence in the determination of Italian, Portuguese and Japanese

CDS spread variations. In all the countries, in comparable terms, the shocks in the Spanish CDS spreads played a dominant role in the sovereign CDS price variations.

3.5.1.2 *Impulse Response Functions (IRF)*

Focusing on the Euro sovereign crisis period, an Impulse response function provides insights into the responses of other sovereign CDS spreads to an unexpected shock to the error term of the variables in our system. We seek to understand how the crisis in Europe, especially from Greece and Spain, propagated to the CDS market for Portugal, Italy and Japan.

Interpreting the responses to the shocks in an IRF analysis depends on whether the researcher wants to identify the effect of a unit shock to a variable or to ascertain the magnitude of the shocks. In this study, we are interested in analyzing the magnitude of how a one standard deviation shock to the orthogonalized residuals of a sovereign CDS spread affect the CDS price variations of other sovereign CDS spreads in the system.

Furthermore in IRF analysis, if the variables used in the analysis are in logs, as we used in this study, then the responses of the variables to a one standard deviation shock to another variable could be interpreted as percentages. For example, a response of 0.03 of Italian CDS spreads in time *t* to a one standard deviation shock to Spanish CDS spreads could be interpreted as; a one standard deviation shock to the Spanish CDS spreads causes a 3% change in the price variations of Italian CDS in time *t*, if and only if, the input variables are in logarithms.

It then follows that, in figures 3.1, 3.2, 3.3 and 3.4, we have rescaled the responses into percentages since our input variables are in logarithms. To save space, we present the responses of all the countries in our analysis to shocks to the Spanish and Greek CDS spreads. From figure 3.1, Italy, Portugal and Japan respond positively to the shocks to the Spanish CDS at the earlier time horizons.

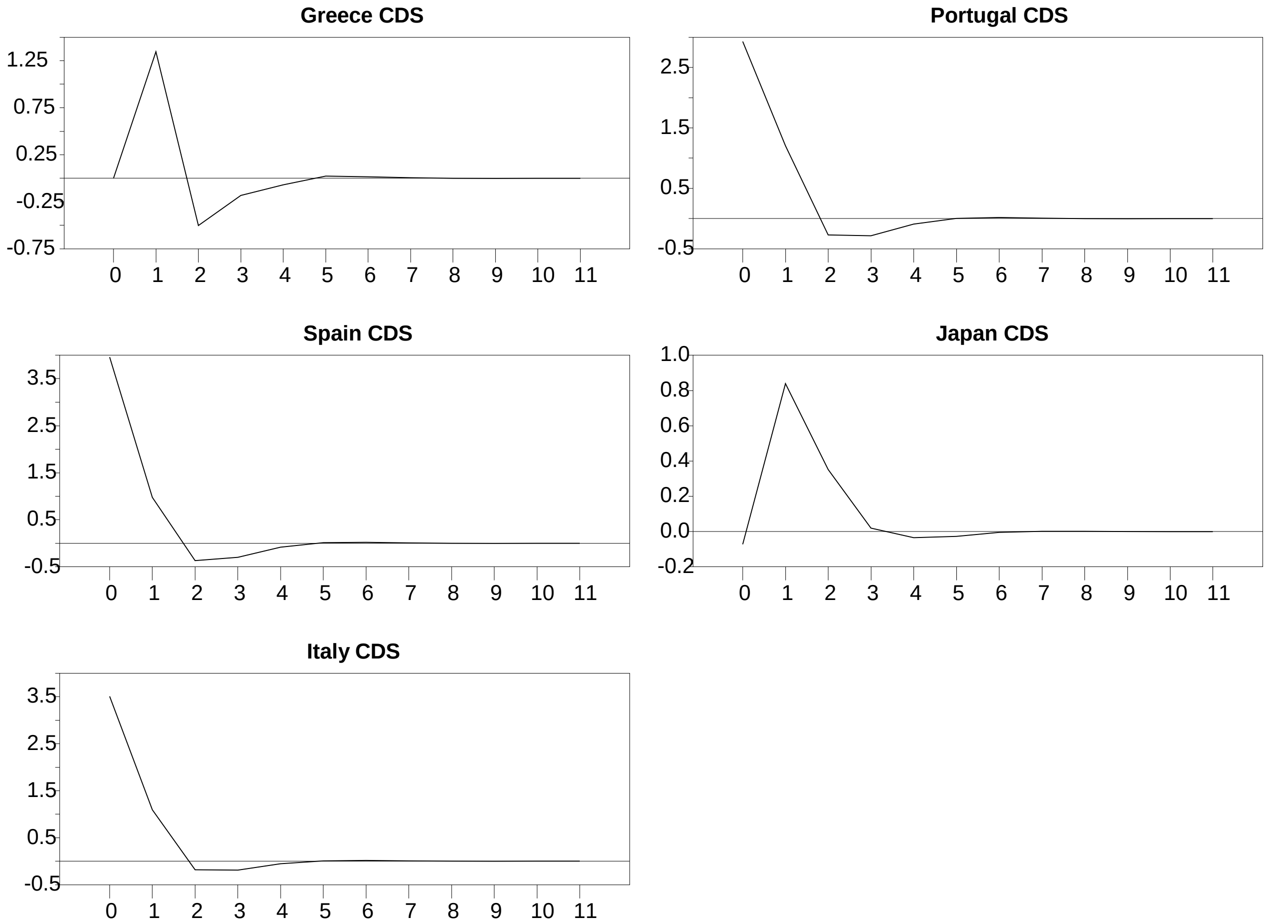

Figure 3.1 Responses to a one standard deviation shock to the Spanish CDS during the European sovereign crisis Vertical axis are percentages changes in prices due to a one standard deviation shock.

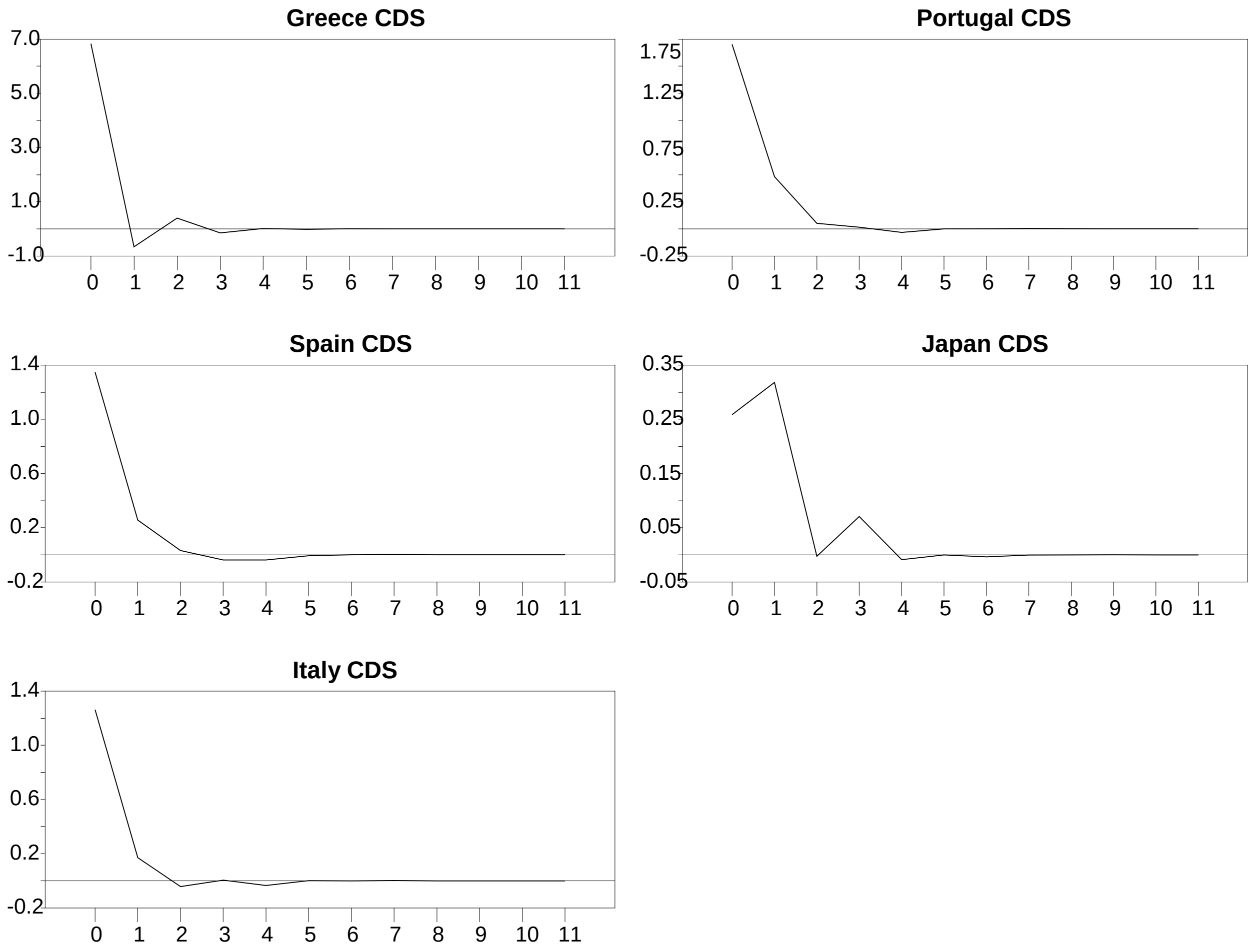

Figure 3.2 Responses to one standard deviation shock to Greece CDS spreads during the Euro sovereign crisis. Vertical axes are percentages changes in prices due to a one standard deviation shock

Even though after the first period, the effects decrease for Portugal and Italy until they begin to respond negatively after the second period. For Greece, it reacts negatively to the Spanish shock after the second period. The responses begin to fluctuate around zero for all the variables due the stability of the system.

Also, the graph shows that as countries in Europe show contemporaneous decrease, the Japanese CDS spreads continue to respond positively. This is an indication that there is a delay or lag in information flow from the European market to the Japanese CDS market. The path and responses of all the country CDS spreads is an indication of the possible contagion from the shocks in the Spanish CDS to these countries.

We extend the analysis to the reaction of our sample countries to shocks in the Greek CDS spreads. Figure 3.2 show that all the countries respond positively to the shocks in the Greek CDS spreads. Even though the effects seem to be positive and the system become stabilized after the fourth period. For Japan the effects seem to follow an upward trend in the earlier time horizon in contrast to the path taken by the countries in our sample. This also shows the gap in information flow, and an indication of the increasing concern of foreign investors in the Japanese market during the crisis in Greece.

3.5.2 LEHMAN CRISIS PERIOD

3.5.2.1 Variance decomposition analysis

This section details the results from our analysis for the Lehman crisis period. The discussion is narrowed to the contagion effects from Greece and Spain to Italian, Portuguese and Japanese CDS market.

Results indicate that innovations from Greece explain its own forecast variance. The contribution of other countries to the Greek variance is negligible with the exception of Japan, which show a modest contribution of 3%.This is partly due to the fact that the recent Euro crisis emanated from Greece before spreading to our countries.

Focusing on the Spanish CDS spreads, innovations from Greece plays a dominant role in explaining the variations of the Spanish CDS spreads. The contributions from Greece is even greater than the innovations from Spanish CDS itself .The shocks in Greek CDS maintain a steady rate of about 57% contributions to the forecast variance of Spanish CDS spreads, even in later time horizons. The contributions of other variables are negligible except Japan which provides about 3% contribution to the Spanish CDS variations. On the other hand, the contributions from shocks to the Spanish CDS to the variations in the Greek CDS spreads are negligible. Thus, the bilateral net spillover effect from Greece to Spain is about 57%.

Analyzing the results for Italian CDS and Portuguese price variations, Greece dominates the contributions as compared to the Spanish CDS spreads. On average about 61% of the price variations in Italian CDS prices and 36 % of Portuguese CDS are explained by Greece in later time periods. The shocks to all the other countries in our sample, in sum, explain about 52% of the variance in the Portuguese CDS contemporaneously in the earlier time. However, the average contributions increases to about 55% in later time horizons.

For Italy, above 69% of the variations are coming from the other countries in the sample in the earlier time periods. However, their contributions declines to about 73% in the later time periods. On the contrary, shocks to the Italian and Portuguese CDS spreads have a negligible impact on the Greek and Spanish CDS spread variations.

Moreover, estimates from the variance decomposition analysis for the Japanese CDS spreads show that most of the changes in its price variations are due to its own innovations. In the earlier period, its own innovations account for about 91% but decreases to about 86% in later periods. The contributions of all countries to the Japanese CDS price variations are modest, averaging around 14% in later time periods. With the highest contribution coming from Greece which showed about 4% contribution in the early period but later increases to about 9%.The shocks in the Spanish CDS, on average, explains about 3% of the price variations in Japanese CDS price variations. On the reverse, the contributions from Spain, in terms of the bilateral net spillover effects, to Japan are negligible. However, the bilateral net spillover effect for shocks to the Greek CDS spreads to Japanese price variations is about 6%.

It is interesting to note that the shocks in the Greek CDS maintained a dominant role in the CDS price variations of all the other countries in the sample. The global nature of the Lehman bankruptcy and the result obtained in our analysis should have been a wakeup call to policy makers on the possible threat that a Greek initiated crisis would have on other sovereign countries.

Table 3.4
Forecast error variance decomposition for Lehman crisis period

Step	Std Error	GREECE	SPAIN	ITALY	PORTUGAL	JAPAN
Decomposition of Variance for GREECE						
1	**0.04**	**100**	**0**	**0**	**0**	**0**
2	**0.04**	**96.29**	**0.53**	**0.36**	**0**	**2.83**
4	**0.04**	**95.83**	**0.56**	**0.36**	**0.01**	**3.23**
6	**0.04**	**95.83**	**0.56**	**0.36**	**0.01**	**3.23**
9	**0.04**	**95.83**	**0.56**	**0.36**	**0.01**	**3.23**
12	**0.04**	**95.83**	**0.56**	**0.36**	**0.01**	**3.23**
Decomposition of Variance for SPAIN						
1	**0.04**	**52.27**	**47.73**	**0**	**0**	**0**
2	**0.04**	**57.12**	**39.38**	**0.17**	**0.34**	**2.99**
4	**0.04**	**57.15**	**38.84**	**0.17**	**0.36**	**3.48**
6	**0.04**	**57.15**	**38.84**	**0.17**	**0.36**	**3.48**
9	**0.04**	**57.15**	**38.84**	**0.17**	**0.36**	**3.48**
12	**0.04**	**57.15**	**38.84**	**0.17**	**0.36**	**3.48**
Decomposition of Variance for ITALY						
1	**0.04**	**59.49**	**9.05**	**31.45**	**0**	**0**
2	**0.04**	**61.24**	**9.20**	**27.28**	**0.18**	**2.10**
4	**0.04**	**61.20**	**9.04**	**26.89**	**0.18**	**2.69**
6	**0.04**	**61.20**	**9.04**	**26.89**	**0.18**	**2.69**
9	**0.04**	**61.20**	**9.04**	**26.89**	**0.18**	**2.69**
12	**0.04**	**61.20**	**9.04**	**26.89**	**0.18**	**2.69**
Decomposition of Variance for PORTUGAL						
1	**0.05**	**31.22**	**17.22**	**2.63**	**48.93**	**0**
2	**0.05**	**36.15**	**15.47**	**2.38**	**45.32**	**0.67**
4	**0.05**	**36.34**	**15.37**	**2.36**	**44.85**	**1.08**
6	**0.05**	**36.34**	**15.37**	**2.36**	**44.85**	**1.08**
9	**0.05**	**36.34**	**15.37**	**2.36**	**44.85**	**1.08**
12	**0.05**	**36.34**	**15.37**	**2.36**	**44.85**	**1.08**
Decomposition of Variance for JAPAN						
1	**0.05**	**4.30**	**3.37**	**0.79**	**0.11**	**91.43**
2	**0.05**	**8.89**	**3.37**	**0.83**	**0.21**	**86.70**
4	**0.05**	**9.49**	**3.37**	**0.83**	**0.21**	**86.11**
6	**0.05**	**9.49**	**3.37**	**0.83**	**0.21**	**86.10**
9	**0.05**	**9.49**	**3.37**	**0.83**	**0.21**	**86.10**
12	**0.05**	**9.49**	**3.37**	**0.83**	**0.21**	**86.10**

NOTES: Each panel shows how variance in each country's Credit default swap spreads is explained in percentage points by shocks to other countries in our sample.

3.5.2.2 *Impulse Response Functions (IRF)*

Shocks to the Spanish CDS spreads, as shown in figure 3.3, exerts a positive response in all countries in our sample. Italy and Portugal show the same response to the path taken by the shocks to the Spanish CDS spreads. The response of the Greek CDS spread was gradual and by the end of the first period has reached its peak. The responses are stabilized around zero by the fourth period. The Japanese CDS spreads respond to the shocks to the Spanish CDS by taking a similar path. The responses become stabilized due to the stationary nature of our data.

The shock to the Greek CDS spreads (figure 3.4) results in a spontaneous increase in all the countries in our sample. Portugal, Spain and Italy respond positively and follow a similar path to that of the Greek CDS. The path shows an immediate and direct transmission of the shocks from Greece to these countries. This is due to the interconnectedness of the countries in the European Union.

A closer look at the response of the Japanese CDS spreads to the shocks to the Greek CDS show a delayed information flow from the shocks. The estimates on the vertical axis show that the Japanese CDS is the least affected by the shocks to the Greece CDS spreads. It justifies the results obtained from the decomposition analysis. The responses show a contemporaneous positive increase in the CDS spreads of the shock receiving countries.

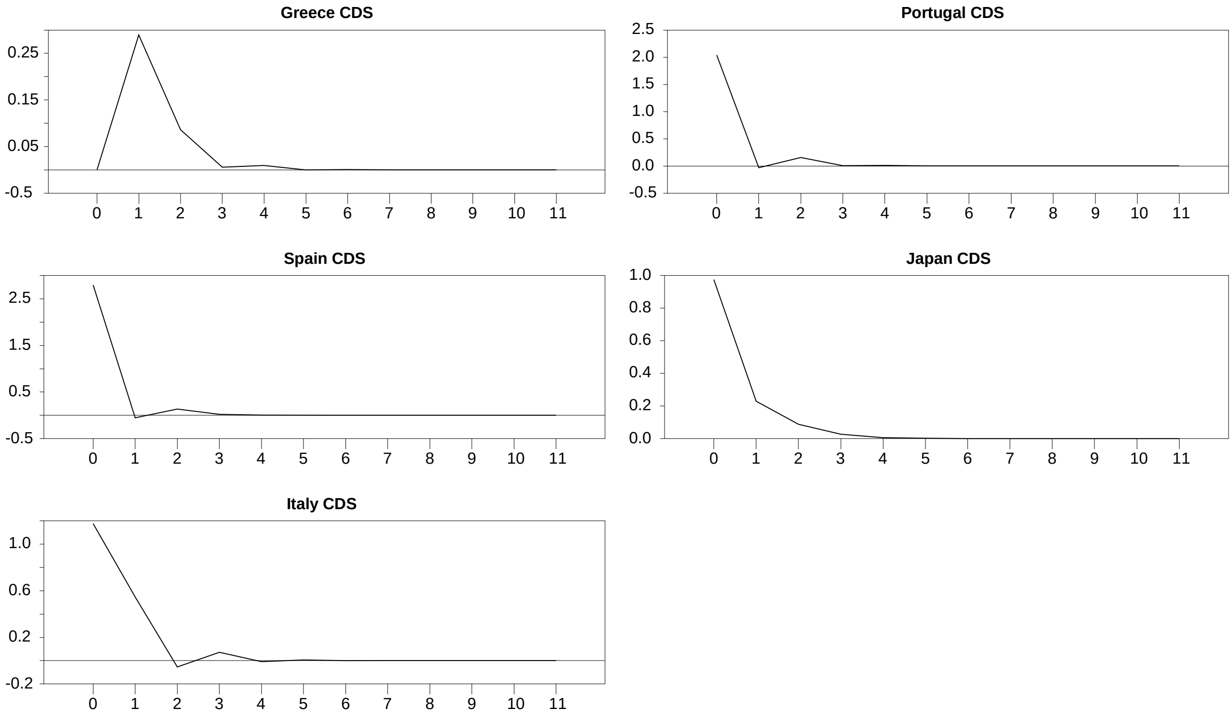

Figure 3.3 Responses to the one standard deviation shock to the Spanish CDS during Lehman crisis
Vertical axes are percentages changes in prices due to a one standard deviation shock.

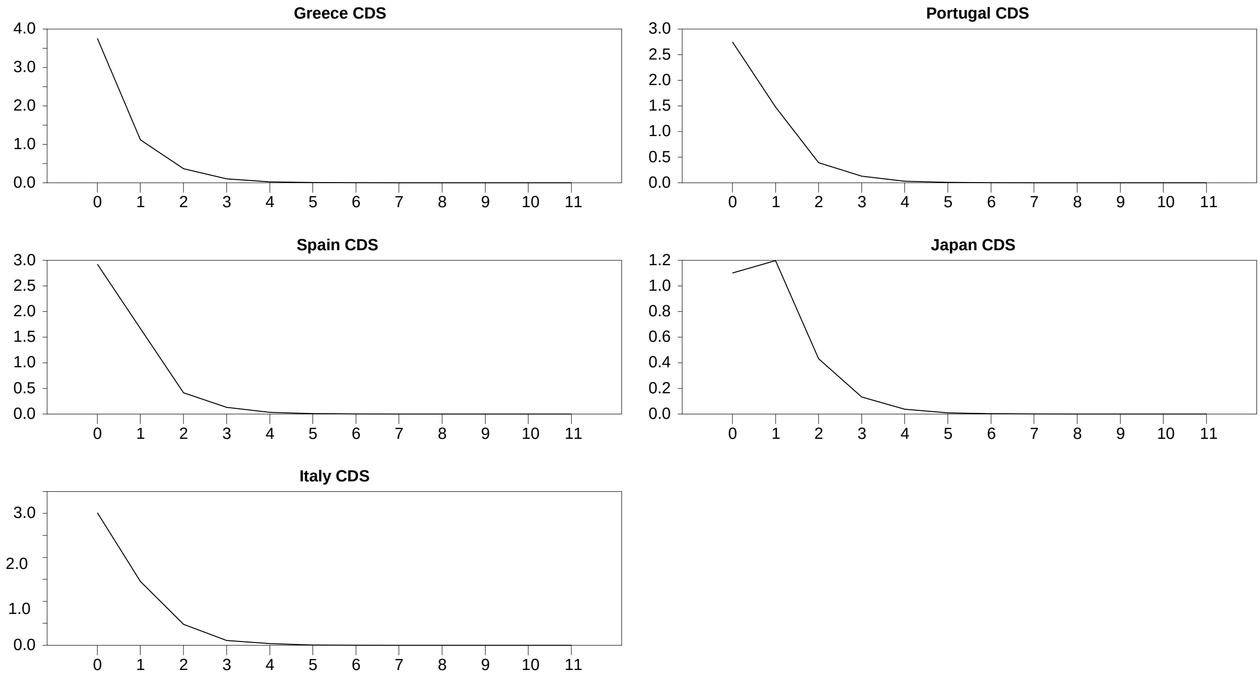

Figure 3.4 Responses to one standard deviation shock to the Greece CDS during the Lehman crisis. Vertical axes are percentages changes in prices due to a one standard deviation shock

3.6 CONCLUSION

The European sovereign crisis has, once again, shown the vulnerability and interconnectedness of sovereign markets. Countries separated by both space and time have experienced the effect of the crisis. This deepens our resolve to understand whether there was propagation of default risk to other sovereign entities within the EU and to countries outside the union, such as Japan.

Sovereign credit default swaps is used by investors to both hedge the sovereign risk associated with government bonds and to speculate on the risk of a country. In countries like Japan, where earlier research has established that foreign institutional investors are the dominant players in the credit default swap market provide an opportunity to study the international transmission of sovereign default risk or contagion from the EU to Japan.

The research focused on understanding the possible contagion in the Sovereign CDS market during two crises: the Leman crisis and the European sovereign debt crisis. The study focused on possible propagation from Greece and Spain to other so-called periphery countries in the EU and Japan. To achieve this goal, we employ a VAR (p) methodology whiles controlling for global factors that have been found to play important roles in the determination in Credit default swap spread.

The results from the analysis provide ample evidence that show a possible contagion from Greece and Spain to other countries in EU area.

Estimates from the variance decomposition analysis demonstrate that investors underestimated the possible impact of the Greek crisis. Though, Greece had varying effects on the variations of the sovereign CDS spreads of other countries.

During the European sovereign crisis, the Spanish CDS spreads to a greater extent was influential on the spread variations of countries like Italy and Portugal. This is similar to results in Kalbaska and Gatkowski (2012) ,who confirm that the effect of the shocks to the Spanish CDS was higher than all other countries in their sample. Similar analysis for our sample during the Lehman crisis show that Greek CDS spreads played a dominant role over the Spanish spreads in the fluctuations of sovereign CDS spreads.

The leading role of the Spanish CDS and the Greek CDS in later time horizons in the spread variations in Japanese CDS depicts the information flow and the possible changes in investor risk appetite. In economies like Italy and Portugal, information flow or transmission of risk from Greece and Spain was contemporaneous and faster because Investors in the CDS markets in the European Union hold the underlying government bonds, and use the CDS contract as hedging tool. Thus, any increase in sovereign risk in Greece and Spain prompts investors on the possible default risk embedded in government bonds in other EU countries. This perceived increase in sovereign risk will result in a reduced risk appetite. Investors will be willing to pay more to insure against risk which results in an increase in the premium they pay, in other words, higher CDS spreads.

For Japan, where the public debt is higher in comparable terms to Greece, uncertainty about the economy will result in a widening of the spreads. There is evidence to support the propagation of risk or contagion from the European market to Japan but the effects are limited. This limited lower contagion effects in the Japanese market may be due to the speculative reasons held by foreign investors in the Japanese markets.

CHAPTER 4

On the CDS – Bond spreads parity

4.1 INTRODUCTION

Research on the dynamics of bond spreads and the associated credit default swap spreads continue to receive attention. The advent of the credit default market as a hedging tool to cover the default risk of a bond issued by a reference entity has been phenomenal. CDS and Bond spreads provide a relative equivalent measure of the credit risk embedded in an entity. In this research, we provide insights about the two markets in Japan.

First, the theoretical no-arbitrage relation exerting that CDS spreads and the spreads between Corporate Bond and a similar floating rate should be the equal for a given reference entity was first developed by Duffie (1999). This parity derives from the pricing of these assets. Credit spreads is the difference between a corporate bond and a comparable government bonds with similar maturities.

Firstly, by sampling some companies from the Japanese market, we test this theoretical no-arbitrage relation between the CDS and credit spreads. In practice, this parity condition may not hold under certain conditions.

Secondly, we further examine whether this non-parity is only in the short term or there is a long term equilibrium relationship between the two spreads. In other words, if the parity relationship holds in the long run for the two assets.

As explained by Blanco, Brennan and Marsh (2005), assume an investor buys a bond maturing in T years with a yield to maturity **y,** then buying a CDS with the same maturity on the same reference entity at a cost of ***pCDS*** eliminates the default risk. It then follows that the net annual return ***y-pCDS*** should be equal to the T year risk free rate (x) in an arbitrage setting. If ***y-pCDS*** is less than or exceeds the risk free rate (x) , an arbitrage opportunity occurs. This pricing relation suggests that the price of buying protection (CDS spreads) should be equal to the credit spreads between a risky coupon bond and a risk free coupon bond.

In an extended analysis, we delve into the relationship between credit rating downgrades and default probabilities that have been documented in literature. By appealing to the Risk neutral pricing framework, we analyze the default component of bond spreads. Specifically, we seek to analyze the effect that credit rating downgrade has on default probabilities of the receiving firm and companies that have direct credit exposure to it.

We focus on the effects that the Tohoku-Chihou-Taiheiyou-Oki Earthquake in 2011 had on Tokyo Electric power Company (TEPCO) and its associated creditors. By computing the one year Risk neutral default probabilities for TEPCO and the 3 mega banks; MUFJ Financial Group, Mizuho Corporation and SMBC Financial Group, which had high credit exposure to TEPCO, we can analyze if TEPCO's credit downgrade led to an increase in default probabilities for the three mega banks.

This paper makes a number of contributions to existing literature. First, it provides insights into the corporate CDS and Bond markets in Japan. Again, the paper enables us to understand how the TEPCO credit crisis in 2011 affected its lenders default risk.

The research proceeds as follows. Section 2 provides a brief review of existing literature. Section 3 focuses on the methodology used. Section 4 looks at the data used in our research. We analyze the results for the theoretical no -arbitrage relation in sub section 5.a and the results of the TEPCO analysis in subsection 5.b. Thereafter, conclusions are drawn in Section 6.

4.2 LITERATURE REVIEW

The results on the theoretical parity condition between the CDS and Bond markets are mixed.

Baba and Inada (2009) explore the price discovery and parity condition between subordinated bonds and CDS spreads for four mega banks in Japan. To analyze the long run equilibrium relationship, a Vector Error Correction model and cointegration analysis are used whiles the bivariate GARCH model is used to analyze the volatility spillovers between subordinated bonds and CDS spreads. They find evidence of cointegration in three out of the four banks. Their price discovery analysis shows that CDS spreads leads the subordinated bonds. Their study concludes that the deviation from parity condition is due to volatility of CDS spreads and Equity returns.

Blanco, Brennan, and Marsh (2005) test the relation between investment grade bonds and CDS spreads for thirty three reference entities. By interpolating between yields, they are able to obtain 5 year bond spreads to match with the corresponding CDS spreads. Their results show that for most US firms in their sample, the no-arbitrage relations holds. However, for some reference entities like France Telecom and FIAT, the equivalence does not hold, the CDS spreads are higher than the bond spreads. They argue that the deviation is due to the difference in contract specification and the interpolated credit spread used in the study.

In another development, Giannikos, Guirguis and Suen (2013) study the price discovery between the Stock, Bond and CDS assets and examine the long run relationship between the Bond and CDS spreads in the U.S.They assemble CDS and Bond data for about ten financial companies. The corresponding bond spreads to match with the CDS spreads with similar maturities is obtained through interpolation. The evidence from their analysis shows a cointegrating relationship between the Bond and CDS markets. They also note that the CDS market leads the Bond market in terms of price discovery.

Analyzing the CDS and Bond spread basis using Asset swap spreads as a proxy for the yield spread, Wit (2006) explores the no-arbitrage relation and the determinants of the basis. The author employs daily data covering the period, January 2004 to December 2005. The study uses over 70,847 observations for the CDS-Bond basis analysis. The results indicate that the CDS and Asset Swap spreads are cointegrated and there is evidence for the equivalent relationship in the long run. Also, the basis for emerging market sovereign reference entities is higher than for corporate reference entities.

Zhu (2006) examines the theoretical no-arbitrage relationship and the lead-lag relationship between CDS and the bond markets, and the factors that determine the basis. Cointegration tests and Vector Error correction models are used to test the long run and the lead –lag relationships respectively from January

1999 to December 2002. Their findings indicate that the parity relationship holds in the long run but there are situations where there are price discrepancies. The author argues that the deviations from parity are mostly due to changes in credit conditions. Results from their study suggest that the CDS market leads the Bond market in price discovery.

In another study, Adler & Song (2010) examine the parity relation between CDS and Bond spreads for emerging market sovereign entities .They construct the implied bond yield spread and use it as an approximation for CDS spreads to test the parity condition. The authors find that the long run relationship does not hold .However, using a novel approach they were able to restore the parity condition between CDS and Bond spreads. This novel approach involved the use of their estimated implied bond yields. However for some countries in Latin America, the parity condition still does not hold.

Analyzing European financial and non- financial firms over the period 2004 to 2008, Ioana, Andersson, and Georgescu (2009), study the existence of a long run relationship between the CDS and Bond markets and explore why price deviations occur between the markets. By focusing their analysis on the period after the financial crisis of August 2007, they separate the credit risk into two components: the "price of risk" and the "amount of risk". Results from the study confirm the no arbitrage relationship between the CDS and Bond market. On price discovery, the evidence shows that European CDS market absorbs information earlier than the Bond markets. They show that during the onset of the financial crisis, the leading role of the CDS in the price discovery process became more dominant.

Aktuga, Vasconcellosb, and Bae (2012) focus on the sovereign market over the period 2001 to 2007. The research tests the price discovery process between sovereign CDS and Bond market for thirty sovereign countries. The authors suggest their results are in contrast to earlier studies on corporate entities. They find that the bond market leads the CDS market in 63% of the cases in their sample.

Longstaff, Mithal and Neis (2005) estimate the default and non- default components of credit spreads. In a reduced form framework, the authors use credit default swaps spreads in the computation of the default component of credit risk. Their findings suggest that default component accounts for the majority of credit spreads. For AAA/AA, A and BBB rated bonds, the default components are 51%, 56% and 71% respectively.

Ando (2014) focuses on estimating the term structure of default probability and recovery rate , by studying the impact of the subprime mortgage crisis using Japanese CDS and Bond data. The author separate the study period into two phases; immediately after the subprime mortgage crisis but before the Lehman crisis and after the Lehman crisis. The author develops a pricing model and tests it on the data. The findings indicate that default probability increased after the failure of Lehman brother's.

Kim and Lee (2014) decompose sovereign bond yields into four: risk free, default risk, risk premium and non - default components. Their findings indicate that when the risk premium and default risk are simultaneously assessed, their explanatory power explains half of the Korean credit spreads. Also, the risk premium played a dominant role in the sovereign debt crisis as compared to the default risk.

On default risk estimation, Kazemi and Mosleh (2012) propose a Bayesian methodology for improving default risk estimation. The authors use the predictions and performance data from rating agencies for the estimation of the parameters of their model. Further, they compare the results from their model to predictions of other models and actual default data. Specifically, the authors compared their results to the estimates from Moody's and S&P's model. The authors argue that their proposed Bayesian model produces much better estimates than the Moody's and S&P models.

In another study, Vallascas and Hagendorff (2011) use Merton distance to default model to study the effect that bank mergers have on default risk of the acquiring banks. They sampled mergers that occurred in the European Union , Norway and Switzerland between 1992 to 2007.The results from their analysis indicates that, on average, mergers do not increase nor do they reduce the default risk of the acquiring firms. However in a handful of banks in their sample, there is an increase in the likelihood of default.

Also, Bharath and Shumway (2008), study the contribution of the Merton distance to default model on several measures. The authors analyze the models explanatory power for probabilities estimation, Credit default swap spreads, yields on corporate bonds and the forecasting of bankruptcy. For comparative purposes, the authors use the Merton model to develop what they refer to as a "naïve model". They examine 1449 firm defaults between 1980 to 2003.Their result show that their "naïve" model performs better in forecasting default than the traditional Merton model. The explanatory power of the Merton distance to default probability to credit default swap spreads and yield spreads seems to be limited.

4.3 METHODOLOGY

Bonds are debt instruments issued by sovereign, municipal and corporate entities to raise funds for their respective activities. When bonds are issued, the issuer pays interest, what is referred to as Coupon, at several frequencies depending on the type of bond issued. The coupon payments could occur once annually, semi-annually or at higher frequencies in a year. The valuation of a bond entails calculating the present value of all expected future payments. A bond that pays coupons (C) and a face value (F) plus an Accrued interest is given as;

$$B_0 = \sum_{k=1}^{N} \frac{C}{(1+R)^k} + \frac{C+F}{(1+R)^{N+\alpha}} \quad \ldots. (1)$$

Where

B_0 = Market price of the Bond

N = the number of coupon payments before the maturity (integer)

τ = time t maturity

α = decimal fraction of time to maturity = $\tau - N = [\tau]$ ($[\tau]$ is a Gauss's symbol)

R = Discount rate

C = Coupon Rate

F = Face value

However, most listed bonds pay coupons semi-annually but if the number of payment periods increase then a more complex modelling is required. Researchers sometimes use continuously compounded yield in bond valuation as in [Duffie,1999]. In a Continuously compounded framework, the market price of a coupon bond is given as;

$$B_0 = \sum_{k=1}^{n} C\, \mathrm{e}^{-\mathrm{RK}} + (C\alpha + F)\mathrm{e}^{-(\mathrm{R}(\mathrm{N}+\alpha)} \quad \ldots\ldots. (2)$$

Where k = yearly coupon payment date,

R = yield to maturity

Recently, practitioners and researchers alike employ the use of risk neutral valuation in bond pricing. A common used numeraire in the continuous time risk neutral valuation (discount bond) is given as;

$$\mathrm{P(t,T)} = E^{Q}\,[e^{-\int_t^T r(s)(ds)}] \ \ldots (3)$$

Where;

(t, T) = is the current time and Time at maturity respectively,

E^Q = Expectations operator under the Risk neutral measure Q,

r (s) = the instantaneous spot rate.

In this study, to examine the parity relationship requires obtaining a bond spread with a similar maturity to the credit default swap spreads. Consequently, to compute the risk neutral default probabilities require an appropriate pricing model. Modelling of default probabilities is a tedious work.

To facilitate our work, we adopt the pricing model developed by Takahashi (2012) in his discussion paper. The author extends the model (3) in continuously compounded coupon rate framework under four types of recovery scheme.

The author argues that, using a yield to maturity expression and a flat term structure, equation (3) can be expanded to derive a government discount bond formula as;

$$P_{GD}(t,T) = \exp(-R(T-t)) = \exp(-R\tau) \quad \ldots.. (4)$$

where τ is the term to maturity.

From equation (4), the author derives a defaultable coupon bond pricing model whiles assuming the recovery of face value at maturity.

If recovery is a realized fraction δ of the face value at maturity. Then,the price of a defaultable coupon bond with $1 is given as

$$P_D(c,0,T) = E^Q\left[I(\tau \geq T)e^{(c-R)T} + I(\tau < T)\delta e^{-RT}\right] \quad \ldots. (5)$$
$$= e^{(c-R-\lambda)T} + \delta(1 - e^{-\lambda T})\, e^{-RT}$$

Where *I(x)* is an indicator function of *x* ; λ is the intensity parameter; E^Q is the Expectations operator under the risk neutral measure Q and δ is the recovery rate.

Given;

C_G = Government Coupon

C_D = Corporate Coupon

τ_G = Government term to maturity

τ_D = Corporate term to maturity

R = Risk free yield on τ_G

λ = One year Risk Neutral default probability

Then, the yield spread relation between a Government Coupon bond and a comparable Corporate Coupon bond under the assumption of Recovery of Face Value at maturity could be derived.

Takahashi (2012) shows that, the Corporate Coupon Bond and Government Coupon Bond prices are derived as:

$$P_G\ (C_G\ ,0,\tau_G\ ) \equiv P\big(C_{G\ ,}\tau_G\big) = \ e^{(c_G\ -R)\tau_G}$$

$$P_D\ (C_D\ ,0,\tau_D\ ) \equiv P\big(C_{D\ ,}\tau_D\big) = \ e^{(c_D\ -R-\propto)\tau_D}; = \ e^{(c_D\ -R-\lambda)\tau_D}\ +\ \delta(1-e^{-\lambda t_D}\ )e^{-Rt_D}$$

$$\therefore\ \frac{1}{\tau_G}\ lnP_G\left(\ C_{G\ ,}\tau_G\right) = \ C_G\ -R,$$

$$\frac{1}{\tau_D}\ lnP_D\left(\ C_{D\ ,}\tau_D\right) = \ C_D - R - \mathrm{s} = C_D\ - R - \lambda + \frac{1}{\tau_D}[1+\delta(e^{(\lambda-C_D\ )\tau_D}\ -\ e^{-C_D\tau_D})$$

Therefore, the yield spread (s) is given as;

$$\mathrm{s} = \ \lambda - \ \frac{1}{\tau_D}ln[1+\delta\big(e^{(\lambda-C_D\ )\tau_D}\ -\ e^{-C_D\tau_D}\big)\ \ \ldots..\ (6)$$

$$= \ C_D - \ C_G\ -(\frac{1}{\tau_D}lnP_D - \frac{1}{\tau_D}lnP_G)$$

Then, the one year daily default probability is given as,

$$\lambda = C_D - C_G + \left(\frac{\ln\big(P_G\ (C_G,\tau_G)\big)}{\tau_G}\ -\ \frac{\ln\big(P_D\ (C_D,\tau_D)\big)}{\tau_D}\right) + \frac{1}{\tau_D}\ln(\ 1+\delta e^{(\lambda-C_D\ )\tau_D}\ + e^{-C_D\tau_D}))\ \ \ldots.\ .(7)$$

We employ Takahashi’s (2012) model in equation (6) in our estimation of yield spreads to compare to CDS spreads of similar maturities. We further use the model in equation (7) to estimate the one year default probability in our research to capture the effect of the TEPCO’s credit rating downgrade on default probabilities of its creditor banks. Chen (陳蓓) (2013) uses the above model in a Brownian bridge framework in bond spread estimation. Zhou (張什什) uses another recovery scheme, and succeeds to analyze and estimate for Japanese CB market. Chia (2012) focuses on the valuation of CDS and in part, uses a model from the author’s discussion paper in the comparison of Bond yield and CDS spreads.

4.4 DATA

In this study, we obtain daily bond data from the Japanese Securities Dealers Association (JSDA).Our data period for the analysis of the parity relationship between Bond spreads and CDS spreads spans from October 2007 to December 2011.To derive the bond spread to compare with a corresponding 5 year CDS spreads require extracting corporate and government bonds with 5 year maturities. Bonds that have exactly 5 year maturities are difficult to come by. Earlier papers employ interpolation to derive an exact 5year bonds.Others,resort to extracting the closest bonds with a 5 year maturity form the date of issue. We follow the latter methodology, in that, for any given bond issued by a company on a specific date we extract those with maturities closest to 5 years.

To derive the bond spread between a corporate bond and Government Bond, a similar Japanese Government bond with 5 year maturities is obtained. The corresponding 5 year Credit default swap spread data is obtained from Markit group. After the data cleaning, we obtain about 1008 daily observations for each company in our sample. The companies employed in our analysis of the parity relationship are the Tokyo Mitsubishi UFJ Bank, Mitsubishi Heavy Industries, Nippon Yusen (NYKLINE), and Sony Corporation.

In our extended study on the effect of TEPCO’s credit rating downgrades on default probabilities, we assemble bond data for Tokyo Electric Power Company, Mitsui Sumitomo Financial Group (SMBC), Mizuho Financial Group and Mitsubishi UFJ Financial Group for only 2011.In total, for the extended analysis we obtain 235 daily observations for the estimation of default probabilities.

4.5 RESULTS

4.5.1 CDS-BOND YIELD SPREADS

Using the credit spread model in equation 6, figures 4.1 to 4.4 provide the comparison of our estimated 5yield spreads with the corresponding CDS spreads. The results indicate that the parity condition do not hold for the sample companies in our analysis. This non parity relationship that we find is consistent with other studies on the topic in other markets. The non- parity results could be attributed to several factors.

First, the contract terms and the over the counter nature of CDS, embeds in it several clauses which may cause the parity condition to deviate in real world applications. More so, matching corporate and government bonds with similar 5 year maturities to derive the credit spreads is a daunting task. It is almost impossible to get similar bonds with the same maturity. In this study, we sampled both Corporate and Government bonds with maturities close to 5 years. These factors may cause the parity condition to deviate in practice.

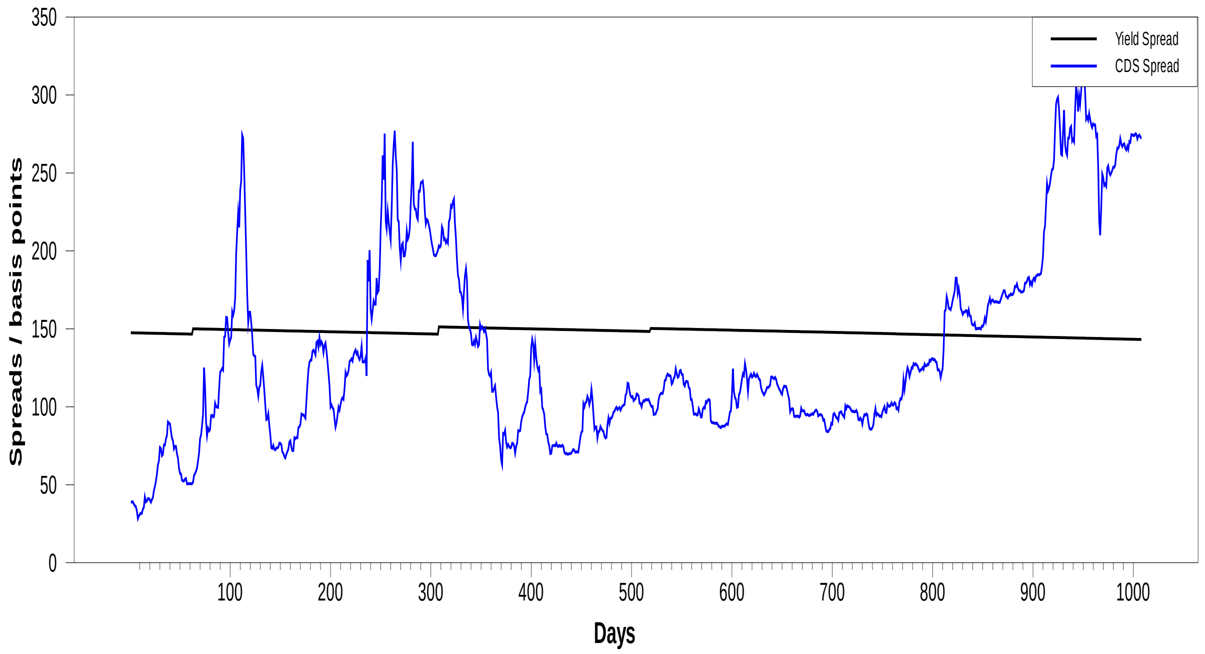

Figure4.1 Comparison of CDS - Bond yield spreads for MUFJ

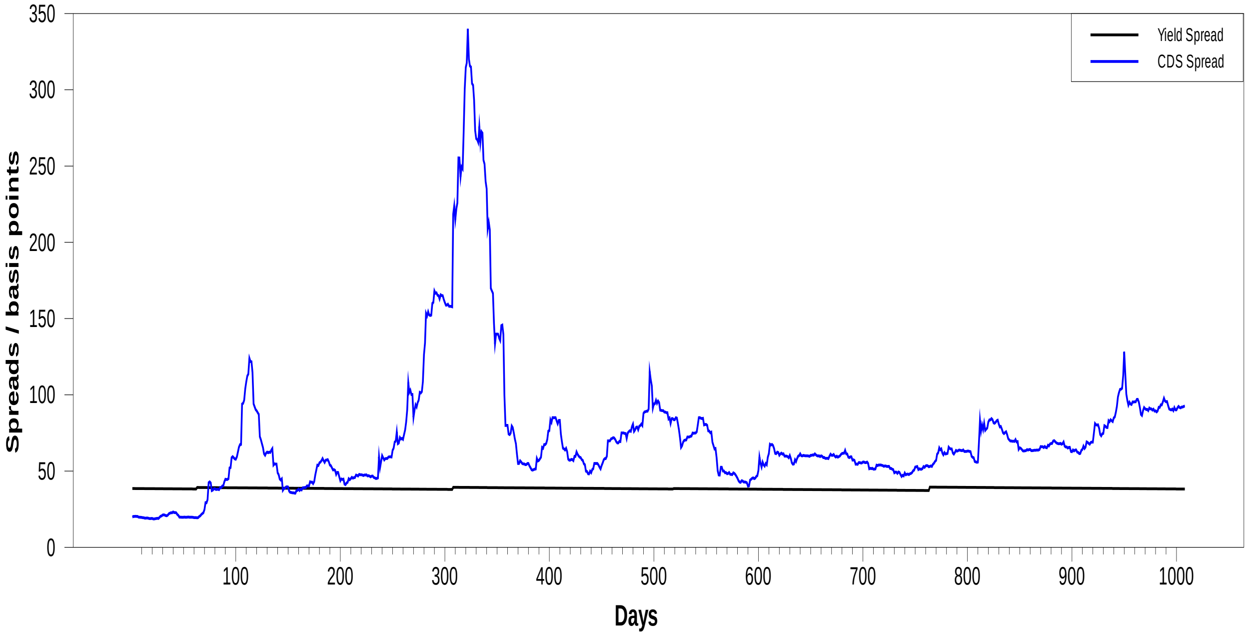

Figure 4.2 Comparison of CDS - Bond yield spreads for Mitsubishi Heavy Industries

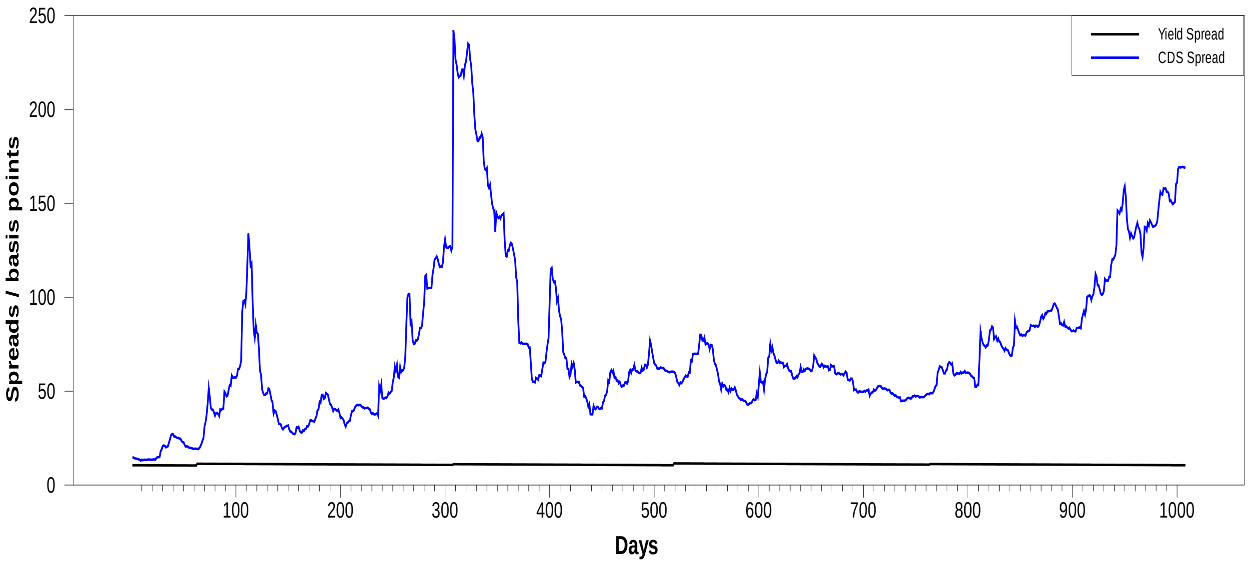

Figure 4.3 Comparison of CDS - Bond yield spreads for Sony

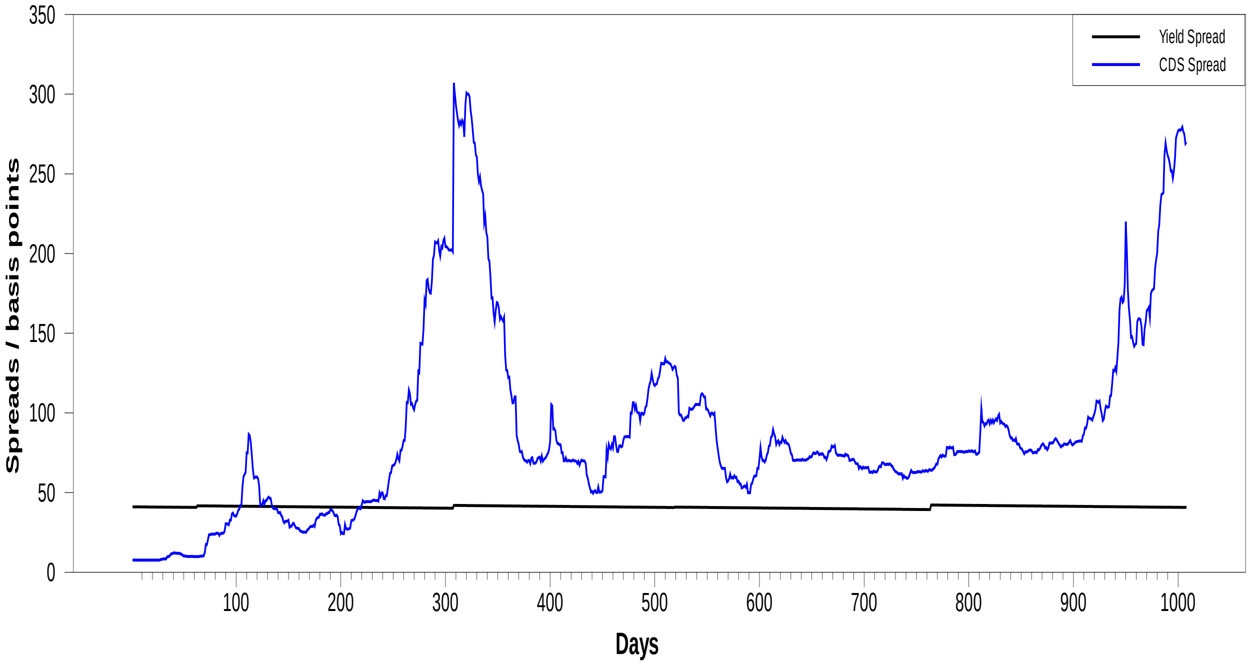

Figure 4.4 Comparison of CDS - Bond yield spreads for Nippon Yusen

This non-parity conditions we evidenced in our study may only hold in the short run. Further, we try to understand whether this non parity relationship obtained in our analysis holds in the long term. That is, we test whether there exist a long term co-movement between the Bond spreads and the CDS spreads. Unit root tests are performed using the Dick- Fuller tests; we examine their lag and test the cointegration of the two spreads in the Long run using a Johansen ML test for Cointegration.

The results provided in Appendix C, shows that for all the sample companies, there exist no cointegration in the long run. These results confirm that arbitrage opportunities exist between the two markets for our sample companies in both the short and long run.

4.5.2 DEFAULT RISK COMPONENT OF CREDIT SPREADS

The Tohoku-Chihou-Taiheiyou-Oki Earthquake placed enormous burden on the utility provider, TEPCO.The Company in its annual report for the year ending March 31st, 2011, reported a net loss of 1,247.3 billion yen. According to a PWC report[6], Mitsui Sumitomo Financial Group (SMBC) which is

[6] PWC Industry Analysis – Banking and Capital Markets. Available at https://www.pwc.com/jp/en/japan-knowledge/archive/assets/pdf/archive_research_analytics_japan_industry_banking-capital-markets-en.pdf

TEPCO's main creditor bank, Mizuho Financial Group and Mitsubishi UFJ Financial Group had almost 700 billion yen in exposure to TEPCO before the earthquake.

Immediately after the Earthquake, SMBC and other financial institutions offered over 1.9 trillion yen in emergency loans to TEPCO (Reuters, May 2011)[7].The continued financial distress of TEPCO raised concerns in the financial market. By June 2011, Moody's Investor Service and Standard & Poor Rating Services have cut TEPCOs credit rating to Junk status (Bloomberg Business, June 2011)[8]. What does this perceived risk mean for TEPCOs major creditors? Was there an increase in default probability for these mega banks? By focusing on this TEPCO credit crisis, we analyze the effect of TEPCOs credit event on the default probability of the major banks.

One of the major concerns for researchers is trying to understand how much of Credit spreads is due to default risk. By employing the risk neutral default probability model developed by Takahashi (2012), we are able to back out the default component of the credit spreads. To be able to investigate the impact of the TEPCO crisis, we estimate the risk neutral default probability in equation 7.Figure 4.5, shows the estimated yield spreads for TEPCO in 2011.The inverted yield curve shows the investor uncertainty about TEPCOs financial situation.

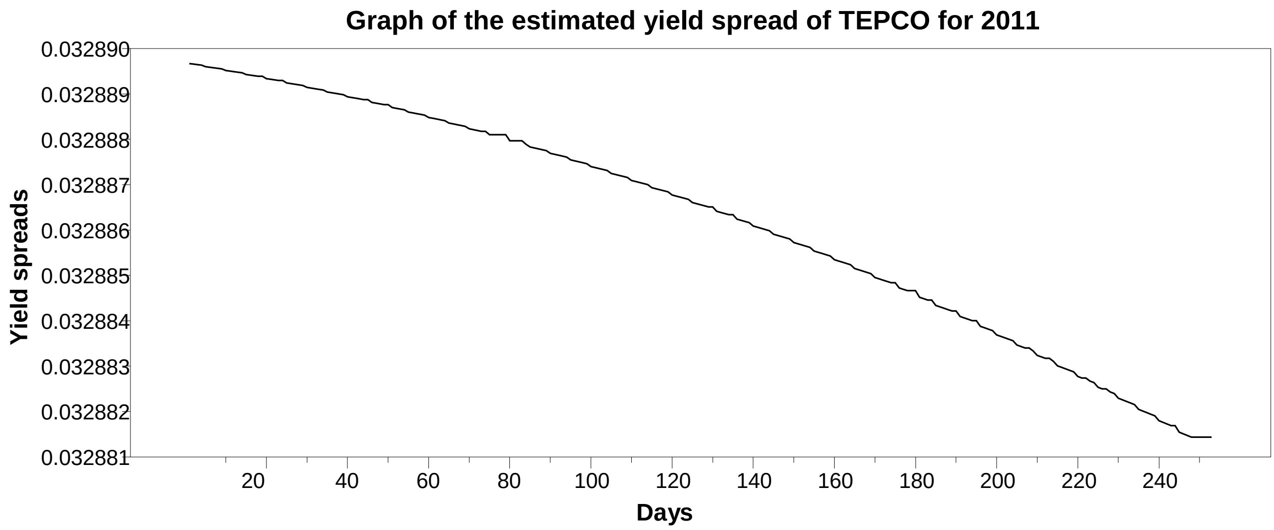

Figure 4.5 Yield curve for TEPCO

[7] WRAPUP 3-Japan banks post Q4 losses, shares fall on TEPCO. http://mobile.reuters.com/article/idUSL3E7GD29Y20110513

[8] Tepco Rating slashed to Junk by Moody's, Matching S&P downgrade. Available at http://www.bloomberg.com/news/articles/2011-06-20/tepco-rating-slashed-to-junk-by-moody-s

The results show that there is an increase in the probabilities of default risk for the major banks due to their exposure to TEPCO.Figures 4.6 - 4.9 shows the estimated one year risk neutral daily default probabilities. From Figure 4.6, we can infer that the one year daily default probability for TEPCO rose from a low level in January 2011 to almost 60% by the end of the year.

All the other figures show an increase in default probabilities for the 3 banks due to the crisis in TEPCO.The results also reveal that the impact was sudden and we could observe a jump in the default risk immediately after the Earthquake occurred in March. A closer look at Figure 4.7 shows that, the default probability for SMBC rose from about 2% from the start of the year to about 4.5% at the end of 2011.

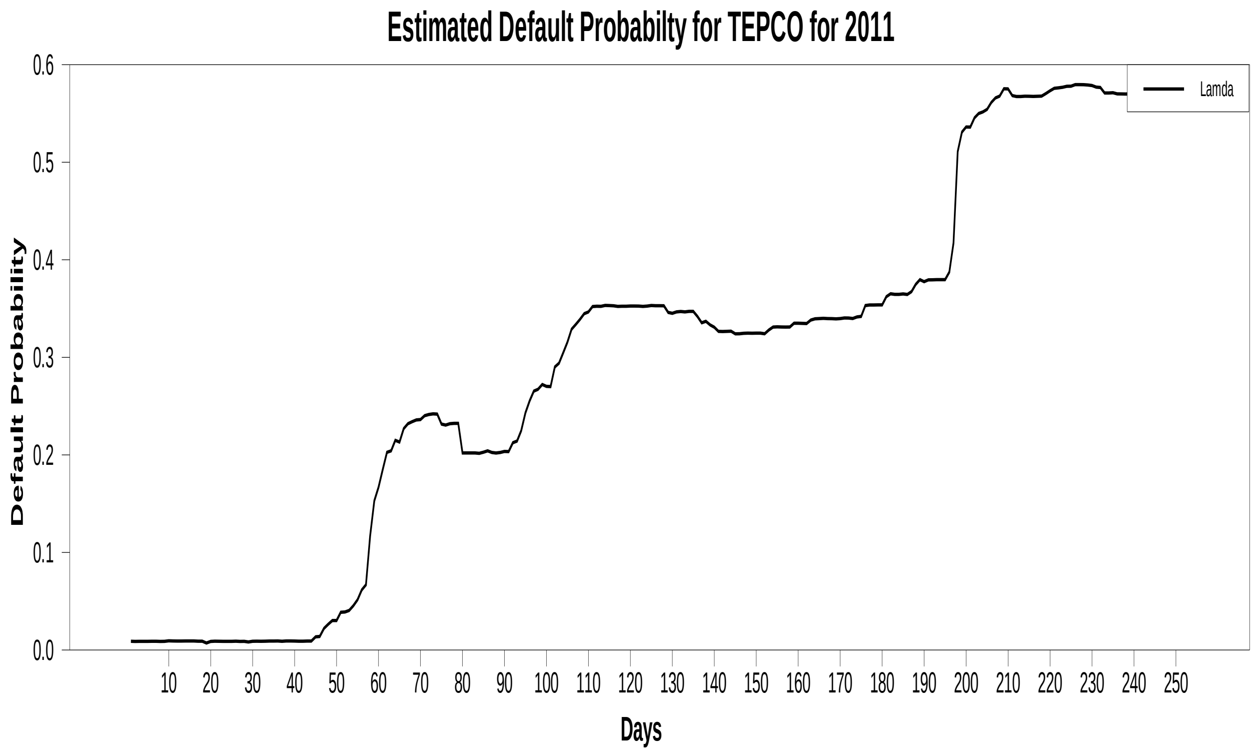

Figure 4.6 One year daily default probability for TEPCO

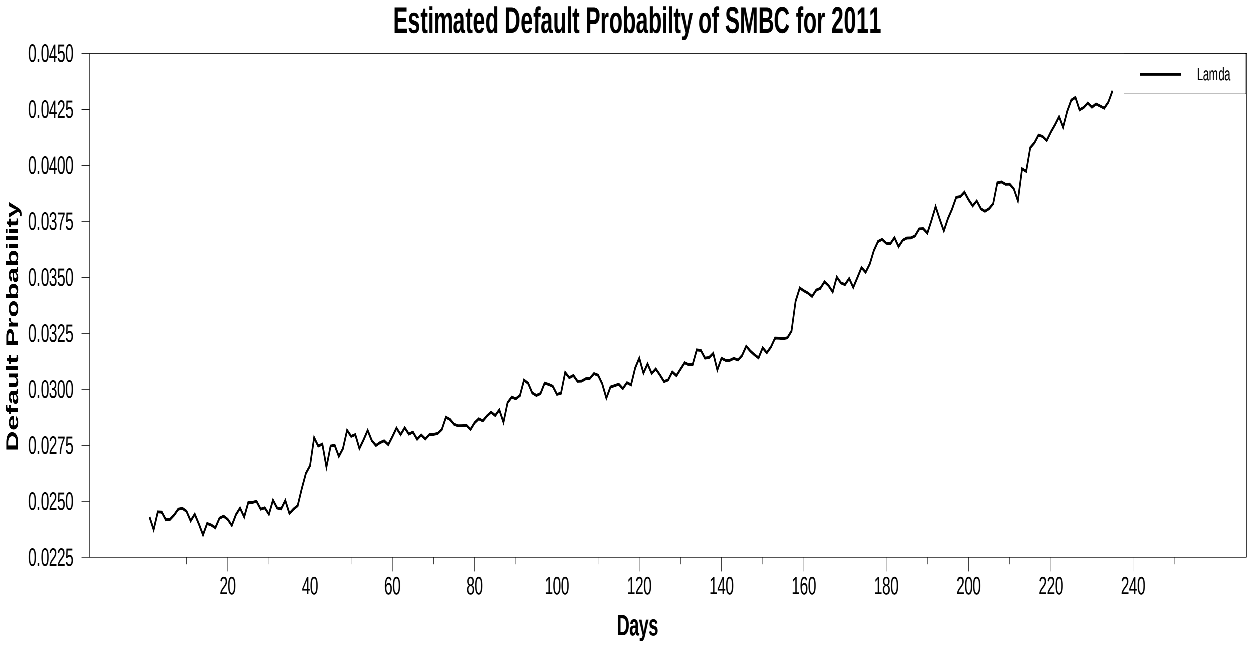

Figure 4.7 One year daily default probability for SMBC

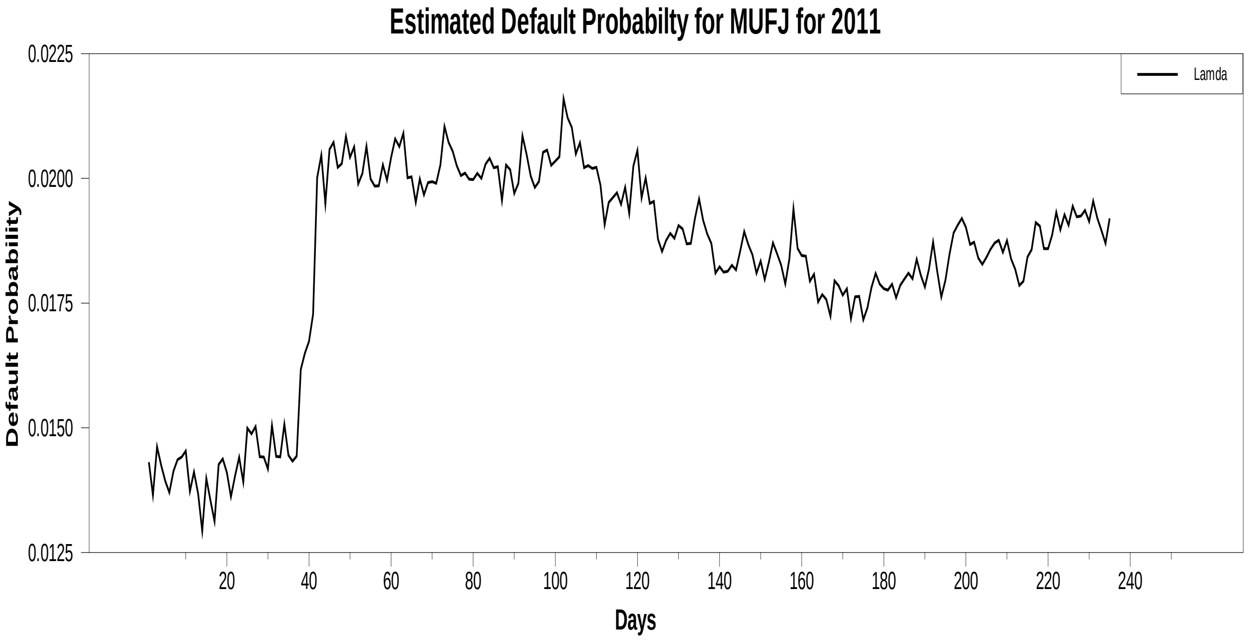

Figure 4.8 One year daily default probability for MUFJ

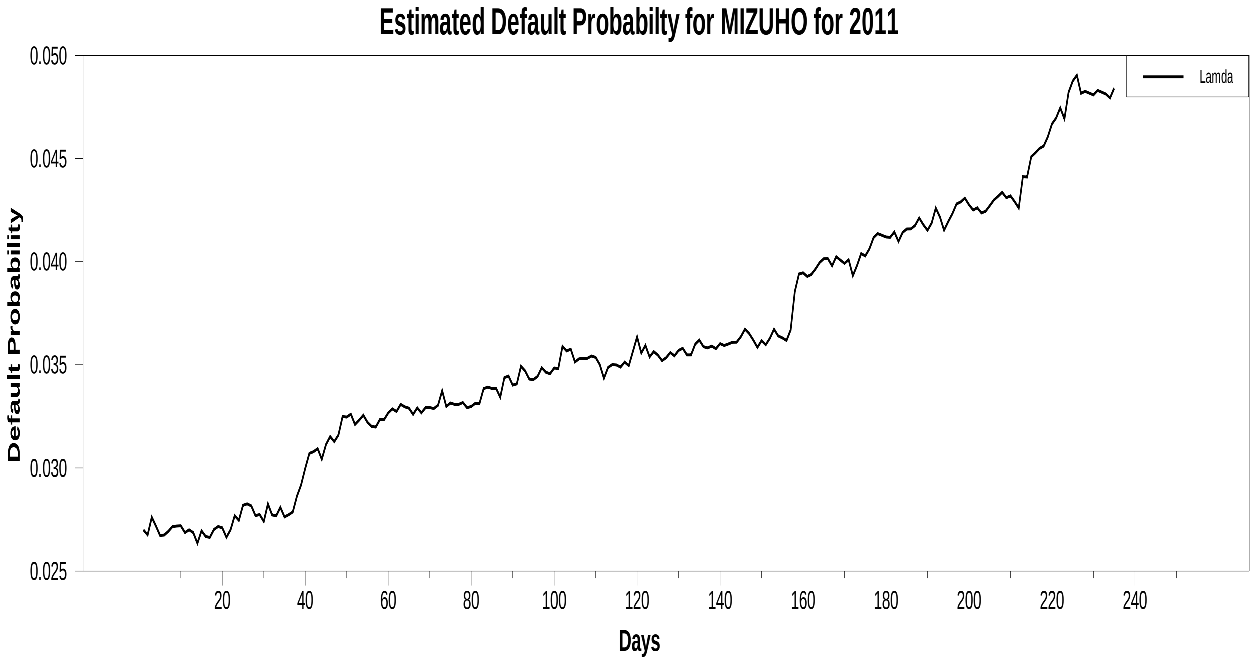

Figure 4.9 One year daily default probability for MIZUHO

Estimates obtained for MUFJ (figure 4.8) shows that there was a sudden increase in the default probability immediately after the Earthquake, signaling investor uncertainty about TEPCO's ability to honor its obligation. The default probability rose from a low of about 1.3% at the start of 2011 to a maximum of 2.1% after the Earthquake before beginning to decrease.

Turning the discussion to the effect of the credit crisis on the default probability for MIZUHO, Figure 4.9, shows that the default risk increased from a low of 2.5% to about 5% at the end of the year. In comparative terms, MUFJ is the least affected during the period. In line with existing literature, we have established that default probability estimates increase when credit ratings decrease.

4.6 CONCLUSION

In this study, we analyzed Bond and CDS spreads in the Japanese corporate market. First, we tested for the no-arbitrage theory by analyzing the Bond spreads and their corresponding CDS spreads over a 4 year period. Results from the analyses indicate that the no-arbitrage relation does not hold for our sample companies in the short run.

Further analysis to ascertain if there exists long run equilibrium relationship, that is, if the parity would be restored in the long run is conducted. The results from the cointegration test reveal there exists no long run relationship between the bond spreads and CDS spreads for our sample companies.

We argue that this non-parity relation that we evidenced is due to a number of reasons .Firstly, the nature of the market participants. As it has been observed, the large majority of Bond holders in Japan are local Japanese investors whereas the major participants in the CDS market are foreign hedge fund and other institutional investors who do not own the underlying bonds. Thus, the measures of risk across the two asset classes differ among the participants. In that, the CDS market is more or less used for speculative purposes than as a risk hedging tool. Thus, an increase in the number of investors speculating on the default risk of an underlying corporate entity would result in an increase in demand causing the CDS spreads to widen than its corresponding Bond spreads.

Also, the non-parity is also as a result of the difficulty in obtaining bonds with exact maturities to compare with the 5 year CDS spreads used in the study.

Furthermore, since credit spreads are theoretically linked to default risk. We took the opportunity to analyze the effect of the TEPCO credit crisis in 2011 on its major creditors. Appealing to Risk neutral default pricing, we quantified the default risk component of credit spreads. Results show that the TEPCO credit crisis had a contemporaneous increase in the one year default probabilities for all the three mega banks.

CHAPTER 5

CONCLUSION

The overall theme for this dissertation was to deepen our understanding of the credit default swap and bond markets. The paper first showed that non-linear models, specifically Markov switching models should be used in the analysis of financial time series data. The determinants of the Japanese sovereign CDS spreads are regime dependent and explain about 89% of the CDS price variations when the spreads are in the volatile regime and a corresponding 52% in normal regime. The study of the determinants revealed that global factors play an important in role in price variations in the Japanese sovereign CDS spreads.

This paper then empirically analyzed the possibility of propagation of default risk from Greece and Spain to other EU countries and Japan during the Lehman and European sovereign crises. Of particular interest is that, the study shows that during the Lehman crisis and European Sovereign crisis, the Greek CDS and Spanish CDS played the leading roles in contagion propagation respectively.

To further provide insights into the Japanese CDS and Bond markets, we tested the theoretical parity relationship between CDS spreads and bond spreads. The study finds no evidence of non-arbitrage relationship. We extended the analysis to empirically analyze how TEPCO's credit rating downgrades affected default probabilities of its creditors. We proved that increase in default probabilities occurred after the credit rating downgrade.

Considering our analysis covered both markets in Japan and Europe, we think we have made a meaningful contribution to the understanding of the CDS and Bond markets. On our future work, we would develop a model to analyze the price discovery between the CDS and Bond spreads in Japan.

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APPENDIX A

UNIT ROOT TESTS FOR FIRST-DIFFERENCED CDS DATA FOR EURO-CRISIS PERIOD

Table A1

Dickey-Fuller Unit Root Test for GREECE	
Regression Run From 9 to 583	
Observations	**576**
With intercept	
Using 6 lags on the differences	
Sig Level	**Crit Value**
1%(**)	**-3.444**
5%(*)	**-2.8668**
10%	**-2.5696**
T-Statistic	**-8.4054**

Table A2

Dickey-Fuller Unit Root Test for SPAIN	
Regression Run From 9 to 583	
Observations	**576**
With intercept	
Using 6 lags on the differences	
Sig Level	**Crit Value**
1%(**)	**-3.444**
5%(*)	**-2.8668**
10%	**-2.5696**
T-Statistic	**-9.7443**

Table A3

Dickey-Fuller Unit Root Test for ITALY	
Regression Run From 9 to 583	
Observations	**576**
With intercept	
Using 6 lags on the differences	
Sig Level	**Crit Value**
1%(**)	**-3.444**
5%(*)	**-2.8668**
10%	**-2.5696**
T-Statistic	**-9.4859**

Table A4

Dickey-Fuller Unit Root Test for PORTUGAL	
Regression Run From 9 to 583	
Observations	**576**
With intercept	
Using 6 lags on the differences	
Sig Level	**Crit Value**
1%(**)	**-3.444**
5%(*)	**-2.8668**
10%	**-2.5696**
T-Statistic	**-9.4467**

Table A5

Dickey-Fuller Unit Root Test for JAPAN	
Regression Run From 9 to 583	
Observations	**576**
With intercept	
Using 6 lags on the differences	
Sig Level	**Crit Value**
1%(**)	**-3.444**
5%(*)	**-2.8668**
10%	**-2.5696**
T-Statistic	**-9.3718**

APPENDIX B

UNIT ROOT TESTS FOR FIRST -DIFFERENCED CDS DATA FOR LEHMAN CRISIS PERIOD

Table B1

Dickey-Fuller Unit Root Test for GREECE	
Regression Run From 9 to 285	
Observations	**278**
With intercept	
Using 6 lags on the differences	
Sig Level	**Crit Value**
1%(**)	**-3.4554**
5%(*)	**-2.8720**
10%	**-2.5723**
T-Statistic	**-5.5995**

Table B2

Dickey-Fuller Unit Root Test for SPAIN	
Regression Run From 9 to 285	
Observations	**278**
With intercept	
Using 6 lags on the differences	
Sig Level	**Crit Value**
1%(**)	**-3.4554**
5%(*)	**-2.8720**
10%	**-2.5723**
T-Statistic	**-6.6277**

Table B3

Dickey-Fuller Unit Root Test for ITALY	
Regression Run From 9 to 285	
Observations	**278**
With intercept	
Using 6 lags on the differences	
Sig Level	**Crit Value**
1%(**)	**-3.4554**
5%(*)	**-2.8720**
10%	**-2.5723**
T-Statistic	**-6.1151**

Table B4

Dickey-Fuller Unit Root Test, Series PORTUGAL	
Regression Run From 9 to 285	
Observations	**278**
With intercept	
Using 6 lags on the differences	
Sig Level	**Crit Value**
1%(**)	**-3.4554**
5%(*)	**-2.8720**
10%	**-2.5723**
T-Statistic	**-6.5554**

Table B5

Dickey-Fuller Unit Root Test for JAPAN	
Regression Run From 9 to 285	
Observations	**278**
With intercept	
Using 6 lags on the differences	
Sig Level	**Crit Value**
1%(**)	**-3.4554**
5%(*)	**-2.8720**
10%	**-2.5723**
T-Statistic	**-5.9314**

APPENDIX C

JOHANSEN CONTEGRATION TESTS

Table C1

Johansen ML test for Cointegration for Sony Corporation

Likelihood Based Analysis of Cointegration

Variables: **Bond yields and CDS**

Estimated from 1 to 1008

Data Points 1006 Lags 2 with Constant restricted to Cointegrating Vector

Unrestricted eigenvalues and -T log(1-lambda)

Rank	EigVal	Lambda-max	Trace	Trace-95%	LogL
0					**-1337.03**
1	**0.011678**	**11.81739**	**13.97422**	**20.16**	**-1331.12**
2	**0.002142**	**2.156832**	**2.156832**	**9.14**	**-1330.04**

Cointegrating Vector for Largest Eigenvalue

yields	CDS	Constant
-3.52279	**-0.01317**	**39.71105**

Table C2

Johansen ML tests for Cointegration for MUFJ

Likelihood Based Analysis of Cointegration

Variables: **Bond yields and CDS**

Estimated from 1 to 1008

Data Points 1004 Lags 4 with Constant restricted to Cointegrating Vector

Unrestricted eigenvalues and -T log(1-lambda)

Rank	**EigVal**	**Lambda-max**	**Trace**	**Trace-95%**	**LogL**
0					**-3161.16**
1	**0.012836833**	**12.97162**	**13.88557**	**20.16**	**-3154.68**
2	**0.000909899**	**0.913955**	**0.913955**	**9.14**	**-3154.22**

Cointegrating Vector for Largest Eigenvalue

yields	**CDS**	**Constant**
-0.52535	**-0.017643594**	**80.27894**

Table C3
Johansen ML test for Cointegration for Nippon Yusen

Likelihood Based Analysis of Cointegration

Variables: **Bond yields and CDS**

Estimated from 1 to 1008

Data Points 1006 Lags 2 with Constant restricted to Cointegrating Vector

Unrestricted eigenvalues and -T log(1-lambda)

Rank	EigVal	Lambda-max	Trace	Trace-95%	LogL
0					**-2287.7**
1	**0.010173**	**10.28596**	**12.31379**	**20.16**	**-2282.56**
2	**0.002014**	**2.027829**	**2.027829**	**9.14**	**-2281.54**

Cointegrating Vector for Largest Eigenvalue

yields	CDS	Constant
-1.50228	**0.001716**	**61.58755**

Table C4

Johansen ML test for Cointegration for Mitsubishi Heavy Industries

Likelihood Based Analysis of Cointegration

Variables: **Bond yields and CDS**

Estimated from 1 to 1008

Data Points 1002 Lags 6 with Constant restricted to Cointegrating Vector

Unrestricted eigenvalues and -T log(1-lambda)

Rank	**EigVal**	**Lambda-max**	**Trace**	**Trace-95%**	**LogL**
0					**-1930.96**
1	**0.008723**	**8.778588**	**16.90181**	**20.16**	**-1926.58**
2	**0.008074**	**8.123217**	**8.123217**	**9.14**	**-1922.51**

Cointegrating Vector for Largest Eigenvalue

yields	**CDS**	**Constant**
-1.33052	**-0.0132**	**52.30881**

APPENDIX D

IRF's for other sovereigns during the Euro sovereign crisis

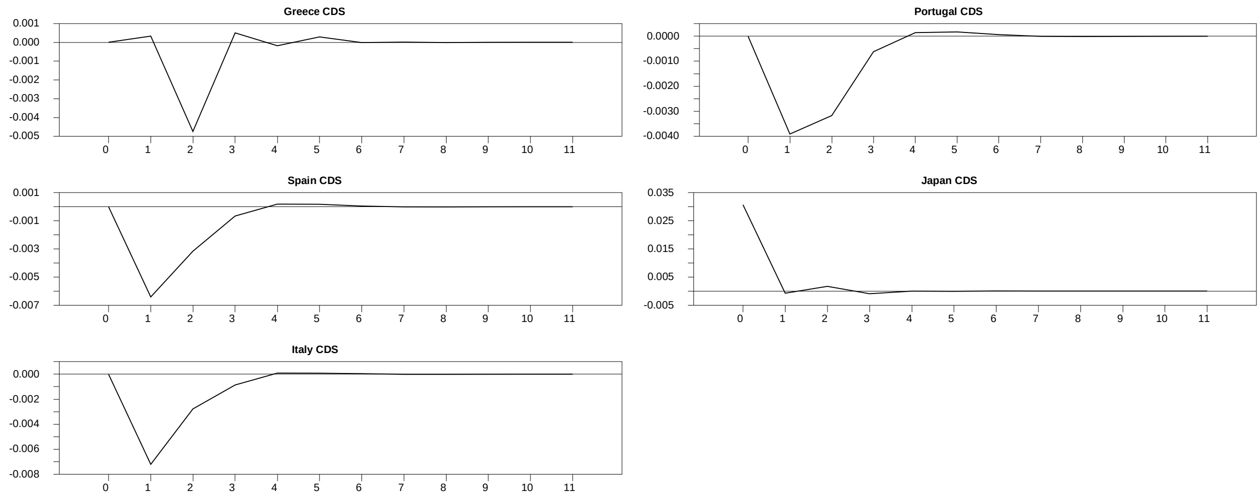

Figure D 1: IRF to shocks to Japanese CDS during the Euro sovereign crisis . For interpretation, express the estimates on the vertical axis in percentages

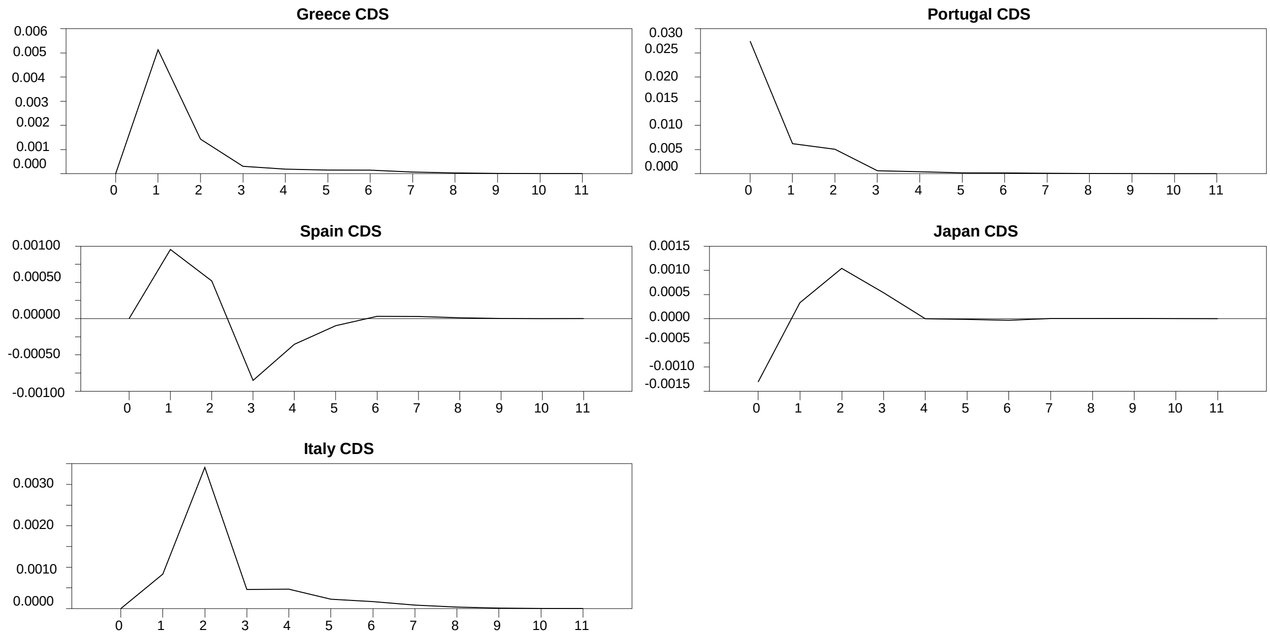

Figure D 2: IRF of shocks to Portuguese CDS during the Euro sovereign crisis. For interpretation, express the estimates in the vertical axis as percentages

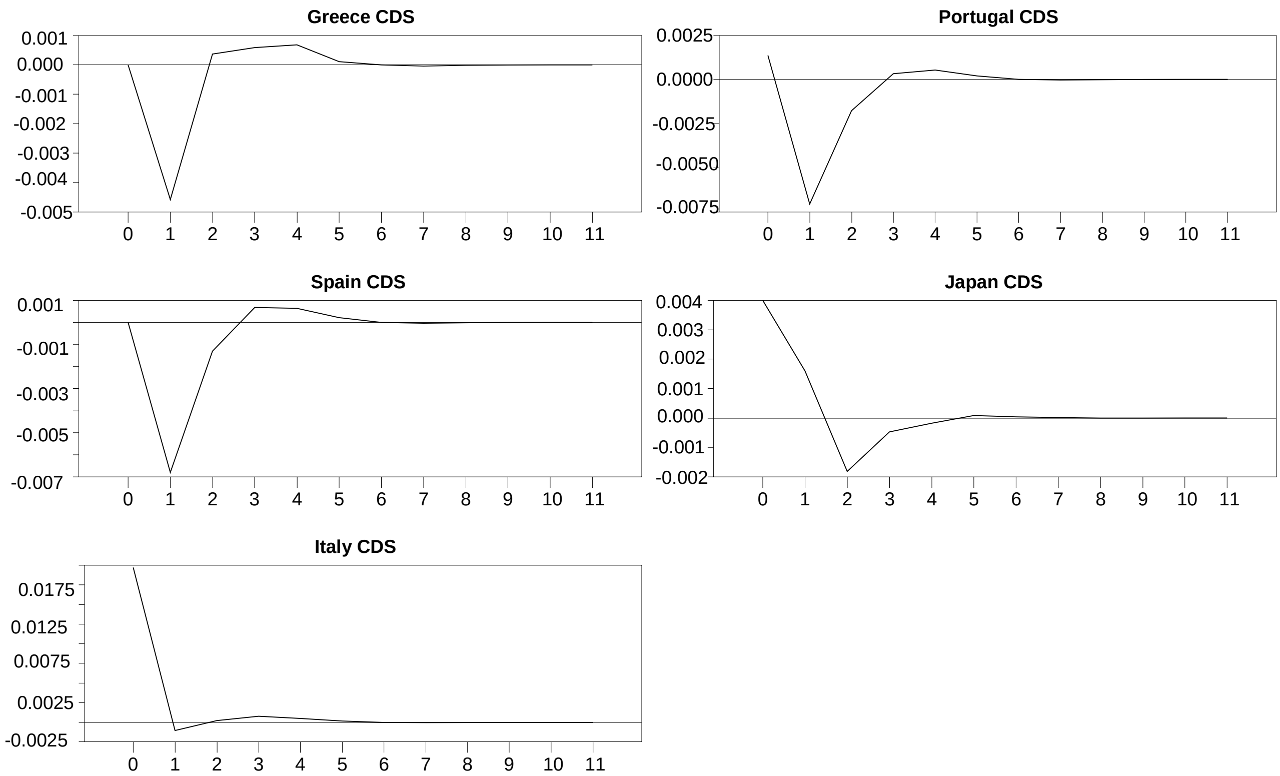

Figure D 3: IRF to shocks to the Italian CDS during the Euro sovereign crisis. For interpretation, express the estimates on the vertical axis into percentages

List of Papers

1. Peer Reviewed Manuscripts/ Refereed Journal Papers

Ofori, S. K. (2015). Regime Switching Determinants of the Japanese Sovereign Credit Default Swaps Spreads. *International Journal of Trade, Economics and Finance, 6(2),* 134-139.

2. Conference Papers

Ofori, S. K. (2015). Regime switching determinants of the Japanese sovereign credit default swap spreads. Paper presented at JCTEF 2015 1st at Kyoto, April 8-10, 2015.