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MODELING THE JOINT RESPONSE OF REAL ECONOMY AND SOVEREIGN CDS SPREADS WITH MACRO-FINANCIAL SURPRISES

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Abstract

This study investigates the sovereign credit default swap (CDS) price discovery process onthe major European financial markets. Using data for CDS spreads of Portugal, Ireland, Italy, Greece, and Spain, the results show that there is a strong evidence of cross market linkages between the sovereign CDS market and the corporate bond market after the crisis developed. But the evidence of predictability for the stock market during the sovereign debt crisis is limited. The testing framework is also allowed to analyze the contagion from the financial sector to real economy. The results demonstrate that no sector was immune to the adverse shock resulted from the sovereign debt crisis. Taken together, these findings tend to support the hypothesis that financial contagion was propagated primarily through liquidity channel, rather than through the correlated-information channel. The empirical results for impact of surprises in major financial markets indicate that no sector was immune to the distress event of the sovereign debt crisis limiting the effectiveness of portfolio diversification. Cross- market linkages became much stronger and significant during the sovereign debt crisis (but not before the sovereign crisis).

Keywords: Financial contagion, Sovereign CDS spreads, Sovereign debt crisis

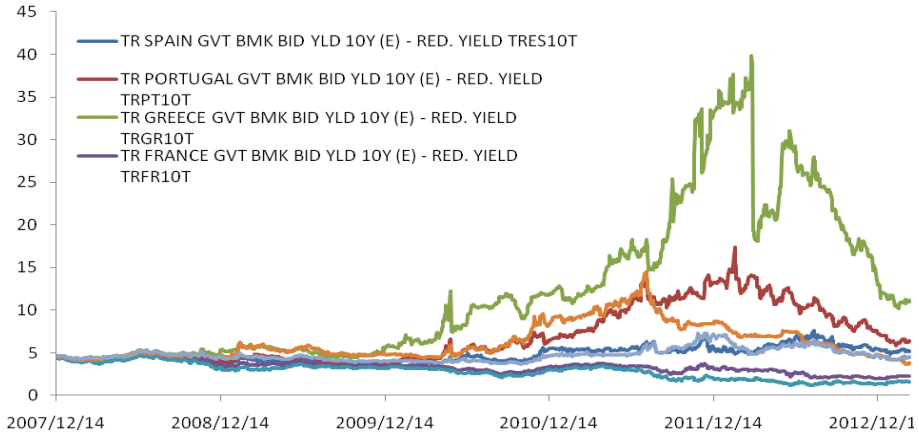
1. INTRODUCTION

After the general election in October 2009, New Greek Prime Minister, George Papandreou, announced that a revised 2009 budget deficit of 12.7 percent of GDP - more than twice the previous estimate of 6 percent[1]. The ―above-normal‖ in deficit/GDP ratio as well as larger-than-expected increases in public debt ratio cast the doubt of fiscal irresponsibility of the peripheral nations. Furthermore, as a result of bubble burst in construction activity and asset prices, tax revenue in Spain and Ireland fell much quickly than GDP. As on 8 December 2009, Fitch Ratings cut Greece ‘s sovereign credit rating to BBB+ from A-. The outlook was ―negative. These adverse developments were reflected in rising yields on sovereign bonds. Market participants tend to view the spread on country-level ten-year bond yields between Germany and high-yielders countries, such as Portugal, Ireland, Italy, Spain, and Greece as indicator of the stress in the sovereign debt market. If investors worry that the probability of default is higher in some countries, the countries more likely default will have to pay a higher premium to compensate investors for the risk. This is exactly what happened to Greece in early 2010 when the European Central Bank, European Commission and the IMF agreed to a 110-billion-euro loan for Greece on 2 May 2010, conditional on a promise to cut its budget deficit to 3 percent of GDP by 2014. The Greek yield began to diverge from the other EU

members, mostimportant Germany. Figure 1 displays the annual spread of 10-year sovereign bond yields of selected EU members since the late 2007. Euro area sovereign debt markets remained relatively calm during 2008 and most of 2009. In addition, the Irish and Portuguese yields were closely moving together during 2010 and the first half of 2011. Ireland agreed with the other euro zone members and the IMF to a €85 billion bailout package on 28 November 2010, conditional on the implementation of a painful four-year austerity plan. As on 17 May 2011, EU finance ministers and the IMF backed a €78 billion bailout loan for Portugal, making it the third euro zone country to receive international financial support. Portugal would have to carry out an ―ambitious but credible‖ fiscal adjustment programme to balance its books in return for receiving the loans from the European Financial Stability Facility (EFSF), the European Commission's European Financial Stabilization Mechanism (ESFM) and International Monetary Fund (IMF).

Figure 1

Yields on 10-Year Sovereign Bonds, December 2007 to February 2013



As indicated by Buiter and Sibert (2006), the euro members ‘main monetary policy instruments are collateralized loans and repurchase agreements (Repos). The euro area banks used these euro-denominated sovereign bonds as collateral in obtaining short-term loans. The fear of sovereign defaults could help trigger liquidity problems of banking sector with sizable sovereign debt holdings. Central banks can stand in as a ―lender of last resort‖ creating as much as liquidity as needed to solve the problem. The European Central Bank did increase the volume of loan they made to the banking sector and the amount of assets they held on their own balance sheet by 39% between August 2008 and August 2011.

Professional investors often make bets against sovereign debt by purchasing credit default swaps, or CDS contracts. These derivatives investments act as insurance on the debt, so they rise in value when doubts grow about sovereign debt, and the bond prices of various nations

drops. In the credit default swap (CDS) market, CDS price also escalated steeply. The annual cost of protection of insurance on a $10 million Italian bond rose from $200,000 at the end of August, 2010 to almost $600,000 at the end of 2011. In case of Spanish bond, it went up from slightly more than $200,000 to nearly $400,000 in the same time period. As the possibility of default increased, so did the cost of protection against default.

Much of the funding provided by European Union and the IMF in each of three bailouts has been motivated by the objective of avoiding broader contagion and spillovers to other markets and sectors of the economy. Understanding the nature of financial contagion is important and there is a vast amount of literature addressing its discovery process and the influences to other markets. Important papers on financial contagion include Baur (2012), Dornbusch, Park, and Claessens (2000), Dungey et al. (2005), Hui and Chung (2011), Longstaff (2010), and many others. Longstaff (2010) describes unpleasant shocks can be transmitted into other markets mainly through three different channels. First, the liquidity channel describes a mechanism where negative shocks in one financial market detrimentally impacts market liquidity of some or even all financial markets. Second, the risk-premium channel describes a mechanism in which a shock event in one market affects investors‘ risk- bearing willingness in other markets whereby changes in equilibrium risk premiums affect asset prices in all markets. Third, the correlated-information channel describes a mechanismin which negative shocks in one market represent the arrival of economic information whichis relevant for asset prices in other markets.

This paper is related to recent literature on interconnectivity between the real and financial sectors. Wehinger (2011) summarized the discussions at the OECD Financial Roundtable held on 7 October 2010 with participants from the financial sector and members of the OECD Committee on Financial Markets. The participants conveyed a rather somber view regarding the interconnectedness between the financial, economic and government debt. Each of these sectors is very vulnerable and adverse shocks in one area could lead to repercussions in another, triggering a negative chain reaction. Given the interconnectivity between the real economy and sovereign debt market, the purpose of this paper is to explore the lead-lag relationship between the real economy and sovereign CDS spreads by gauging any information flow between them during the euro debt crisis. While previous studies focused on contagion across different financial markets, the influences of financial contagion upon real economy have been largely ignored. A notable exception is the paper by Baur (2012), in which non-aggregate data in 25 major developedand emerging countries are characterized by the co-movement of returns among financial sector stocks across countries and between financial stocks and real economy stocks. He estimated the degree of co-movement of a sector-

portfolio with a global financial sector portfolio in tranquil and crisis times during the Global Financial Crisis using the univariate GJR-GARCH framework.

This paper extends the extant literature of contagion in three major aspects. First, instead of looking at the stock market only, the real sectors of corporate bond market are also included to obtain detailed information about the specific impact of the euro debt crisis. Second, the lagged changes in credit default swap contracts of fiscal weakness countries, namely Portugal, Italy, Ireland, Greece and Spain, are involved in financial contagion to shed some light on mechanisms of information flow between sovereign CDS market and the real economy. Third, this paper explicitly considers the response of stock and corporate bond market returns to the surprises emanating from the US CBOE VIX, commodity market, and the sovereign bond market within a simultaneous system of equations that allows for the cross-market and cross-country linkages for asset returns. The remainder of the paper is structured as follows. Section 2 briefly introduces the literature on financial contagion. Section 3 outlines the econometric model used in this study. Section 4presents the data used in this study and the empirical test for contagion. Section 4 summarizesthe findings and concludes the remarks.

2. THEORIES OF FINANCIAL CONTAGION

International capital markets appear to be volatile, both on the upside and downside. Widening spreads on sovereign debt of Greece, Portugal, Ireland, Italy and Spain could lead to increased funding costs for banks and, faced with such a liquidity squeeze, they could drain liquidity from their operations in other countries. A liquidity retreat would disrupt not only the financial sectors in the region, but also have a large impact on the local economies.

Broadly speaking, financial contagion refers to a situation whereby instability in a specific market or institution is transmitted to one or several other markets or institutions—mostly on the downside—from one country to the other, a process observed through co-movements in exchange rates, stock prices, bond yields, sovereign spreads, and capital flows. Concerning the theories of financial contagion, we adopt a working definition of three information transmission mechanisms, by which shocks in one market spill over into other markets, proposed by Longstaff (2010).

The first channel can be named the liquidity channel. In this mechanism, a shock to one financial market results in a decrease in the overall liquidity of all financial markets. Contagion occurs when investors respond to financial shocks on a specific country by optimally rebalancing their portfolio ‘s exposure to the shared trade or macroeconomic risk in other‘s markets. For example, Kaminsky and Reinhart (2000) describe the behavior of

commercial banks, when facing negative financial shocks not only may exacerbate the initial crisis by calling loans and drying up credit line, but also can propagate crises by calling loans elsewhere. Kodres and Pritsker (2002) present a model in which –uninformed‖ investors, hit by a idiosyncratic shock, cannot fully identify the source of the change in asset demand; they therefore either liquidate leveraged positions or rebalance their portfolios in response. Brunnermeier and Pedersen (2009) show that when funding liquidity is tight, economicagents may become reluctant to take on positions. This lowers market liquidity of the other financial assets in the markets, leading to higher volatility. An important implication of the liquidity-related channel of contagion is that a negative financial shock may be associated with subsequent declines in the availability of credit and increases in trading activity in other markets. For example, sharp currency depreciation in Thailand during Asian financial crisis resulted in huge capital losses for some hedge fund investors. These losses may have induced investors selling off securities in other financial markets to raise cash in anticipation of a higher frequency of redemption. The second channel can be termed as the risk premium channel. In this mechanism, a severe surprise in distressed market may affect the willingness of investors to bear risk in other market via a time-varying risk premium. Acharya and Pedersen (2005) present models in which investors require a return premium for a security that is illiquid when the market as a whole is illiquid. Illiquid securities generally have high liquidity risk, consistent with __flightto liquidity ‘‘ in times of downside markets. On the other hand, investors are willing to pay a premium for a security that is liquid when the market return is low. An important implication of this time-varying risk premium is that a persistent negative shock to a security ‘s liquidity results in low contemporaneous returns and high predicted future returns. Due to feedback effects, the measurement of contagion via the risk-premium channel can be tested in a vector autoregressive (VAR) framework.

The third channel can be designated the correlated- information channel. In this mechanism, anegative shock in one financial market signals economic news that is directly or indirectly relevant for security prices in other markets. Contagion can be seen as fast and furious information transmission from more-liquid market to other markets. For example, Dornbusch, Park, and Claessens (2000) describe direct effects occurring through fundamentals such as global shocks transmitted through changing commodity prices or local shocks transmitted through trade links and financial links. A marked increase in correlation among different economies in foreign exchange rates, stock prices, and sovereign spreads is considered evidence of contagion. Kaminsky, Reinhart, and Vegh (2003) referred contagion to the fast and furious effects in other countries after a negative shock occurred. Three elements-an abrupt reversal in capital inflows, surprise crises, and a common creditor- are the

key of financial contagion. Hui and Chung (2011) find that currency option prices contain important information transmitted from the sovereign CDS spreads during crisis period. Kiyotaki and Moore (2002) examine two different mechanisms by which balance-sheet contagion may occur. First, indirect balance-sheet contagion happens if firms in the economy use similar assets as collateral, then the effect on net worth of changes in asset prices will cause sector specific shocks to spread out across sectors. Second, direct balance-sheet contagion occurs when many firms simultaneously borrow from and lend to each other, and when these firms are credit-constrained, default on or postponement of debt repayment in some firms may cause a widespread loss in the other firms. An important implication of the correlated-information literature is that contagion occurs rapidly via the price-discovery process. In general, a VAR framework can be conducted to test the implication of the correlated-information contagion mechanism.

3. THE VAR-GARCH MODEL

3.1 The VAR-GARCH model without surprises parameter

Following the description of three possible contagion mechanisms in section 2, it is appropriate to use a VAR framework to test contagion across financial markets. Motivated by the standard definition of financial contagion as its significance transmitting crisis from one country to other countries after a distressed event, the empirical model conducted in this paper is based upon the vector autoregressive model with error terms following the GARCH process, which is referred by Mun (2012) as VAR-GARCH model, employing sovereign CDS spreads, European stock and corporate bond data. The advantage of the VAR-GARCH model provides not only a test whether there are spillover effects from sovereign CDS marketto sectors bond or stock after controlling for the lagged returns of asset markets and financial sector but also a simultaneous system of equations that allows for the cross-market linkages for asset returns. The specification for the conditional mean and covariance of returns of the corporate bond and stock sectors for the VAR-GARCH framework can be formulated as

$$Y_t = \alpha + \sum_{i=1}^{6} \beta_i Y_{t-i} + \sum_{i=1}^{6} \gamma_i CDS_{t-i} + \pi X_t + \varepsilon_t \quad (1)$$

$$\varepsilon_t \sim N(0, H_t)$$

$$vech(H_t) = C + Kvech(\varepsilon_{t-1}\varepsilon_{t-1}^{'}) + Fvech(H_{t-1}) \quad (2)$$

Yt = the logarithmic return on the European STOXX or corporate bond sector price index, including Basic Materials, Consumer Goods, Consumer Services, Healthcare, Industry, Oil and Gas, Technology, Telecommunications and Utilities. the logarithmic return on the average of 5-year CDS spreads of Portugal, Ireland, Italy,Greece and Spain.

X_t= European STOXX price index of financial sector or corporate bond price index of financial sector at time t.

The VAR-GARCH models are in spirit very similar to their univariate counterpart. Several different VAR-GARCH formulations have been proposed in the literature, including the VECH, the diagonal VECH and the BEKK models. To ensure that the variance-covariance matrix H is always positive definite, this paper adopts BEKK model to estimate cross market asset returns specified by equation (1) and (2)2. The parameters of the VAR-GARCH model can be estimated by maximum likelihood method under the assumption of conditional normality.

Eq. (1) is estimated separately for each of the twenty-two different dependent variables Y_t described above. Specifically, dependent variables are the returns on the European STOXX Price index, the returns on the sub-index of STOXX financial firms, Basic Materials, Consumer Goods, Consumer Services, Healthcare, Industry, Oil and Gas, Technology, Telecommunications and Utilities, the returns on the aggregate corporate bond index and the returns on the sub-index of corporate bond of Financials, Basic Materials, Consumer Services, Consumer Goods, Healthcare, Industry, Oil and Gas, Technology, Telecommunications and Utilities. The six-day lag structure is suggested and is consistent with Akaike Information Criterion (AIC). For every specification of dependent variable, the VAR-GARCH model is estimated separately for pre-crisis and crisis period, respectively. In Eq. (1), the conditional mean of the corporate bond and stock returns is influenced by the past history of the corresponding asset returns (captured by the parameters of β_i), the sovereign debt crisis (captured by the parameters of), and financial sector of STOXX or corporate bond price index (captured by the parameters of). The parameters of and π_i in Eq. (1) allow for tests for various hypotheses concerning cross-market spillover effect. The tests and hypotheses are given below.

Test 1 (contagion of CDS spreads)
Granger-cause subsequent returns in other financial markets examined. The null hypothesis (H_0) and alternative hypothesis (H_1) are given by

$$H_0: \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = 0$$

$$H_1: one\ of\ the\ \gamma_i is\ not\ equal\ to\ 0$$

Test 2 (financial contagion of real economy sector) Increase co-movement of non-financial sector to financial sector in European stock and corporate bond markets. The null hypothesis (H_0) and alternative hypothesis (H_1) are givenby

$H_0: \pi_i \leqq 0$

$H_1: \pi_i > 0$

3.2 The VAR-GARCH model with surprises parameter

Recent studies emphasize that sovereign CDS spreads are strongly influenced by a set of local and global variables. Given the evidence of strong similarity in sovereign credit spreads, Longstaff et al. (2011) found that CDS spreads were primarily driven by a set of local and global macroeconomic factors, including the variables representing the state of the local economy (e.g. local stock market returns), the measures from the U.S. equity and fixed income markets, global risk premiums (e.g. monthly changes in the earning-price ratio for theS&P 100 index) ,and the changes in the CDS spreads of the other sovereigns. Pan and Singleton (2008) showed that sovereign CDS risk premiums co-varied with several economicvariables of global event risk (U.S. CBOE VIX option volatility index), financial market volatility (the own-country currency option implied volatility) and macroeconomic policy (the spread between 10-year return on U.S. BB-rated industrial corporate bonds and the 6- month U.S. Treasury bill rate). Hui and Chung (2011) further indicated that a series of macro-financial variables, such as TED spread, the CBOE VIX index, the term spreads between 10- year and 2-year yields of the US Treasuries and euro-area government bonds, should be responsible for the euro crash risk premium.

It is widely recognized that the equity market returns could be explained a different set of factors. The same is true for the set of factors determining the corporate bond yields. However, there is no general consensus as to what is the correct set of factors. In order to determine whether sovereign credit risk represents a separable risk factor different from othereconomic and financial determinants in driving equity and corporate bond market returns, thefollowing set of factors as a fair and parsimonious representation of the fundamentals are chosen: (i) fiscal irresponsibility; (ii) commodity price; (iii) global risk appetite.

(i) Fiscal irresponsibility. Unable to adjust exchange rates in response to unpleasant shocks, some European countries try to alleviate pressures with fiscal expanding. This poses an obvious free-rider problem if there is strong incentive to bail out a country thatborrows excessively. The resulting indebtedness has been exacerbated by the financial crisis. The underlying financial instability has forced euro area facing asymmetric real shocks through external competitiveness and trade over past few years. As a proxy for the fiscal irresponsibility for some European countries, I use the changes in the spreadsbetween yield to maturity on 10-year bonds issued by Germany and the average of 10-year bonds issued by Portugal, Italy, Ireland, Greece, and Spain (sovereign spreads). Sovereign issuers that

are perceived as having a problem of insolvency must pay investor a default risk premium. Based on this, the euro debt crisis brought about sizableinterest rate differential during the period of 2010 to 2012.

(ii) Commodity price. The interest rate differential has an impact on short-term movement ofcapital. As the market participants sense the higher probability of insolvency for highly indebted countries, the spreads between the yield of sovereign bond issued by Germany and the yields of sovereign bond issued by those countries who experienced unusually high debt/GDP ratio during the sovereign debt crisis are expected to widen. Capital flows induced by a portfolio-balance mechanism provide an important channel through which the interest rate differentials impact the commodity market. To capture broad changes in the state of the commodity market, I include a measure from the most widely recognized measure of global commodities markets: TR/Jefferies CRB Index (TR/J CRB Index). The CRB Index is a commodity price index, which was originally composed of 28 commodities, including cocoa, coffee "B", copper, eggs, lard, oats, onions, and rye. Itcurrently is made up of 19 commodities, sorted into 4 groups: petroleum based products,liquid assets, highly liquid assets, and diverse commodities.

From currency diversification to investing in real estate or commodities to holding precious metals, one has many different avenues to hedge against inflation. One thing people do to fight inflation is to buy goods that should appreciate under inflationary times. All over the world, commodity price indexes have helped in monitoring the actual costs of goods and services and not on perceptions. The value of commodity price index should be revised upward in the presence of inflation surprise. In this regard, the relationship between stock returns and CRB index is expected to be positive. However, the stock prices could be negatively related to higher-than-expected inflation because higher inflation reduces after-tax corporate profits.

(iii) Global risk appetite. Higher volatility implies higher risk. Pan and Singleton (2008) considered the VIX index as a measure of event risk in credit markets. As a proxy for the global risk appetite, the CBOE VIX index, the implied volatility index that measures the market‘s expectation of 30-day S&P 500 volatility implicit in the prices of near-termS&P 500 options, is chosen to gauge the investors‘ risk aversion. VIX has become very popular among traders and risk managers as a ―gauge of fear‖. Market participants across asset markets would expect a higher return after a significant increase in VIX.Hence, the negative relationship between the stock returns and the change in VIX is expected. The VAR-GARCH framework incorporating the set of financial and macroeconomic factors also allows us to estimate the

surprises emanating from commodity price, sovereign spreads, and CBOE VIX index. Previous literature employs actual value deviated from their expected value in response to unanticipated events as surprise variable, I use the VAR framework to derive the value of surprise variables. The VAR approach is superior to traditional approachin that the VAR allows us to capture cross market interaction for commodity returns and risk appetite after controlling for the lagged returns of commodity returns, sovereign spreads, and the CBOE VIX index. The following VAR specification is used to calculate the surprises variables:

$$y_t = \alpha + \sum_{i=1}^{\rho} \beta_i y_{t-1} + \varepsilon_t \quad (3)$$

where $y_t$denotes the logarithmic returns on VIX, CRB, and sovereign spreads at time t. Based on the lag length criterion of minimization of Akaike Information Criterion (AIC), one lag is chosen in estimating the VAR model. If the actual value of a dependent variable is greater (less) than its expected value, the surprise is viewed as positive (negative). After considering the set of relevant factors that capture the influence of a potential crisis trigger market in pre-crisis period and crisis period, Eq.(1) and (2) can be augmented as follows:

$$Y_t = \alpha + \sum_{i=1}^{6} \beta_i Y_{t-i} + \sum_{i=1}^{6} \gamma_i CDS_{t-i} + \pi X_t + \psi Z_t + \phi(D_t Z_t) + \varepsilon_t \quad (4)$$

$$\varepsilon_t \sim N(0, H_t)$$

$$vec\hbar(H_t) = C + Kvec\hbar(\varepsilon_{t-1}\varepsilon_{t-1}^{'}) + Fvec\hbar(H_{t-1}) \quad (5)$$

where Z_t denotes the surprises emanating from the CBOE VIX, TR/J CRB index and sovereign spreads at time t. The dummy variable D_t takes on the value of 1, if the surprise is negative or 0, otherwise. The parameters of ψ and ϕ in Eq. (4) effectively capture potential joint response and asymmetric response of asset markets to VIX, CRB, and sovereign spreads, respectively. For example, the significant value of in the estimated results of stockmarket denotes that a CRB return surprise influences the equity return. Also, significantly negative value of in the estimated results of corporate bond market implies that lower- than-expected of CBOE VIX index leads to lower corporate bond returns by more than equivalent positive surprise increase in the corporate bond returns. The data series for the surprise value derived from Eq. (3) will be used as exogenous variable in Eq. (4). To determine whether surprises variables mentioned above represent the separate factors different from sovereign credit risk and financial sector in driving the returns of stock and corporate bond markets, the tests and hypotheses are given as follows.

Test 3 (surprise from VIX)

The relationship between VIX and returns in equity and corporate bond markets is examined. The null hypothesis (H_0) and alternative hypothesis (H_1) are given by

$$H_0: \psi_1 \geqq 0$$
$$H_1: \psi_1 < 0$$

Test 4 (surprise from CRB)

The relationship between CRB and returns in equity and corporate bond markets is examined. The null hypothesis (H_0) and alternative hypothesis (H_1) are given by

$$H_0: \psi_2 \geqq 0$$
$$H_1: \psi_2 < 0$$

Or

$$H_0: \psi_2 \leqq 0$$
$$H_1: \psi_2 > 0$$

Test 5 (surprise from fiscal irresponsibility)

The relationship between sovereign spreads and returns in equity and corporate bond markets is examined. The null hypothesis (H_0) and alternative hypothesis (H_1) are given by

$$H_0: \psi_3 \geqq 0$$
$$H_1: \psi_3 < 0$$

4. DATA AND EMPIRICAL TEST OF CONTAGION

4.1 Crisis Identification and the Data

As mentioned by Dungey et al. (2005), identifying crisis periods is a particular difficult problem. In this paper, the sample selection is based on ex post rationalizations and news-based data to identify the dating of crisis. To obtain the sovereign debt crisis period which encompasses all financial events and unpleasant shocks, this paper uses the timelines provided by Longstaff (2010), the Bank for International Settlement (BIS) and Thompson Reuters. In his article of financial contagion involved in subprime asset-backed collateralized debt obligation (CDO) market, Longstaff provided a brief chronology of some of the major

events during the subprime credit crisis in Table 2. The crisis period could be separated into two distinct phases: the subprime crisis of 2007 and the global financial crisis of 2008. According the BIS study, crisis had developed in five distinct stages of varying intensity, starting with the subprime mortgage-related turmoil between June 2007 and mid-March 2008. Stage 2 spanned a period from March 2008 until mid-September 2008 and the risk of outright bank failure had been continuously elevated. One such failure, the demise of Lehman Brothers on 15 September, triggered the third and most intense stage of the crisis. Stage 3 covered a period from 15 September to late October 2008 and was described as ―global loss of confidence‖. Stage 4, late October 2008 to mid-March 2009, was uncertain with regard to both financial sector stability and the likelihood of a deepening global recession. Stage five, beginning in mid-March 2009, has been marked by signs that the hardest hit economies experienced a classic V-shaped recovery[3].

In late 2009, Ireland and Spain reported larger-than-expected increases in deficit to GDP ratio. In addition, after the general election in October 2009, new Prime Minister, George Papandreou, revealed that the 2009 budget deficit would hit 12.7% of GDP, more than twice its predecessor‘s forecast and four times the EMU guidelines. As on 8 December 2009, Fitch Ratings cut Greece‘s sovereign credit rating to BBB+ from A-. The outlook was ―negative.‖ Greece‘s problems have laid bare the dangers of divergent fiscal policies in the euro area. As a result, 5 November 2009 could be viewed as the onset of European sovereign debt crisis. Given the timeline discussed above, the sample period in this paper comprises a pre-crisis period from 9 March 2009 to 4 November 2009, and a crisis period from 5 November 2009 to22 February 2013. This yields a total sample of 1,035 observations, 173 in pre-crisis period and 862 in crisis period. The returns of the stock and corporate bond market are computed as the difference of the logarithm of the stock and corporate bond market index, respectively.

To test the contagion of the sovereign debt crisis of late 2009-2012 from the financial sector to the real economy (shares of firms that represent the real economy), the daily observation of aggregate stock index, sector stock indices, aggregate corporate bond index, and corporate bond sector indices for Europe are collected. All of the variables are denominated in euro dollar. Regarding the stock market variables, the returns of Dow Jones EURO STOXX Price index (STOXX) and its associated specific sector indices are employed to capture contagion effect of the financial sector to real economy. For the bond market variables, the returns of FTSE corporate bond and its associated specific sectors are included to estimate contagion effect of the financial sector to real economy. Furthermore, in order to test whether the sovereign credit risk is a separate risk factor in driving the returns of stock and corporate bond after controlling aggregate stock market and corporate bond indices, the 5-year CDS spreads

of Portugal, Italy, Ireland, Greece and Spain are collected. To avoid inconsistency, allof these data are obtained from Thompson Reuters Financial DataStream.

4.2 Empirical Results of Contagion

Both Table 1 and Table 2 report some descriptive statistics and correlation matrix of sovereign CDS spreads, euro corporate bond returns and euro stock market returns during the pre-crisis and crisis period respectively. In the sample period before the euro debt crisis, the mean of logarithmic sovereign CDS spreads is -0.0045. The mean of logarithmic sovereign CDS spreads is .0052 in crisis period, revealing a marked increase in sovereign credit risk after the euro debt crisis developed. Table 1 shows that the return of aggregate stock market declined significantly after the onset of sovereign debt crisis. The returns on the sub-index of STOXX financial firms became increasingly negative during the crisis period. For the non-financial sectors, the change of stock returns exhibited the same pattern as it happened in aggregate stock market index. Table 1 also shows that there are major changes in relation between the sovereign CDS spreads and stock sector returns during the sample period.During the pre-crisis period, the average correlation of returns across all sectors is -0.23. During the crisis period, this coefficient decreases to -0.31. Note that the negative correlation coefficient implies that the increase in the sovereign CDS spread is associated with the decrease in the stock return. Table 2 presents the similar results as those reported by Table 1. The euro corporate bond market experienced lower returns in the crisis period than in the per-crisis period. In addition, the average correlation of returns across all corporate bond sectors increases markedly from 0.064 during the per-crisis period to 0.174 during the crisis period.

Given the significant difference in the relation between the sovereign CDS spreads and the returns of corporate bond and stock markets during the sovereign debt crisis period, it is essential for us to examine the possible channels of cross-market linkages across the financial markets by using the VAR-GARCH framework. Table 3 presents the results of the VAR-GARCH estimation without surprise variables for the euro stock markets, while Table 4 summarizes the results of the VAR-GARCH estimation without surprise variables for the corporate bond market. The γ_k coefficients in Table 3 and Table 4 capture the impact of the sovereign CDS spreads on subsequent asset (stock or corporate bond) returns. The p-value for the F-test that the γ_k coefficients are jointly zero is given at column 7. The joint hypothesis F-test allows us to determine whether the sovereign CDS spreads plays an important role in the price discovery process in European corporate bond or stock market during the sovereign debt crisis period[4].

Turning first to the results for stock returns, Table 3 indicates that there is little evidence that

sovereign CDS spreads are able to forecast STOXX Price index and its sub-indices during the pre-crisis period. In contrast, the sovereign CDS spreads have some predictive ability for aggregate stock market returns as the sovereign debt distress event unfolded. Prior to the euro debt crisis, the sovereign CDS spreads have little or no forecast power for financial sector and non-financial sectors. The exceptions are the Industrials and Utilities sectors, in which the F-statistics for these two sectors are significant at the 5% and 10 % level, respectively. Surprisingly, the sovereign CDS spreads are no longer jointly significant in explaining subsequent changes in the Industrials and Utilities sectors during the crisis period. In addition, the sovereign CDS spreads exhibit highly significant forecast power for Financials and Basic Materials sub-indices. Table 3 also shows that most of the significant coefficients for the sovereign CDS spreads in the period of crisis are negative in sign, indicating that a negative shock to the sovereign CDS market (the rise in the value of CDS) translates into a decline in stock returns. Taken together, there is no clear pattern of contagion to the Europeanstock market both in pre-crisis period and in crisis period. The sovereign CDS marketprovides limited evidence in predicting subsequent changes in the euro stock market.

The testing framework also allows an analysis of the homogeneity of the contagion effects across countries and sectors. Baur (2012) argued that there are two types of contagion: investor-induced contagion and fundamental-caused contagion. Investors-induced contagion results from selling off their portfolio of stock as a reaction to a financial shock. This type of contagion, which is more inclined to homogenous picture of contagion, relates to liquidity and other constraints on lenders or investors. For example, the sharp currency depreciation and the decline in equity prices in the United States during the subprime crisis resulted in large capital losses for some international institutional investors, such as hedge funds. These losses may have induced fund managers to sell off securities in other financial markets toraise cash in anticipation of a higher frequency of redemptions. Fundamental-caused contagion occurs if investors observe a change in fundamentals and non-financial (real economy) sectors stocks may fall in response to a crisis in the financial sector. For example, firms in East Asia that are linked to Thailand by trade, investment, and financial transactions would be adversely affected during the East Asian financial crisis. It naturally leads to co- movement in asset prices and capital flows in other countries. On the other hand, Dornbusch et al. (2000) indicate that asset prices and other economic variables will move closelytogether if the financial markets in a region are tightly integrated. The higher the degree of integration, the more extensive could be the contagious effects of an unpleasant shock or a real shock to another country.

Table 1 Summary statistics for CDS and euro stock marketreturns

a. Pre-crisis period

	Mean	Std. dev						Correlation						
			CDS	STOX X	Financial	Basic Materials	Consumer Goods	Consumer Services	Health care	Industrials	Oil andGas	Technology	Telecom.	Utility
CDS	-0.0045	0.0371	1											
STOXX	0.0026	0.0153	-0.3030	1										
Financials	0.0049	0.0236	-0.3260	0.9433	1									
Basic Materials	0.0027	0.0200	-0.3076	0.8946	0.8155	1								
Consumer Goodss	0.0024	0.0150	-0.2734	0.9044	0.7975	0.8096	1							
Consumer Services	0.0012	0.0110	-0.2186	0.8559	0.7581	0.7376	0.7989	1						
Healthcare	0.0013	0.0124	-0.0772	0.5004	0.3438	0.3565	0.4746	0.5378	1					
Industrials	0.0028	0.0192	-0.2641	0.9551	0.9005	0.8795	0.8560	0.8283	0.4107	1				
Oil and Gas	0.0016	0.0162	-0.2380	0.8653	0.7553	0.7933	0.8016	0.7275	0.4688	0.7919	1			
Technology	0.0023	0.0191	-0.1568	0.7792	0.7186	0.6677	0.7105	0.6519	0.3783	0.7381	0.6264	1		
Telecomm.	0.0010	0.0108	-0.1626	0.6371	0.5216	0.4451	0.5950	0.5917	0.5688	0.5218	0.5529	0.4439	1	
Utilities	0.0013	0.0147	-0.2341	0.8017	0.6556	0.7050	0.6874	0.6687	0.5301	0.7219	0.7449	0.5994	0.5838	1

b. Crisis period

	Mean	Std. dev						Correlation						
			CDS	STOX X	Financial	Basic Materials	Consumer Goods	Consumer Services	Health care	Industrials	Oil and Gas	chnology y	Telecom.	Utility
CDS	0.0052	0.0462	1											
STOXX	0.0001	0.0140	-0.3728	1										
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Financials	-0.0002	0.0212	-0.4239	0.9401	1									
Basic Materials	0.0005	0.0150	-0.2858	0.9280	0.8019	1								
Consumer Goods	0.0006	0.0126	-0.2827	0.9105	0.7616	0.8954	1							
Consumer Services	0.0003	0.0112	-0.3453	0.9363	0.8369	0.8710	0.8880	1						
Healthcare	0.0006	0.0109	-0.2344	0.7853	0.6509	0.7660	0.7717	0.7646	1					
Industrials	0.0004	0.0154	-0.3213	0.9592	0.8551	0.9256	0.9070	0.9134	0.7392	1				
Oil and Gas	0.0001	0.0144	-0.2949	0.9209	0.8316	0.8627	0.8316	0.8537	0.7408	0.8736	1			
Technology	0.0003	0.0137	-0.2559	0.8246	0.7077	0.7944	0.7887	0.7934	0.6745	0.8183	0.7574	1		
Telecomm.	-0.0006	0.0131	-0.3247	0.8517	0.8353	0.7286	0.6922	0.7838	0.6586	0.7632	0.7855	0.6325	1	
Utilities	-0.0005	0.0143	-0.3164	0.8878	0.8468	0.7785	0.7432	0.8260	0.6931	0.8120	0.8268	0.6728	0.8460	1
Financials	-0.0002	0.0212	-0.4239	0.9401	1									
Basic Materials	0.0005	0.0150	-0.2858	0.9280	0.8019	1								
Consumer Goods	0.0006	0.0126	-0.2827	0.9105	0.7616	0.8954	1							
Consumer Services	0.0003	0.0112	-0.3453	0.9363	0.8369	0.8710	0.8880	1						
Healthcare	0.0006	0.0109	-0.2344	0.7853	0.6509	0.7660	0.7717	0.7646	1					
Industrials	0.0004	0.0154	-0.3213	0.9592	0.8551	0.9256	0.9070	0.9134	0.7392	1				
Oil and Gas	0.0001	0.0144	-0.2949	0.9209	0.8316	0.8627	0.8316	0.8537	0.7408	0.8736	1			
Technology	0.0003	0.0137	-0.2559	0.8246	0.7077	0.7944	0.7887	0.7934	0.6745	0.8183	0.7574	1		
Telecomm.	-0.0006	0.0131	-0.3247	0.8517	0.8353	0.7286	0.6922	0.7838	0.6586	0.7632	0.7855	0.6325	1	
Utilities	-0.0005	0.0143	-0.3164	0.8878	0.8468	0.7785	0.7432	0.8260	0.6931	0.8120	0.8268	0.6728	0.8460	1

Table 2 Summary statistics for CDS and euro corporate bond returns

a. Pre-crisis period

	Mean	Std. dev						Correlation						
			CDS	Corporate	Financial	Basic Materials	Consumer Goods	Consumer Services	Healthcare	Industrials	OilandGas	Technology	Telecom.	Utility
CDS	-0.0045	0.0371	1.0000											
Corporate Bond	0.0007	0.0020	0.1099	1										
Financials	0.0002	0.0011	0.1129	0.9028	1									
Basic Materials	0.0002	0.0017	0.0196	0.5757	0.4591	1								
ConsumerGoods	0.0003	0.0014	0.0198	0.8258	0.6771	0.3918	1							
Consumer Services	0.0002	0.0013	0.1542	0.5245	0.3480	0.3951	0.4731	1						
Healthcare	0.0001	0.0020	0.0082	0.2193	0.3368	-0.0525	0.1809	-0.1611	1					
Industrials	0.0002	0.0016	0.1091	0.8332	0.6696	0.4698	0.6470	0.4616	-0.0391	1				
Oil and Gas	0.0002	0.0016	-0.1156	0.4369	0.2941	0.4054	0.3086	0.2081	-0.0555	0.3736	1			
Technology	0.0003	0.0023	0.0395	0.5047	0.3580	0.2594	0.5043	0.4467	-0.0526	0.3988	0.1491	1		
Telecomm.	0.0002	0.0016	0.1089	0.9206	0.7891	0.4602	0.7748	0.5019	0.2402	0.7001	0.3525	0.5652	1	
Utilities	0.0001	0.0018	0.1344	0.7680	0.6235	0.4352	0.5902	0.3455	0.2315	0.5683	0.3095	0.2916	0.6551	1

b. Crisis period

	Mean	**Std. dev**						**Correlation**						
			CDS	**Corporate**	**Financial**	**Basic Materials**	**Consumer Goods**	**Consumer services**	**Healthcare**	**Industrials**	**Oil and Gas**	**Technology**	**Telecom.**	**Utility**
CDS	0.0052	0.0462	1											
Corporate Bond	0.0001	0.0016	0.2022	1										
Financials	0.0001	0.0016	0.1503	0.9650	1									
Basic Materials	0.0000	0.0016	0.1784	0.8243	0.7970	1								
Consumer Goods	0.0001	0.0013	0.2435	0.8848	0.8036	0.7330	1							
Consumer Services	0.0001	0.0018	0.2004	0.8588	0.7817	0.7636	0.7961	1						
Healthcare	0.0002	0.0039	0.1908	0.6303	0.5839	0.5257	0.6483	0.5731	1					
Industrials	0.0001	0.0022	0.2078	0.7809	0.6522	0.5844	0.6722	0.7048	0.4326	1				
Oil and Gas	0.0001	0.0016	0.0692	0.7226	0.6897	0.6315	0.6430	0.6265	0.4598	0.4906	1			
Technology	0.0000	0.0050	0.0195	0.4869	0.4634	0.3998	0.3810	0.3932	0.2400	0.3073	0.3352	1		
Telecomm.	0.0001	0.0020	0.2065	0.9400	0.8797	0.7664	0.8488	0.7959	0.6073	0.6864	0.6660	0.5457	1	
Utilities	0.0001	0.0024	0.2448	0.9282	0.8547	0.7752	0.8801	0.8378	0.6486	0.6873	0.6601	0.4475	0.9031	1

It is reasonable to assume that the European financial sector is infected by the sovereign debt crisis and spread it to other non-financial sectors with the finding of strong linkage between the sovereign CDS spreads and sub-index of financial firms. The coefficient π_1 estimates the real economy (non-financial sector) contagion spread through European financial system. Table 3 displays that all of the significant coefficients for the financial sector return in crisis period are positive in sign, implying that a negative shock to financial firms map intonegative

returns in real economy sectors in the Euro STOXX Price index. During the pre- crisis period, only the Oil and Gas sector is not affected by the financial sector. The price effect on the real economy sector during the crisis period is larger than the price effect on the real economy sector during the pre-crisis period. The coefficient π_1 also sheds light on the earlier discussion about the nature of financial contagion mechanism. Specifically, there is a remarkable homogeneity of coefficient estimates for some sectors. For example, Oil and Gas, Basic Materials, Utilities and Industrials all show values of around 0.60. This homogeneity of contagion effect suggests a similar reaction of market participants to the sovereign debt crisis. This result is consistent with the view found by Baur (2012) that Global Financial Crisis results in investor-induced contagion being transmitted form financial sector to real economy sector. Focusing next on the corporate bond market, Table 4 displays that only 4 out of 10 sectors areaffected by the sovereign CDS market before the onset of sovereign debt crisis. The sectors affected are Consumer Services, Oil and Gas, Technology, and Telecommunications. Incontrast, there is a marked evidence of forecast ability after the onset of the sovereign debt crisis. The sole exception is that the p-value for the F-statistics is 0.26 for the Telecommunications. Note that the significant coefficients in the VAR-GARCHs are negative in sign, indicating that declines in sovereign CDS spreads translate into greater subsequent corporate bond returns. These results provide strong support for the view that European sovereign debt crisis resulted in contagion as shocks in the sovereign CDS market were transmitted to much larger and more liquid corporate bond market. Turning to the coefficient estimates measuring the change in the level of co-movement of financial sector and the sectors representing the real economy,

Table 3 VAR-GARCH estimation results: STOXX PRICE Index

Table 3 VAR-GARCH estimation results: STOXX PRICE Index									
Y				Pre-crisis period					
	γ_1	γ_2	γ_3	γ_4	γ_5	γ_6	p	π_1	R^2
Stoxx	0.0114	0.0003	0.0237	0.0184	0.0453	0.0176	0.7978		0.2082
Financials	0.0277	-0.0259	0.0264	0.0091	0.0596	0.0383	0.7594		0.1660
Basic Materials	-0.0325	0.0036	0.0322	0.0561*	-0.0264	0.0092	0.1919	.794***	0.6645
Consumer Goods	-0.0258	-0.0375	0.0374	0.0430	0.0196	0.0107	0.6005	.538***	0.6055
Consumer Services	-0.0108	-0.0017	0.0274	0.0010	-0.0011	0.0148	0.8638	.396***	0.6055
Healthcare	-0.0296	-0.0266	-0.0198	0.0092	-0.0040	0.0187	0.8268	.237***	0.1445
Industrials	-0.0013	0.0027	0.0584***	-0.0037	- 0.0468**	0.0284	.0406**	.779***	0.8296
Oil and Gas	0.0011	0.0310	0.0436*	0.0217	0.0091	0.0357	0.1282	0.562	0.6083
Technology	0.0083	0.0018	0.0011	-0.0030	0.0081	-0.0495	0.8238	.612***	0.5573
Telecomm.	-0.0239	0.0033	-0.0198	0.0120	-0.0067	0.0170	0.8612	.250***	0.2995
Utilities	-0.0138	-0.0220	0.0329	0.0520*	0.0192	0.0196	.065*	.476***	0.4691

Y			Crisis period						
	γ_1	γ_2	γ_3	γ_4	γ_5	γ_6	p	π_1	R^2
Stoxx	-0.0147	0.0147	-0.0139	-0.0142	-0.0139	-0.015**	0.0204**		0.0098
Financials	-0.031**	0.0210	-0.0257	-0.0183	-0.0244	- 0.0216*	0.0096***		0.0162
Basic Materials	0.0177***	0.0090	-0.0089	0.0024	- 0.00006	-0.0012	.0488**	.576***	0.6482
Consumer Goods	0.0137	0.0024	-0.0032	-0.0005	0.0050	-0.0011	0.3629	.463***	0.5837
Consumer Services	0.0044	0.0020	-0.0086*	-0.0026	0.0082	-0.0048	0.3448	.496***	0.7054
Healthcare	-0.0018	0.0025	-0.0035	-0.0092	-0.0033	0.0110	0.3860	.342***	0.4290
Industrials	0.0136***	0.0064	-0.0031	0.0001	0.0074	-0.0075	0.1238	.617***	0.7337
Oil and Gas	0.0081	0.0051	-0.0072	-0.001	0.0097	-0.0023	0.5496	.598***	0.6940
Technology	0.0089	0.0056	-0.0163*	0.0023	-0.0129	-0.0058	0.1264	.461***	0.5093
Telecomm.	0.0032	0.0066	-0.0010	-0.0062	-0.0072	0.0036	0.4613	.513***	0.7040
Utilities	0.0030	-0.0008	-0.0038	-0.0041	0.0012	0.0088	0.6781	.569***	0.7205
Note: Coefficient estimates of conditional volatility are not reported. The p-value for the F-test ofthe joint hypothesis that $\gamma_1=\gamma_2=\gamma_3=\gamma_4=\gamma_5=\gamma_6=0$ is reported.									
The VAR-GARCH model is as follows: $Y_t = \alpha + \sum_{i=1}^{6} \beta_i Y_{t-i} + \sum_{i=1}^{6} \gamma_i CDS_{t-i} + \pi X_t + \varepsilon_t$									

The superscript *** denotes significance at the 1 % level. The superscript ** denotes significanceat the 5 % level.The superscript * denotes significance at the 10 % level.

Table 4 shows a very similar pattern. During the pre-crisis period, all but the Gas and Oil sector exhibit significantly positive interdependence. A positive and statistically significant estimate of the coefficientπ_1 indicates a strong evidence of cross-sector contagion. The lower panel of Table 4 shows that all of theπ_1 are statistically significant at 1% level. The magnitude of coefficient estimates in crisis period is greater than as those in pre-crisis period.These results indicate a clear evidence of financial contagion between financial sector and real economy for the corporate bond market as the sovereign debt distress event unfolded. Again, there is a significant homogeneity of coefficient estimates for some sectors. For example, Oil and Gas, Consumer services and Consumer Goods all display values of around 0.70, Telecommunications, Technology, and Utilities values around 1.20, and Consumer Services and Industrials values around 0.9. This homogeneity of the contagion effect for groups of comparable sectors suggests a similar reaction of investors to the sovereign debt crisis.

Table 4 VAR-GARCH estimation results: European corporate bond

Y				Pre-crisis period					
	γ_1	γ_2	γ_3	γ_4	γ_5	γ_6	p	δ_1	R^2
Corporate Bond	-0.0064***	-0.0016	-0.0025	0.0007	0.0029	-0.0045*	.024**		0.7463
Financials	-0.0006	0.0002	0.0004	-0.0012	-0.0005	0.0012	0.9768		0.7091
Basic Materials	0.0003	0.0012	0.0027	0.0004	-0.0004	0.0038	0.9965	.8304***	0.2931
Consumer Goods	-0.0045*	-0.0003	0.0023	0.0000	-0.0010	0.0013	0.677	.7041***	0.5091
Consumer Services	0.0001	0.0027*	-0.0011	-0.0032	0.0003	0.0066***	.0002***	.4807***	0.4225
Healthcare	0.0025	0.0016	0.0006	0.0012	-0.0024	0.0020	0.703	.4901***	0.4564
Industrials	-0.0018	0.0010	0.0012	-0.0028	0.0028	0.0004	0.858	.6448***	0.5864
Oil and Gas	-0.0094***	-0.0039	0.0057	-0.0023	-0.0025	0.0020	.006***	0.3361	0.3433
Technology	-0.010***	0.0025	0.0059**	-0.0030	-0.0037	-0.0015	.005***	.7775***	0.3676
Telecomm.	-0.0027	-0.0019	0.0049**	-0.0012	-0.0024	0.0042**	.025**	.6196***	0.7355
Utilities	0.0001	0.0010	-0.0006	0.0006	0.0065	-0.0031	0.636	0.656***	0.4569

Y			Crisis period						
	γ_1	γ_2	γ_3	γ_4	γ_5	γ_6	p	δ_1	R^2
Corporate Bond	-0.003**	-0.0010	0.0022*	-0.0010	-0.0012	0.0014	0.006***		0.0156
Financials	-0.0013	-0.0021*	0.0010	-0.0005	-0.0013	0.0009	0.04**		0.0290
Basic Materials	0.0018**	-0.0025***	0.0023***	0.0020**	-0.0004	0.0014*	0.00***	.722***	0.6345
Consumer Goods	0.0013**	0.0006	0.0011**	-0.0001	-0.0002	0.0007	0.02**	.698***	0.6478
Consumer Services	-0.002**	-0.0022***	-0.0021***	0.0006	-0.0009	0.0016	0.00***	.895***	0.6003
Healthcare	0.0013***	0.0006	0.0011	-0.0001***	-0.0002***	0.0007**	0.00**	1.49***	0.3280
Industrials	0.0009	0.0016	0.0047***	0.0004	0.0012	0.0027***	0.00***	.936***	0.4275
Oil and Gas	-0.0001	0.0011	-0.0006	-0.0014**	-0.0018**	0.0012	0.008***	.6679***	0.4862
Technology	-0.0075***	-0.0024	0.0010	-0.0016	-0.0022	0.0014	0.00***	1.217***	0.2056
Telecomm.	-0.0009	-0.0006	0.0003	0.0005	-0.0006	0.0010	0.2558	1.078***	0.7767
Utilities	0.0015	-0.0005	0.0021**	0.0012	-0.0004	0.0011	0.09*	1.32***	0.7321

Note: Coefficient estimates of conditional volatility are not reported. The p-value for the F-test of thejoint hypothesis that $\gamma_1=\gamma_2=\gamma_3=\gamma_4=\gamma_5=\gamma_6=0$ is reported.

The VAR-GARCH model is as follows: $Y_t = \alpha + \sum_{i=1}^{6} \beta_i Y_{t-i} + \sum_{i=1}^{6} \gamma_i CDS_{t-i} + \pi X_t + \varepsilon_t$

The superscript *** denotes significance at the 1 % level. The superscript ** denotes significance atthe 5 % level. The superscript * denotes significance at the 10 % level.

Taken together, cross-market linkages become much stronger during the sovereign debtcrisis, which is consistent with the standard definition of financial contagion mentioned earlier. To be more specific, sovereign CDS spreads are able to Granger-cause returns on the corporate bond market and some sectors of the stock market after the onset of euro debt crisis[5]. The evidence of for financial sector and the sectors representing the real economy can also be employed to detect the nature of contagion channels in financial market. Note that in previous section, Longstaff (2010) indicated at least three possible contagion propagation channels: the liquidity channel, the correlated-information channel, and the risk-premium channel. Besides that, Dornbusch et al. (2000), according the standard definition of contagion, also identified two possible contagion mechanisms: investor-induced contagion and fundamental-caused contagion.

The weak evidence that the sovereign CDS spreads were able to forecast subsequent changes in much larger and more liquid sub-indices of European stock market during the sovereign debt crisis argues against the correlated-information channel as mechanism of financial contagion. If the source of contagion was correlated information, there would be a more rapid price discovery from sovereign CDS market to stock, stock index option, and corporate bond market. Thus, the clear pattern of nearly contemporaneous relation between shocks in the sovereign CDS spreads and actively traded stock is expected after the onset of crisis.

On the other hand, the strong evidence for homogeneous contagion of the financial sector to some ―real economy‖ sectors demonstrates that an unpleasant shock in financial market is propagated primarily through the investor-induced contagion, which is consistent with the contagion spreading via a liquidity/financing channel argued by Longstaff (2010), who investigated CDOs contagion during the subprime crisis period and Baur (2012), who analyzed financial sector contagion during the Global Financial Crisis period.

Focusing next to results of the contagion of financial sector stock to real economy sector stocks, the estimated results with surprises parameter are similar those without surprises parameter. A positive and significant coefficient of π_1 implies contagion (hypothesis 2). Furthermore, there is a remarkable homogeneity of coefficient estimates for some sectors. For example, Basic Materials, Oil and Gas, Telecommunications, Utilities and Industrials all show values of around 0.50. Consumer Goods, Consumer Services, and Technology display values of around 0.40. This strong evidence of homogeneous contagion effect suggests that market participants pool sectors or markets and act similarly during the sovereign debt crisis. The evidence of similar investor reaction across real economy sectors indicates that the contagion mechanism is via an investor-induced contagion.

Table 5 VAR-GARCH estimation results with surprise parameters: European corporate bond

Y				Pre-crisis period											
	γ_1	γ_2	γ_3	γ_4	γ_5	γ_6	p	π_1	ψ_1	ψ_2	ψ_3	φ_1	φ_2	φ_3	R^2
Corporate Bond	-0.012**	0.0035	-0.0055	-0.0017	0.0095**	-0.0078*	0.026**		0.0001**	-0.035*	-0.0104	-0.0001	0.0001	-0.0005	0.0590
Financials	-0.006**	0.0050	-0.0014	-0.0045	0.0059**	-0.0035	0.034**		-0.000001	-0.0118	-0.0013	-0.0001	0.0003	-0.0006*	0.2173
Basic Materials	0.0004	0.0013	0.0035	-0.0002	-0.0005	0.0034	0.9952	.7096***	-0.000013	0.0126	0.0009	-0.0002	0.0007	-0.0003	0.3110
ConsumerGoods	-0.0058**	0.0012	0.0024	-0.0004	-0.0009	0.0020	0.5024	.8470***	0.000028**	-0.0166**	0.0000	0.0001	-0.0003	-0.0001	0.4760
Consumer Services	-0.0018	0.0015	0.0001	-0.0027**	0.0010	0.0044**	0.6610	.4178***	-0.00002***	-0.008**	0.008***	0.0000	-0.0004***	0.0003**	0.4760
Healthcare	0.0013	0.0027	0.0010	0.0025	-0.0022	0.0006	0.8268	.6721***	0.000032	0.0119	-0.0020	0.0001	0.0001	-0.0002	0.4987
Industrials	-0.0026	0.0018	-0.0002	-0.0035	0.0034	-0.0010	0.9981	.9465***	0.000013	-0.0172	0.0061	0.0001	-0.0010	-0.0004	0.5249
Oil and Gas	-0.0220	0.0080	0.0029	0.0480	-0.0228	0.0408	0.7223	-3.27***	-0.000022	1.097***	-0.0695	0.0006	0.0033	-0.0031	0.4576
Technology	-0.011	0.0012	0.0034	-0.004	-0.0045	-0.0001	.000***	.8066***	-0.000024	-0.0036	0.0070	0.0001	-0.0002	0.0005	0.3996
Telecomm.	-0.005	0.0008	0.0013	-0.0004	-0.0011	0.0032	0.2344	1.214***	0.000016	-0.02***	0.0014	0.0003	-0.0007*	0.0001***	0.6903
Utilities	0.0000	0.0002	-0.0011	0.0004	0.0073	-0.0029	0.6801	0.929***	-0.000004	-0.0103	0.012*	-0.0003	-0.0001	0.0002	0.4514

Table 5 VAR-GARCH estimation results with surprise parameters: European corporate bond

Y				Crisis period											
	γ_1	γ_2	γ_3	γ_4	γ_5	γ_6	p	π_1	ψ_1	ψ_2	ψ_3	φ_1	φ_2	φ_3	R^2
Corporate Bond	-0.0034***	-0.0018	0.0017	-0.0001	-0.0018	0.0012	0.0023***		-0.00002**	-0.018**	0.001*	-0.0004***	-0.0001	-0.0004***	0.1265
Financials	-0.0022*	-0.0026**	0.0007	0.0000	-0.0017	0.0007	0.0132**		-0.00002*	-0.0139**	0.0008**	-0.0003***	-0.0001	-0.0003***	0.1053
Basic Materials	0.0016**	-0.0028***	0.0016**	0.0018***	-0.0012***	0.0010	0.000***	.7048***	0.00001	-0.0073**	0.00001	-0.0001	-0.0001	-0.0002***	0.6392
ConsumerGoods	0.0007	0.0006	0.0006	-0.0001	-0.0005	0.0005	0.4187	.6635***	0.00001***	-0.0121***	0.0008***	-0.00003	-0.0002**	-0.0002***	0.6794
Consumer Services	-0.0007	-0.0003	0.0014*	0.0016**	0.0003	0.0008	0.0296**	.8516***	0.000002	-0.0012	0.0036***	-0.0001**	-0.00005	-0.0001	0.5957
Healthcare	0.0059***	0.0007	-0.0014	-0.0049***	0.0109***	-0.0023*	0.000***	1.481***	0.000004	0.0187**	-0.0006	-0.0006***	-0.0001	-0.0003**	0.3424
Industrials	0.0005	0.0018*	0.0049***	0.0004	0.0004	0.0028***	0.000***	.9222***	-0.000003	-0.0006	0.0004	-0.0002**	0.0000	-0.0001	0.4230
Oil and Gas	-0.0002	-0.0027	0.0016	-0.0034	0.0241**	-0.0206***	0.0257**	-.778***	-0.00008	1.0542***	-0.0041	0.0010	0.0015	-0.0013	0.4510
Technology	-0.0069***	-0.0020	0.0016	-0.0014	-0.0019	0.0017	.0067***	1.205***	-0.00004**	-0.0027	0.0017*	0.0001	-0.0002	0.0004	0.2117
Telecomm.	-0.0015**	-0.0008	0.0002	0.0004	-0.0008	0.0008	0.1021	1.055***	0.000002	-0.0058	0.0004	-0.0001	-0.0001	-0.0002**	0.7824
Utilities	0.0001	-0.0007	0.0015	0.0010	-0.0005	0.0009	0.6482	1.269***	0.00001	-0.0127**	0.0016***	-0.0002*	-0.0001	-0.0002**	0.7520

Note: Coefficient estimates of conditional volatility are not reported. The p-value for the F-test of the joint hypothesis that γ1=γ2 = γ3= γ4=γ5 = γ6= 0 is reported.

The VAR-GARCH model is as follows: $Y_t = \alpha + \sum_{i=1}^{6} \beta_i Y_{t-i} + \sum_{i=1}^{6} \gamma_i CDS_{t-i} + \pi X_t + \psi Z_t + \phi(D_t Z_t) + \varepsilon_t$

The superscript*** denotes significance at the 1 % level. The superscript ** denotes significance at the 5 % level. The superscript * denotes significance at the 10 % level.

Table 5 displays the estimation results of the VAR-GARCH model with surprise variables testing for contagion of corporate bond market. Sovereign CDS spreads developed significant forecast ability for subsequent corporate bond market returns as the 2009 sovereign debt crisis unfolded. Hence, hypothesis 1can be rejected for 7 out of 10 sectors at the 5% significant level. In contrast, there is limited predictability by sovereign CDS spreads for the corporate bond returns during the pre-crisis period. Only2 out of 10 sectors are statistically significant. Turning next to results of the change in the level of co- movement of financial sector and sectors representing the real economy (hypothesis 2), Table 6 shows a very similar pattern as those presented in Table 4. A positive and statistically significant coefficient estimate of π_1 implies contagion. The coefficient estimates displayed in Table 6 illustrate that there is increased return co-movement of the real economy sectors and the financial sector in the euro area and a relatively high degree of interdependence in crisis period compared to its counterpart in pre-crisis period. These results suggest that it is possible that investors sell off all corporate bonds in their portfolios as a reaction to the sovereign distress event unfolded and thus is an investor-induced contagion. As for the impact of surprise variables on the corporate bond returns, the estimated results seem to provide some evidence, albeit mixed, that the relation between corporate bond returns and VIX became more pronounced during the late 2009 sovereign debt crisis. In particular, three of the F-statistics for the lagged sovereign CDS spreads are significant during the pre-crisis period. During the crisis period, however, fourof the F-statistics are statistically significant. Moreover, the significantly negative value of φ_1 for VIX indicates that lower-than-expected change in VIX decreases European corporate bond returns by more than equivalent positive surprises increases the returns after the onset of the euro debt crisis. Statistically insignificant values of ψ_3 across sectors reveal that, as documented by other researchers, sovereign spreads between Germany and highly indebted countries have no measurable asymmetrical impact on European corporate bond returns. The statistically significant positive coefficient estimates seem to contradict with the prediction by hypothesis 5. A possible explanation is that investors may sell all sovereign bonds in their portfolio as a reaction to the sovereign debt distress event unfolded. Instead, theyconsider corporate bonds as safer assets and a portfolio-balance mechanism provide an important channel through which the interest rate surprise impacts the corporate bond market. Taken together, the evidence that sovereign CDS spreads developed significant predictive ability for returns in other major financial markets such as corporate bond and STOXX Price index during the sovereign debt crisis provides strong support for the hypothesis that there were spillover effects during thecrisis. Cross-market linkages became much stronger and significant after the sovereign debt crisis developed. Equivalently, the sovereign CDS spreads are able to Granger-cause returns in other markets during the sovereign debt crisis (but not before the sovereign debt crisis, indicating a change in cross- market linkages).

5. CONCLUSION

During the past few years, the subprime crisis originated in the U.S. and the sovereign debt crisis in Europe have rekindled interest in the empirical investigation of the shock transmission mechanisms linking real activity or financial instrument and financial markets, operating both within the U.S. and across world economies. Just like the crisis in the subprime asset-backed market provides a near-perfect ground for studying the contagion in other major financial markets[6], the European sovereign debt crisis also offer the near-ideal opportunity for studying the role that contagion may play in major financial markets. By utilizing data for sovereign CDS spreads for Portugal, Italy, Ireland, Greece, and Spain, this paper adopted a VAR-GARCH framework to determine whether the sovereign CDS market Granger- cause the returns in major financial markets. The cross-sector linkages between financial firms and real economy are also examined after the onset of the euro debt crisis.

The empirical findings in this paper provide significant evidence of an increase in cross-market linkages. Prior to the sovereign debt crisis, sovereign CDS spreads contain little information in forecasting European stock and corporate bond markets. After the crisis developed, the sovereign CDS spreads contain strong forecast power for the corporate bond returns and weak forecasting ability for the sub- indices of stock returns. The evidence for contagion of the sector representing the real economy is Basic Materials only. The fact that the price discovery process is limited in the highly liquid stock market seemsto indicate that the source of contagion is not via the correlation-information channel. Thus, the mechanism of contagion in the financial market after the distress event appears to be propagated through the liquidity channel or the risk-premium channel. Furthermore, the testing framework is also allowed to analyze the propagation of financial shocks fromthe financial sector to ―real economy‖, i.e. shares of firms that represent the real economy. Not surprisingly, the results show that the sovereign debt crisis can be characterized by strong contagion among the corporate bond and stock markets. It is widely recognized that contagion in stock markets is linked to investor behavior. A remarkable homogeneity of coefficient estimates is found in some ―real economy‖ sectors. This empirical finding reinforces the view that market liquidity effect is a major effect in the transmission of financial shock during the sovereign debt crisis. Evidence related to the stock market reveals that the decrease in European stock returns in response to higher-than-expected increases in VIX and sovereign spreads in crisis period. Furthermore, European stock markets are asymmetrically responsive to US CBOE Volatility index and sovereign spreads between Germany and highly indebted countries. By contrast, a positive interest rate shock triggers the increase in the corporate bond returns. Empirical evidence testing for the impact of commodity and fiscal surprises on major financial markets indicates that the modeling of stock and corporate bond market should consider the role of simultaneous effect of surprise emanating from other economic and financial developments. The impact of surprises in major financial markets demonstrates that no sector wasimmune to the distress event of the sovereign debt crisis limiting the effectiveness of portfolio diversification. A key aspect of this paper is that the results allow us to compare among different channels of contagion that appear in the previous contagion literature. For example, there is strong evidence that the source of contagion via the liquidity channel by examining the information flow between the sovereign CDS market and major financial markets in Europe. Furthermore, the price discovery of financial sector in spreading crisis to other sectors is also occurred much more frequently during the sovereign debt crisis. The surprises in VIX, CRB, and sovereign spreads seem to affect European stock market and corporate bond market, respectively. In summary, cross-market linkages became much stronger and significant during the sovereign debt crisis (but not before the sovereign crisis).

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