University of Piraeus

Department of Banking and Financial Management

M.Sc. in Banking and Financial Management

Master Thesis

«News Events and Market Contagion: Evidence from the European sovereign-debt crisis»

Student Information: Nikolaos Charisis

Registration Number: MXPH1313

Supervisor: Dr Christina Christou

Committee: Dr Georgios Diacogiannis

Dr Nikitas Pittis

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Content

Chapter 1

1. Abstract

This master thesis examines the existence of market contagion among the European Sovereign debt crisis. The collected data is divided into two periods; the pre-crisis period of the European crisis period (U.S crisis) and the European crisis period. The selected countries are not only countries that were majorly affected by the crisis (Greece, Ireland, Portugal, Italy, and Spain) but also Germany and United States as benchmark countries. The selected variables are 10 year government bonds and stock price index. The results revealed that the existence of market contagion was not limited among the aforementioned countries that were vastly hit by the crisis. Moreover, the subsistence of contagion was captured more efficiently through tests that included higher order moments.

Key words: market, contagion, European, American, crisis, news, events

2. Summary

This research tried to reveal the existence of contagion through evidence from the European sovereign debt crisis. Through the record of news and events that occurred at the timeline of the European crisis, the potential subsistence of contagion is tested. In order to demonstrate whether European debt crisis was the result of the precedent U.S crisis, two periods were selected (American and European crisis). This project focused on the variables of 10-year government bond and stock price index (ASE, CAC, DAX etc.) The tests that were used through this research were Forbes-Rigobon test, coskewness and cokurtosis. The results of the thesis indicated the existence of contagion not only among the variables of one country (e.g. from Greek bonds to Greek stock price index) but also from a variable of one country to a variable of another country. In addition, market contagion was not limited between the countries that were influenced by the European crisis.

3. Literature Review

1. Introduction

The term contagion itself comes from the Latin word contagio, and its literal interpretation is "from touch". At first, the notion of contagion was used as a manner to explicate and depict the social, in contrast to biological, phenomena that occurred in the late 19th century France, remarkably via the work of James Mark Baldwin (1894), Gabriel Tarde (1903) and Gustave Le Bon (1895). However, it is striking that the empirical research into the phenomenon did not start till the 1950s.

The research in social contagion can be divided into two main categories, studies examining the emotional contagion and studies examining behavioural contagion. The investigation of behavioural contagion can be divided into 6 sub-categories based on the type of the behaviour; consumer behaviour contagions, contagions of aggression, deliberate self-harm contagions, financial contagions hysterical contagions, and rule violation contagions.

The need to explain this phenomenon led to two different theories. On the one hand, the first theory reports that the spread of homogeneity occurs due to imitation in uncertain situations. An example of this theory is Emergent Norm Theory.

On the other hand, the second theory states that contagion occurs because of alleged latent homogeneities from previous incentives that precede the particular phenomenon. An example of this theory is Convergence Theory. Despite the existence of these two different theories, it is important to note that such theories might manage to explain the notion of social contagion occasionally, but none of them can explicate this phenomenon completely.

2. Recent examples of contagion

It is noteworthy that before 1997 the use of the notion of contagion was used in order to express the transmission of a medical illness. However, the reference point for the change in the meaning of the term was in July of 1997. In this year, a currency crisis in Thailand occurred and its consequence was the transmission of this crisis firstly throughout East Asia and then throughout Russia and Brazil. As a result, the period before the East Asian incidents, the spread of financial crisis from one country to an international level was studied scarcely.

This crisis in Thailand spread within a short period to Hong Kong, Indonesia, Malaysia, Philippines, and Korea. This short-term transmission indicates that the importance of the transmission comprehension equals the importance of the factor that triggered the original incidents in Thailand.

During this period, the bankruptcy of Russia occurred in August 1998. This fact led to the increase of the risk premium in countries like Brazil, Mexico and Hong Kong. It is striking that none of these 3 countries share common borders. Moreover, none of them are in the same geographical region with Russia or have economic ties. This event indicates that the irrelevance of economic relationship among countries does not exclude the probability of transmission of economic difficulties from one country to another.

However, it is worth mentioning that the spread of this crisis did not finish in these countries. More specifically, developed markets in North America and Europe were influenced by changes in relative prices of financial instruments. This sequence of events led to the collapse of a large U.S hedge fund (Long-Term Capital Management). These global consequences that started from the economy of Thailand, and can be characterized as a

relatively small one, gave rise to a new meaning for the term of contagion.

Another example of the spread of contagion is through the channel of devaluation expectations. Particularly, the crisis of the European Exchange Rate Mechanism (ERM) in the summer of 1992 raised the expectations for devaluation of the currencies of the member countries in relation to DM. However, it needs to be stressed that the market expectations play a major role and may determine the course of events that occur via the channels of transmission.

One of the most recent examples is the European sovereign-debt crisis that started in 2010. More specifically, the inability of Greece to service its public debt, led the lending rates to unprecedented levels not only for Greece but also for Ireland, Spain and Portugal. It has to be reported though that the twin deficits (budget deficit and current balance deficit) made these 3 countries vulnerable to the spread of the crisis and caused a domino effect.

Despite the fact that the attempt to explain the financial contagion began the last decades, the phenomenon of contagion proves to be timeless. This follows from the fact that through the period of the Great Depression in 1930s the banking crisis that occurred in Austria was spilled over into Germany. Consequently, in all the above cases the common component is the fact that the bad news travel fast.

This difficulty to comprehend the mechanism of transmission of the financial crisis the previous years has led recently to a major shift and increased interest in studying financial contagion.

3. Definitions of Contagion

Before proceeding to any sort of analysis, it is vital to attempt to define the term contagion. On the one hand, a number of economists that used empirical tests referred to a stricter definition of contagion. More specifically, it was defined as a raise in cross-market linkages through the duration of a crisis. For example, **Forbes and Rigobon (2002)** suggested using the term "shift-contagion" in order to purify the meaning of this notion.

On the other hand, a portion of economists revealed a tendency to use a broader definition. For instance, **Pritsker (2002)** sets contagion as an incident when a shock to one market was transmitted to others. This definition gave the opportunity to indicate the weakness of a country to a crisis that occurred somewhere else.

Other economists preferred definitions of contagions that can be categorized between these two reported.

Five definitions of contagion were reported on the paper of **Pericoli and Sbracia (2003)**. This series of definitions is listed as follows:

1st definition: Contagion is an important increase in the probability of a crisis in one country that depends on a crisis that occurred in another country.

This kind of definition is frequently linked with empirical researches of the international implications of exchange rate breakdowns. It is related with the opinion that the domino from exchange rate crises includes a large number of countries. However, it is believed that some of these countries may prevent a potential devaluation although they receive continuous speculative attacks. This proposed definition was consistent with an amount of different perspectives as far as the international spread mechanism is concerned.

2nd definition: Contagion appears when the volatility of asset prices is transmitted from the crisis country to others. This definition sets contagion as a volatility spillover from one market to another. In the same way, a different explanation of this definition reports contagion as a spread of uncertainties across international financial markets.

3rd definition: Contagion appears when cross-country comovements of asset prices cannot be interpreted by fundamentals. This definition of contagion coincided with the theoretical framework of models that allow multiple instantaneous equilibria in the presence of a coordination problem. Consequently, in case that the transmission of a crisis mirrors an arbitrary switch from one balance to another, the fundamentals cannot interpret its timing and modalities individually. This definition may practice in cases where coordination problems between the economic agents are not linked with the arbitrary mechanisms of the equilibrium selection.

4th definition: Contagion is an important raise in co-movements of prices and quantities across the markets, which depends on a crisis that occurred in one market or in a group of markets. The common perception of contagion the previous years (e.g. the Hong Kong stock market crash in October 1997, the Russian crisis in the summer of 1998) coincides with this kind of definition.

5th definition: (Shift-) contagion results when the spread channel becomes larger or, in general, switches after a shock in one market. In other words, the international transmission mechanism may be intensified due to a crisis in one country. For example, some of the spread channels might be effective only during financial crises.

The above categories can be concluded as a revise of the most widely used definitions of contagion.

Forbes and Rigobon analyzed one of the above referred definitions. They presented a definition of contagion in order to distinguish this precise definition from pre-existing perceptions; they suggested utilizing the phrase 'shift-contagion' in position of simply 'contagion'.

In this way, the writers defined contagion as an important increase in cross-market linkages after a shock that happened to an individual country (or to a group of countries). The selection of the phrase shift-contagion makes sense for two different reasons. Firstly, this notion makes clear that contagion occurs from an increase in cross-market linkages. Secondly, this term contributes significantly in order to avoid taking a position on the way that this increase emerged. In the existence literature, this definition appears to be a popular one.

Cross-market linkages that reported above might be measured by different kind of statistics, like the correlation in the returns of the assets, the probability that a speculative attack may occur, or the spread of negative shocks.

It is noteworthy that the above definition of contagion is not globally acceptable. This happens because a portion of economists claim that the spread of a shock from one country to another is defined as contagion despite the fact that a significant shift in cross-market relationships might have not occurred.

On the other hand, some economists claim that it is not possible to define contagion on the basis of simple tests of shifts in cross-market relationships. More specifically, they highlight the necessity of an exact identification of the way that a shock is spread between the countries. They continue by stating that only certain types of spread mechanisms can be regarded as contagion, regardless of their size.

The writers stressed this specific definition of shift-contagion for three particular reasons.

Firstly, an important quotation in the investment strategy theory implies that the majority of the economic perturbations are country specific. As a consequence, based on this logic, it can be concluded that stock markets in different countries should probably demonstrate low correlations. Hence, the diversification at international level should therefore crucially reduce the portfolio risk exposure and increase the expected returns.

However, under a bad case scenario, a negative shock on the economy would probably increase market correlations. In this way, the undermining of this strategy would overweight the positive effects of international diversification that reported above.

Consequently, this definition of the test for contagion can be regarded as a clear way to examine the efficacy of diversification at international level in order to reduce the risk exposure of the portfolio during a crisis period. It is clear that a less strict definition of the notion contagion that is relevant with the size of cross-market relationships would fail to manage this issue.

Secondly, this empirical approach to measuring contagion can contribute to better assess the institutional role and influence of international institutions and bailout funds.

It is believed that a negative shock to the economy of a country may affect another country even if these two countries are not directly linked and the second country appears to

have a strong economic background. In case that if this shock is transmitted to the other country, then it is constituted as contagion based on the definition of the term that Forbes and Rigobon has set.

However, a means of preventing this event to happen in the second country might be a short-term loan. This action can suppress the onset of financial crisis. Nevertheless, in the case of a close economic relationship between two countries the possibility that the second country will be significantly affected is quite possible. It needs to be stressed that, according to the definition of the writers, this kind of spread among the two countries does not constitute contagion.

As a result, when this kind of definition of contagion exists (shift in cross-market linkages) versatile interruptions can be justified. In case that there was no proof for contagion the above versatile interruptions would not be easily justified.

Thirdly, the fact that this definition of contagion is selected is an important tool in order to differentiate the potential various versions of the way that shocks are spread between the markets. In fact, the existing literature based on the international transmission of shocks differs on specific issues. More specifically, on the one hand some empirical models are relied on individual behavior. Furthermore they operate under the assumption of the irrelevance of the counteractions among the investors after a large negative shock.

On the other hand, other empirical models consider that the vast majority of shocks are transmitted via economic fundamentals. The above definition dodges to measure contagion directly. Additionally, tests that follow this kind of definition administer a method of categorizing theories. Particularly, this definition enables the classification of theories on those that occur as a shift in transmission mechanisms after a negative shock those that occur as a continuation of the existing mechanisms. Hence, the existence of contagion would provide information about these different theories of the transmission mechanism.

Despite the fact that this empirical effort constitutes an early stage in order to explain the transmission of adverse effects between countries, it manages to focus on the most important transmission mechanisms that could be investigated into studies in the future.

For better understanding the procedure that the writers follow through this empirical study the theories can be distinguished into two categories; Crisis-Contingent Theories and the Non-Crisis-Contingent Theories.

Crisis-Contingent Theories refer to the way in which negative shocks are spread at an international level. This cluster of theories includes a number of very different channels via which shocks could be spread internationally. They can be divided into three mechanisms of transmission; endogenous liquidity, multiple equilibria and political economy.

The first transmission mechanism refers to endogenous-liquidity shocks that give rise to a recomposition of the portfolio. The second kind of mechanism occurs when the crisis that struck one country can be meant to be a precursor for the other countries. The third transmission mechanism regards political economy and its affection to exchange rate systems.

The second category refers to the Non-Crisis-Contingent Theories. More specifically these theories can be divided into four wide channels of transmission; policy coordination, trade, random aggregate shocks and country reevaluation.

The first transmission mechanism (policy coordination) associates economies in the sense that one country's reaction to a negative economic shock may lead another country to implement similar policies.

The second transmission mechanism (trade) could function via some related influences.

The third transmission mechanism (random aggregate shocks) debates that the aggregation of negative economic shocks globally could influence the fundamentals of several economies at the same time.

The fourth transmission mechanism (country reevaluation) claims that the sequel of events that followed a shock in one country may exemplify investors to adopt specific options to other countries that present similar macroeconomic background.

The wording of different definitions contributes to a better conception of the advantages and disadvantages of each version in order to proceed with the study of this phenomenon.

The complexity combined with the diversity of definitions of the term contagion, highlights the fact that this term incorporates many different notions and ideas. The first attempts to define the concept contagion gave it the interpretation of illness. The economic crisis that occurred recently resulted in the decline of the income and the deterioration of living standards. In the context of parallelism, these difficult economic conditions can be thought as destroying as many medical diseases.

The number of definitions of contagion that the literature review provides, reports different scopes of transmission according to whether the term derived by direct or indirect contact. This separation constitutes an important point of discussion in the context of identifying financial contagion.

The financial contagion refers to the transmission of economic difficulties from one country to others. Moreover, it is likely that countries associated with this kind of transmission do not have economic or other ties. Economic ties include current account balance and financial account balance. As far as the other ties are concerned, political ties stand out.

It is worth mentioning that, all countries irrespective of their size are vulnerable in contagion. During the previous years, countries with a strong financial background claimed that the transmission of contagion within their borders is irrelevant of their own characteristics and policies and the blame was put on the corrupting influence of investors in other countries.

The spread of economic inconveniences can be achieved via two main channels; the risk premium channel and the channel of expectations for competitive devaluation.

Due to the large diversification among the proposed definitions, it can be concluded that there is not a common conception on how exactly to define contagion.

Finally, one topic that can be emerged from the above is that comprehending international financial contagion is extremely hard.

4. Empirical Tests of Contagion

Despite the fact that research on the spread on contagion has made great progress a part of the channels that drive contagion cannot be understood at a satisfactory level because of the omission of certain groups such as hedge funds.

The limitation of damaging influences of contagion should form the basis on which the future studies will proceed. However, in order to achieve that goal it is important to determine and comprehend the channels that drive contagion.

The efforts to measure whether contagion emerged in a specific period are hampered due to econometric reasons. The channels of economic transmission may be prevented by interactions and reduction policies on contagion may prove to be costly.

On the basis of the reform, there have been several proposals in order to shield a country from the upcoming financial crises. Some examples are stricter banking system supervision and more transparent financial policies. Despite these suggestions, the impact that arises from the proposals cannot be measured.

4.1 U.S Crisis

A new class of empirical tests of contagion has occurred in the existing literature. More specifically, the channel through which the financial crisis is spread was stated via switches in higher order moments (asymmetric dependence) of the distributions of returns like coskewness. The implementation of this test in real estate and equity markets (**Fry, Martin and Tang (2010)**), after the crisis that occurred in 1997 in Honk Kong and the recent subprime mortgage crisis that struck U.S(2007), showed significant results. The findings of this procedure were summarized in the fact that additional channels of transmitting contagion have been found which were not included in the correlation based tests. More specifically, accessory linkages were tracked as far as the U.S subprime mortgage crisis is concerned. For this test, the correction of the heteroskedasticity bias was achieved through the implementation of the unadjusted correlation coefficients of the aforementioned test of Forbes and Rigobon.

The significance of defining the importance of skewness and higher order moments as far as univariate distributions are concerned is equally important with the significance of defining the importance of coskewness through comovements for moments in multivariate distributions.

In this empirical analysis of testing contagion two types of tests were studied. Firstly, the Forbes and Rigobon contagion test (2002) which was based on the examination of the changes in correlations. Secondly, a contagion test was studied on the basis of the examination of the changes in coskewness.

In order to discriminate these specific tests, two different periods of time have been created. More specifically, the 1st period was characterized as the pre-crisis period while the 2nd one was defined as the crisis period. Forbes and Rigobon, through their test, reported that the existence of heteroskedasticity in the market returns resulted in biased tests for contagion as far as the cross-correlation coefficient is concerned. Therefore, they advanced in the creation of a test in order to correct this bias through using an assumption of linear relationship among the returns of the market. The test was implemented for the three crises periods (United States (1987), Mexico (1994), Hong Kong (1997)) so that they could check the subsistence of strong interdependence or contagion. Their findings indicated the rejection of the contagion hypothesis. In this way, the occurrence of interdependence between the stock markets appeared to be the key factor of the raise of cross-correlations through the crisis period. In conclusion, the contagion test for coskewness was based on identifying important changes in coskewness between a crisis period and a pre-crisis period.

Another approach to test financial contagion (**Gallegati (2010)**) during the U.S subprime crisis of 2007 is proposed. This paper focused on the issues of contagion and interdependence with the use of a wavelet-based framework.

The existence of contagion was investigated with a simple graphical test on the basis of non-overlapping confidence intervals of the estimated wavelet coefficients through crisis and non-crisis periods.

The results revealed evidence of international contagion influences from the US during the subprime mortgage loan crisis. Moreover, it was revealed that these influences were not uniformly spread except for Japan and Brazil.

4.2 Global equity markets

A different procedure as far as the empirical tests process are concerned, used the Capital Asset Pricing Model (CAPM) in order to examine both the existence and the potential pattern of contagion and capital market integration in the field of global equity markets (**Jon Wongswan (2003)**). Capital market integration could be identified as a case in which pricing includes only systematic risks. In this empirical analysis a panel of 16 countries was used from 1990 to 1999.

It is noteworthy that the empirical research in contagion that took place the previous years, followed different testing methodologies. However, despite this differentiation, common feature in most of these projects is the fact that they have two debatable issues. The first issue concerned the imprecise determination of the proxies for economic fundamentals in relation to the theory. In this way, it was possible that false relationships might be selected and thought to be indication of contagion (see Masson (1998)). This empirical study was based on the Capital Pricing Model under which the economic fundamental is the portfolio of the world market. The existence of contagion was proved by important conditional correlations of the idiosyncratic risk part (which is the inexplicable part).

The second issue referred to the modeling of economic time-series. More specifically, previous studies (**Mandelbrot (1963) Fama (1965)**) demonstrated that most economic time-series exhibit time dependencies in the second moment. This study's analysis showed that equity returns exhibit time-varying correlations. This fact led to the choice of multivariate General Autoregressive Conditional Heteroskedastic (GARCH) model.

The findings of this process showed that there was evidence of regional contagion and capital market integration in equity markets. Moreover, they revealed several significant observations. Firstly, the probability of existing contagion across markets necessitated greater attention to developments in inner and world financial markets. Secondly, the above evidence of existing regional contagion could lead to the conclusion that these regional factors have systematic influence that escaped pricing in world equity markets.

Hence, in case that these topical factors could be observed it is possible to manage to hedge this kind of risks.

Another empirical modelling of Contagion was conducted by **Dungey, Fry, González-Hermosillo and Martin (2005)**. More specifically, this paper concluded the presented methods from the existing literature and tried to show off their relationship in a single framework. As a result, this empirical study's objective was to give emphasis to the main similarities and differences among the diverse existing approaches.

A significant empirical result that could be excluded from this paper is the fact that the differences that occurred in the proposed definitions of contagion appeared to be of minor importance. To make matters worse, under certain circumstances these definitions could be equivalent. Consequently, the diversification among the papers lied in the fact that there were differences on the amount of information used in the data in order to catch-out contagion. Through this approach, a simplified way of classification has emerged since some of the models have adopted full information methods while others have adopted partial information methods.

During this research, a model of interdependence of asset markets during non-crisis periods of time was determined as a latent factor model of the returns of the assets which is based on Arbitrage Pricing Theory (APT).

A number of papers that existed before this empirical study focused on modelling contagion through a variety of asymmetrical adjustments. These empirical researches had as a stimulus the fact that the spread procedures among asset markets may present a non-linear difference for periods that extreme return has occurred rather than for 'normal' periods. In these cases if important relationships among asset markets were tracked through periods of extreme shift then the existence of contagion was confirmed.

However, this paper of **Dungey, Fry, González-Hermosillo and Martin (2005)** dealt with four models of asymmetries (outliers, probability models dichotomous and polychotomous classifications and one-sided asymmetries).

Summarizing, the five tests of contagion that this paper took into consideration were:

1) The false factor framework explicated by the authors themselves, which was alike that of Corsetti, Pericoli, and Sbracia (2001) and Bekaert, Harvey, and Ng (2003).
2) The reported above correlation approach related to Forbes and Rigobon

(2002).

3) The Favero and Giavazzi test (2002), which was based on the use of a VAR in order to identify unusual events and then test the potential spread of them in a certain framework.

4) The based on probability framework of Eichengreen, Rose, and Wyplosz (1996). This test for contagion connected foreign crises with a domestic crisis under a non-zero probability.

5) The extreme returns test of Bae, Karolyi, and Stulz (2003) which formed a further improvement of the Eichengreen, Rose and Wyplosz framework.

Subsequently, a test regarding the shifts of extremal dependence (cokurtosis) of different markets among pre-crisis and post-crisis periods, was developed by **Hsiao (2012)** and **Hsiao and Fry-McKibbin (2014)**. The test was based on the existing framework for coskewness as it was reported above. More specifically, they inquired the potential existence of contagion throughout the period of global financial crisis (2008-2009) as far as banking and equity markets are concerned.

The results revealed the transmission of contagion from the banking sector to the global equity markets. It has to be reported that, the cokurtosis test appeared to track contagion on a more frequent basis in relation to coskewness tests during the occurrence of extreme events.

A different approach to equity market contagion was made by **Dungey and Gajurel (2013)**. Through this research, the existence of equity market contagion was tested coming from the US to both advanced and emerging markets during the period of crisis. The real estate bubble burst and sub-prime crisis in the US were, on a large extent, the events that triggered the global financial crisis. Then, a major fall in equity market indices in the US and in other countries came as a result.

In this paper, with the use of latent factor model, important evidence emerged in the advanced and emerging equity markets. More specifically, contagion that arose from the US explained to a significant degree the variance in stock returns in the advanced and emerging markets. Furthermore, the empirical results disclosed that contagion influences were not powerfully related to high levels of global integration.

4.3 Banking System

An empirical test of contagion through a working paper was made by Fuchun Li and Hui Zhu (2009) in order to test financial contagion to the Canadian Banking system. The proposal of this author lies in the fact that was based on a non-parametric measure of cross-market correlation. The fact that there is no assumption that the data have occurred through a given probability distribution contributed in order to maximize the flexibility of adjustment into the data. This test aimed to examine contagion through the financial crises of the Canadian banking system. From this study, three empirical results were revealed. In particular, this research uncovered the existence of financial contagion to the banking system of Canada that occurred from the 1987 U.S. stock market crash, from the 1997 East Asian crisis and the 2007 subprime mortgage loans crisis.

Nevertheless, this research revealed that the 1994 Mexican peso crisis did not influence the banking system of Canada as far as the contagion part analysis is concerned. Through these empirical results, it is implied that the deepness and magnitude of the 2007 subprime mortgage loans crisis was more powerful. As a result, this subprime crisis seems to have more tenacious influences on the Canadian banking system.

4.4 Real Estate Markets

The study of Eddie Chi-man Hui and Ka Kwan Kevin Chan tested the existence of contagion across equity and securitized real estate markets of Hong Kong, UK and US throughout the global financial crisis with the use of the Forbes–Rigobon, coskewness and cokurtosis tests. The results revealed that the cokurtosis test can detect additional channels of contagion, and as a result this could be considered as a more powerful test. Furthermore, it was found that the cokurtosis test shows a highly significant evidence of contagion between the equity and real estate markets in both directions. The most considerable existence of contagion appeared between the US equity and real estate markets.

Finally, some different approaches from existing empirical research are reported.

In particular, an alternative empirical study (**Pericoli, Sbracia (2003)**) mentioned in the previous section) set a multi-factor model for cash flows into a problem of distribution for

standard international portfolio. This paper proceeded into separation of normal interdependence and contagion. In this way, the existing literature was divided into two groups.

On the one hand, first group studies that calculate the global influences of a negative shock in one country via GARCH models, demonstrated proof of crisis spread.

On the other hand, second group studies revealed unexpected shift as far as the data were concerned either by estimating Markov processes or by examining for important transformations in the correlation of the asset returns .The evidence of this paper showed that the fundamental spread of negative shocks occurred without certain portfolio management norms and imperfections of the market.

Furthermore, a novel research on spatial contagion measure (**Durante, Foscolo, Jaworski, Wang (2014)**) was based on calculating the appropriate conditional Spearman's correlations that emerged from financial time series. This paper tried to reveal the diversification that occurred between the dependence of financial time series in normal time periods and in crisis periods. This methodology may prove to be the risk management of the portfolio in order to improve the potential selection of a diversified portfolio through crisis periods.

On the basis of the aforementioned detailed report of empirical tests, the **Forbes-Rigobon test(2002)**, the coskewness test (**Fry,Martin and Tang(2010)**) and the cokurtosis test (**Hsiao(2012), Hsiao and Fry-McKibbin(2014)**) constitute the number of tests that our analysis will rely on, as far as the structural breaks in correlation are concerned.

5. Contagion and the European Sovereign Debt Crisis

5.1 European Government bonds

Empirical studies have been conducted in order to demonstrate the existence of contagion with evidence of the European Sovereign Debt Crisis. Particularly, an example of this kind of empirical research was developed by **Kohonen (2012)**. The applied test for

contagion took into consideration the abundance of challenges that contagion tests deal with. These were endogeneity, heteroskedasticity and differentiating interdependencies from contagion. The selected model analysis (structural vector autoregression (SVAR)) adopted the hypothesis of a mixed-normal distribution for the reduced form errors. In this way, there was no reason to limit any of the instantaneous bonds between the variables.

This test was applied to a sample of euro-zone government bond data for the years 2009-2010. In this way, this selected sample matched with the beginning of the Euro-zone Sovereign Debt Crisis.

The analysis of this paper dealt with a lot of issues. In brief, the issues included endogeneity, heteroskedasticity and the difficulty in defining contagion.

The issue of endogeneity arose because of the usual instantaneous reaction to the news. Consequently, it was needed to deal with a system of contemporaneous equations. Moreover, frequent phenomenon was the appearance of heteroskedasticity which may be a consequence of contagion. This led to the fact that the selected model should cope with potential switches in the market volatilities.

This empirical study was intended to test if there was evidence of contagion for a specific group of the Eurozone member countries in the government bond markets. The sample period of this test is the years 2009-2010 that coincided with the start of the Eurozone sovereign debt crisis. The sample included data from the countries of Greece, Portugal, Ireland, Spain, and Italy. The selected data was the ten years government bond spreads over Germany. The evidence of contagion in this study was combined with the fact that the influence of contagion appeared to be quite complicated.

In further analysis of this phenomenon, the empirical results of this study revealed that there was not one particular country that led to the start of the spread of contagion. As a matter of fact, the ‘benchmark’ countries of the contagion appeared to be several. Consequently, during a crisis period there was a possibility to appear more complicated effects of contagion successively rather than a single transmission of crisis from one country to another. This very important piece of information was often omitted in the existing literature for the explanation of contagion. It was accomplished to estimate weighted correlation coefficients of the country spreads that occurred both during non-crisis periods and during crisis periods. Since these coefficients instantaneously took into consideration the

potential existence of heteroskedasticity in the spreads, they were the best option for correlation analysis.

In order to acquire extra information for the identification of the model, this paper used non-normalities and non-parametric limitations in this determination method. These options facilitated the estimation of parameters of the instantaneous influences among the variables. As a result the critical point and the basic idea of this contagion test were to examine whether these parameters appeared to remain stable during the normal times and the crisis.

The findings of this process revealed that there was evidence of contagion. Particularly, it showed that the contagion influences were quite complicated without a benchmark country for contagion (the country in which the contagion occurred)

Similarly, testing contagion on sovereign bond markets in Europe was the scheme of an empirical paper of **Peter Clayes and Borek Vasicek (2014)**. The global financial crisis that emerged the previous year's promptly transmitted across the borders and affected the EU bond markets. However, the crisis did not struck all markets uniformly. This paper's goal was to measure the magnitude and direction of the linkages among the sixteen European Union sovereign bond markets with the use of a factor-augmented version of the VAR model in **Diebold and Yilmaz (2009)**.More specifically, a new test for contagion was provided with the application of the multivariate structural break test of **Qu and Perron(2007)** on this factor-augmented version of the VAR model (FAVAR) in order to catch out important sudden shift in the transmission of a shock.

The subprime loan crisis in US banks had a global impact on financial markets. The sequence of this crisis in conjunction with other significant economic events led to the European sovereign debt crisis. Shocks on the European bond markets were one of the latest consequences in this sequel of events. The rise of the sovereign spreads led to fiscal bailouts and serious issues in the banking system. This sequel of events revealed the strong linkages among European financial markets.

The results of this paper revealed the existence of substantial spillover especially between EMU countries. Furthermore it was indicated that despite the fact that the aggregate

spillover among the European Union has always been substantial, it raised and remained to a higher level since the beginning of the financial crisis.

Particularly, the countries of Belgium, Italy and Spain proved to be key markets during the financial crisis. Contagion appeared to be rather scarce phenomenon confined to a few well defined moments of uncertainness the periods of the financial aid packages for Greece, Ireland and Portugal. These usual exacerbations in market co-movement were mainly driven by larger shocks rather than by contagion.

5.2 Greek debt crisis

An empirical study for contagion developed by **Philippas** and **Siriopoulos (2013)** from Greek debt crisis through six EMU bond markets (Netherlands, Germany, Italy, Spain, Portugal and France), was based on the theoretical framework of a spillover switching model and a time-varying copula model. The evidence revealed a contagion appetite effect that transmitted from the country hit by the crisis to the other European Monetary Union countries. Consequently, this crisis created contagion figures among the EMU bond markets.

Another approach that focused on the Greek sovereign debt crisis (**Mink, Haan (2013)**) tested the effect on the negative news about Greece and the potential bailout through European Banks in 2010.

The evidence showed opposite results. On the one hand, the news concerning Greece appeared not to lead to abnormal returns. On the other hand, the news related with a potential bailout seemed to lead to unusual returns. These cases occurred for banks regardless of their exposure and relation to Greece or other countries with high debt. The bailout alternative was interpreted as a possible outflow of public funds as financial aid packages.

5.3 EMU debt crisis

A study of the EMU sovereign-debt crisis (**Arghyrou, Kontonikas (2010)**) adopted use time series and panel estimation techniques in order to model spreads of the Eurozone countries against Germany within the period 1999-2011. The main evidences showed that

the sovereign bond spreads were more sensitive to changes in fundamentals during crisis in comparison to an early crisis period.

5.4 European Debt Crisis

An empiric paper of **Kenourgios (2013)** examined volatility contagion across U.S. and European stock markets during the Global Financial Crisis and the Eurozone Sovereign Debt Crisis. This empirical study looked into the dynamics of asymmetric conditional correlation between non-crisis and crisis periods and between different phases of both crises (GFC and ESDC).This study tried to explore their dynamic co-movement by means of utilizing asymmetric dynamic conditional correlation through a multivariate GJR-GARCH model.

The time difference among the Global Financial Crisis and the Eurozone Sovereign Debt Crisis revealed that the implied volatility markets recognized and reacted to these two incidents in a different way. The results emerged the existence of a general pattern in cross-market volatilities. Moreover it was observed that an increase in volatility dependence risk lowered the amount of effectiveness of a portfolio diversification. It was shown that during the crisis phase level the uncertainty of the stock market, in conjunction the risk aversion of the investors, rose dramatically at the early stages of the Global Financial Crisis. Furthermore, there were strong findings of contagion during the last phase of the European Sovereign Debt Crisis which suggested that the systemic nature of the crisis was not detected in the early stages fully.

Finally, the results provided important implications for the effectiveness of international portfolio diversification and volatility hedging during periods of negative shocks.

In addition, another empirical approach that referred to contagion and the European Sovereign Debt Crisis was developed by **Marta Gómez-Puig, Simón Sosvilla-Rivero (2014)**. This paper applied the Granger-causality approach and endogenous breakpoint test in order to provide an operational definition of the term contagion so that it could investigate European Economic and Monetary Union countries public debt service behavior.

This study focused on examining not only the spread of sovereign risk, but also the contagion that occurred in the euro area public debt markets

The objectives of this investigation were the following:

1) to search for the existence of potential Granger-causal relationships based on the trends in bond yields issued by both central and peripheral and EMU countries,

2) to define endogenously the breakpoints in the trend of those relationships

3) to search for contagion via an abnormal raise in the number or in the magnitude of causal relationships in comparison to that of relatively calm periods, triggered by an endogenously found out negative shock.

The noteworthy evidences that emerged from this study were the following:

(1) About two thirds of the total endogenously defined breakpoints happened after November 2009. That date the Greek government declared that the country's finances were far worse than previous statements.

(2) The number of causal linkages raised as the crisis was further manifested in the euro area, and causality patterns appeared to be more frequent in cases that EMU peripheral countries were the cause of the incidents.

(3) During the crisis period evidence was revealed for 101 causal relationships: 41 demonstrate new causality connections and 60 of them were patterns that pre-existed in the relatively calm period.

An alternative analysis of contagion (**Beirne, Fratzscher (2013)**) for pricing sovereign risk and contagion during the European crisis examined the transmission of the risk for advanced and emerging economies during the debt crisis. Contagion was divided into three subcategories; fundamentals contagion, regional contagion and herding contagion.

The evidence showed that fundamentals contagion has occurred as countries increased their sensitiveness on their own basic economic principles mainly during crisis period rather than during normal times. This sensitivity was more intense for European countries that were majorly affected during crisis (Ireland, Italy, Greece, Spain and Portugal). Furthermore, the study revealed that regional contagion did not create an intense shift of sovereign risk. Finally, it was found that herding contagion occurred in sovereign debt markets during the crisis in specific time periods and geographic regions.

Based on the same pattern, the following paper (**Gorea, Radev (2013)**) tested joint risk default for the members of the Euro area for the years 2007-2011 through joint default probabilities from separate contracts of Credit Default Swaps. It adopted a CIMDO approach (Segoviano 2006, Segoviano & Goodhart, 2009).

The evidence revealed that strong economic relationships determine a major role in spreading negative shocks from the periphery of euro area towards its core. As a result, robust trade links of a country with others that face economic difficulties appeared to create an expectation of higher risk default.

Finally, some other empirical studies were presented below.

In particular, a study developed by **Albi Tola** and **Sébastien Wälti (2012)** examines for the existence of financial contagion during this crisis which is defined as the international transmission of country-specific shocks that exceeds the normal channels of financial interdependence. A combination of the standard contagion test of Favero and Giavazzi(2002) along with a narrative approach was used, in order to distinguish global and euro area shocks from country-specific shocks. It is shown that financial contagion has been widespread during the crisis in the euro area.

Finally**,** an empirical research of **Alter** and **Beyer (2013)** was made in order to measure spillovers between the sovereign credit markets and the euro area banks. The estimation of these spillovers occurred from a Vector Autoregressive (VAR) model in CDS spreads.

The above studies conclude the main literature that exists among contagion and the

European Sovereign Debt crisis.

It has to be noted that from a literature review perspective, the studies that were directly linked with this thesis, and ,therefore, have set the basis for this research, were developed by **Mink and Haan (2013)**, **Philippas and Siriopoulos (2013)**, **Kohonen (2012), Kenourgios (2013)**.

6. Empirical study proposal

The aim of this thesis is to try to relate contagion with news and events. The evidence for this kind of research will arise from the European Sovereign Debt Crisis. More specifically, the purpose of this project is to attempt to identify and determine which channel or transmission mechanism drives contagion based on the news and events through findings from the European Debt Crisis.

This topic is particularly interesting because the way of transmission of negative shocks has not been established on a large extent. As a result, the definition of a framework that could detect the factors that drive contagion is of particular importance, so that institutions and governments make decisions and regulate centrally in order to potentially prevent negative shocks that will significantly affect the market and can signal the beginning of a crisis.

The empirical literature on this subject has revealed the existence of contagion in certain circumstances. However, the fact that a large number of different definitions for contagion are proposed and the fact that the existence of contagion has occurred in some empirical studies without an exact determination of the channel through which contagion spreads among the countries highlights the need to make efforts to define this channel.

The data will be provided from Bloomberg database. The sample of our study will occur mainly from European countries. Through the process, we will try to reveal the potential linkages among the European countries. This study will divide the included periods of time into crisis and non-crisis periods. The non-crisis period refers to pre European Sovereign debt crisis period (U.S crisis).Econometric tests will be used in order to provide an economic result.

Potential missing data issues may be handled with the method of interpolation.

The potential existence of econometric problems may be dealt with econometric tests in case it is needed.

The existing literature, as referred in the above chapter, attempted to measure contagion through the European Sovereign Debt Crisis.

The literature review revealed that econometric issues may arise. Under these circumstances, complementary tests may be needed.

Through this thesis, we expect to detect a way through which contagion is driven through news from the European Debt Crisis. In case that a clear channel of contagion arises, this may indicate potential actions that could prevent this transmission mechanism from spreading negative shocks among the countries. In this way, we will attempt not only to detect contagion (as the majority of the existing literature does) but also to reveal the channels and factors that drive contagion.

Chapter 2

1. European Debt crisis

The years that preceded the European Sovereign debt crisis, the member countries of the Eurozone had to comply with the Maastricht Treaty rules. In particular, the requirements of this treaty were to constraint potential annual budget balance deficit under the limit of 3% of Gross Domestic Product and to sustain the public debt under the limit of 60% of Gross Domestic Product. Despite the fact that these requirements were established, the non-compliance with the rules did not impose some punishment.

The European crisis can be considered as a transition from banking sector crises to Sovereign debt crises. This can be justified by the fact that the majority of the countries chose to bailout their banking systems protect as a means of protection. In the case of Greece the combination of issues in banking system and the existence of a large public debt resulted in different situation compared with other European countries. The European Banking system had to deal with significant banking impairments that were appreciated at 940 billion euros during the period of 2008 and 2012.

It should be mentioned that countries were majorly affected from the crisis (Portugal, Italy, Ireland, Greece and Spain) by different factors in some circumstances (Spain housing bubble, Ireland banking sector problem).

2. Gross Domestic Product

The existence of these important fiscal issues resulted in the beginning of fiscal adjustment programs. As far as the economic indicators are concerned, Greece ameliorated its budget deficit balance from 10, 4% of Gross Domestic Product (GDP) in 2010 to 9,6% in

2011. Austerity programs were implemented not only to Greece but also to other European countries.

Despite the fact these programs led to improvement of the budget deficit relative to the Gross Domestic Product for the countries France, Ireland, Italy, Portugal and Spain from 2010 to 2011, they led to opposite variation in other economic indicators. More specifically, the above mentioned countries presented increase in public debt to GDP ratios. Consequently, the improvement of the budget deficit was not combined with a GDP growth that would prevent the raise of the public debt to GDP ratio for these countries in this period of time. At the European Level, the indicator of debt-to-GDP ratio for the 17 countries was 85,3% in 2010 and 87,2% in 2011based on the report of Eurostat for all the countries as a whole. The public debt-to-GDP ratio for Greece increased from 143% in 2010 to 165% in 2011.

3. Unemployment rate

The impact of the implementation austerity measures could also be reflected on the unemployment indicator. On the one hand, the unemployment rates increased in countries that were majorly influenced from the European sovereign debt crisis (Ireland, Greece, Portugal and Spain) along with United Kingdom. On the other hand, in countries like Germany and Iceland the unemployment rate diminished, while in other European countries (Italy, France) this indicator did not appear to have noticeable changes. At overall European level, the unemployment rate reached the level of 11,6% in September 2012 in comparison to 10,3% in September 2011.

As a result of the economic crisis, United States faced a prolonged recession period along with the loss of approximately 9 million jobs during 2008 and 2009.

Consequently, the fiscal adjustment of the budget balance in order to limit the existing deficit did not act as a deterrent in order to avoid recession that emerged in that period of time.

4. The precursor of the European Sovereign Debt crisis

The crisis had long-term effects for both the European and the U.S economies. The European crisis was occurred and, to some extent, was triggered by the world economic downturn that took place during 2008 and 2009.

1. Subprime mortgage crisis

One of the primary reasons for the beginning of the economic crisis was the high level of subprime lending which contributed to a large extent to an increase of housing demand.

The significant increase in subprime mortgages of low credit quality which appeared during the pre-crisis period (2004-2006) in the United States was combined with the existence of floating interest rates for the vast majority of them. As a result, as soon as the residential property prices experienced a sharp reduction after a preceded progressive increase, there was a significant difficulty in refinancing the cost of the loans.

The raise of the floating interest rates led to higher payments and, to make matters worse, to a significant loss of the subprime mortgages securities value. The flow of credit was tightened since doubts about the robustness of the U.S financial markets appeared.

The burst of the 'housing bubble' in the United States during 2007 occurred during a time period that banks, at an international level, were exposed to toxic debt. More specifically, the United States subprime mortgage crisis came as a result of the sharp decrease in house prices that entailed a devaluation of house related securities. In circumstances where large household debt along with a sharp decrease in residential property prices emerged, the reduction of the expenditures was more considerable.

The above mentioned cases of large household debt were primarily financed with collateralized debt obligations and mortgage backed securities. Despite the fact that these

securities provided high interest rates, their low quality level led to a large amount of defaults.

Even though the first incidents of the economic crisis showed up in 2007, the following year appeared to have a noteworthy amount of collapses of financial institutions that worsened the flow of credit towards enterprises and individuals.

2. Stock markets

During the first 10 days of October 2008 the S&P 500 index lost 21,6% of its value. To make matters worse, through the 2nd week of October the biggest percentage decrease of Dow Jones Industrial Index was recorded. [1]

In relation to the 2007 highest peak, the S&P 500 index decreased 45% until the start of November 2008. However, despite the fact that U.S Stock market had diminished about 50% since the start of 2009, at the first months of 2013 the U.S Stock market managed to reach the peak of the pre-crisis period.

3. Housing prices

At a historical level, the residential property prices in the United States remained approximately stable until the start of the 'housing bubble' that occurred in 1997. The house ownership rate lifted to 69.2% in 2004.

The main features of this bubble were high house prices and high rates of household debt along with the decrease of the savings rate. Higher housing prices were combined not only with lower savings but also with greater level of borrowing.

[1] "Dow Jones Industrial Average Historical Data". Dave Manuel.com. Retrieved 27 February 2013.

It was noticed that regions with limited ability to construct new house buildings were more affected from this incident. Between the years of 2001 and 2007, the United States mortgage debt rose to almost double levels. [2]

As a consequence of the large increase of residential property prices, the amount of unsold houses rose. On the basis of this event, residential property price began to decrease after the peak of mid-2006. This shift worsened investors ability due to a larger refinancing cost. Furthermore, the number of new residencies that was sold in 2007 declined 26.4% year on year. The decrease of the prices resulted in the increase of the homeowners who were under the risk of confiscation.

This initial incident led to a growing difficulty in refinancing the loans for the borrowers. That sharp decline in mortgage loan payments appeared to be an important problem for the banking system. After the above mentioned peak of the prices, during the third quarter of 2008 house prices presented 20% reduction on average. [3,4]

This reduction resulted in the fall of the house prices at a lower level than the mortgage itself. More specifically, until the end of the third quarter of 2008, 23% of U.S residencies prices were at a lower level than the mortgage loan. [5]

In addition, during the period of the third quarter of 2008 and the third quarter of 2012 about 4 million confiscations occurred in the United States. In a comparison framework, the

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[2] "The Financial Crisis Inquiry Report: Final Report of the National Commission on the Causes of the Financial and Economic Crisis in the United States" Financial Crisis Inquiry Commission (Washington D.C.: Government Printing Office),2011-01-25, retrieved 2012-06-04

[3] "The McGraw-Hill Companies". Standardandpoors.com. Retrieved 2012-11-18.

[4] "Economist-A Helping Hand to Homeowners". Economist.com. 2008-10-23. Retrieved 2009-02-27.

[5] Wells Fargo Economic Research-Weekly Economic and Financial Commentary-September 17, 2010

decrease of the property values was 26% from June 2006 to November 2010, while the 5-year period from 1928 to 1933 that was included in the Great Depression period the decline was 25.9%.[6]

Moreover, at September 2012 about 1.4 million houses were in the process of seizure, compared to 1.5 million houses a year ago.

5. Subprime mortgage crisis Timeline

2007 to 2008

The peak of residential property prices of U.S in 2006, led to unwillingness to investors for mortgage-backed securities. During 2007, important losses occurred along the financial system. More specifically, the first significant loss in relation to these securities happened in February 2007 in HSBC.[7]

Subsequently, before the start of the third quarter of this year, subprime mortgage problems rose in BNP Paribas that resulted in the constraint of the redemptions on three investment funds. [8]

April to December 2008

After the end of 2007, another benchmark point of the crisis occurred in September 2008, In particular, as far as the United States shadow banking is considered, the failure of Lehman

[6] Babad, Michael (2012-09-10). "Decline in U.S. housing now greater than in Depression". The Globe and Mail (Toronto). Retrieved 2012-11-20.

[7] Timeline: Sub-prime losses". *BBC* (News.bbc.co.uk). May 19, 2008. Retrieved2008-10-26.

[8] NYT-Paul Krugman-Conscience of a Liberal Blog-Eco 348 The Great Recession

Brothers along with the purchase of Merrill Lynch were some of the noteworthy events of that period.

Furthermore, Morgan Stanley and Goldman Sachs acquired access to Federal Reserve's emergency bank lines of credit. [9]

AIG dealt with difficulties in fulfilling its commitments. Fed selected the bailout option through secured credit facility that reached 85 billion U.S dollars in order to prevent the breakdown of the insurance company. [10]

Drastic measures were required to be taken on this period of time. Specifically, in a meeting that was held on 18 September of 2008, where Ben Bernanke (chairman of the Federal Reserve) and Henry Paulson (74th United States Secretary of the Treasury) participated, a proposal of 700 billion U.S dollars emergency bailout of the U.S banking system was made. [11]

On 16 December of 2008, FED reduced the interest rate (Federal funds rate) to 0-0.25% without subsequent changes. It is noteworthy that this monetary policy of interest rates has never happened before in US history.[12]

[9] CNBC-Goldman, Morgan Stanley May Shed 'Bank' Status: Analyst-October 12, 2011

[10] "PBS Frontline-Inside the Meltdown". Pbs.org. 2009-02-17. Retrieved 2009-02-27.

[11] NYT The Reckoning – As Crisis Spiraled, Alarm Led to Action

[12] Historical Changes of the Target Federal Funds and Discount Rates from the New York Federal Reserve Branch. Retrieved 2013-02-27.

6. Timeline of the European Sovereign debt crisis

News and Events

2009

November 2009

Greece

- The staff of the Prime Minister accused the previous government of a misleading way of accounting that covered up immoderate borrowing. It was showed that the deficit for the year 2009, as far as the Greek budget is concerned, was 12.7% of Gross Domestic Product.

December 2009

Greece

- Standard and poor's along with Fitch credit agencies downgraded the credit rating of Greece to a level under investment-grade. As a consequence, the ASE index of Greece decreased, and Greek Public debt reached the level of 113% of Gross Domestic Product. It is worth noting that the above mentioned level of public debt exceeded the allowable amount of public debt as it was established by the Maastricht Treaty (≤60% of Gross Domestic Product)

Ireland

- Austerity measured needed to be taken in Ireland that followed the bailout of the Irish banks by the Government.

2010

February 2010

Greece

- Greek Prime Minister revealed an austerity project with the aim of diminishing budget deficit. More specifically, it contained the stagnation of the wages in the public sector combined with a tax policy that focused on higher taxes. This project had the approval of the European Union.

Spain

- The combination of the fall of the residential property prices and the increase of the unemployment rate led the Spanish Prime Minister to propose an austerity project that included the raise of the retirement age from 65 years to 67. This project was finally endorsed approximately after one year (January 2011)

March 2010

Greece

- The proposed financial package from the Greek Prime Minister contained measures like a 2 % raise of sales tax and public sector cuts. The International Monetary Fund(IMF) along with the leaders of the members of the euro zone reached an agreement in order to administer financial aid to Greece.

April 2010

Greece

- The above mentioned budget deficit of Greece appeared to be inaccurate. More specifically, a revision was made in April 2010 and revealed that the deficit was up to 13,6% of Gross Domestic Product(GDP) As a consequence, an immediate increase on the yield of the Greek Government yields occurred and the Standard and Poor's credit agency downgraded these bonds to junk status.

May 2010

Greece

- On 2 May 2010, the three sides (Greek Prime Minister, leaders of the Eurozone and the International Monetary Fund (IMF)) reached an agreement of a 110 billion euros bailout package that would be valid for the following three years.

- In order to strengthen the weakened euro zone economies, European Union along with the International Monetary Fund (IMF) established a 750 billion euros emergency fund.

June 2010

- As far as the exchange rate framework is concerned, a noteworthy date was 8 June 2010. In particular, this date the euro presented the lowest exchange rate in relation to the U.S dollar since March 2006($ 1.19).

July 2010

- The stress tests were conducted during this month. More specifically, on the basis of the results that the European Union announced, from the 91 European institutions that participated in the tests, seven institutions did not possess the minimum required capital.

September 2010

Ireland

- The deficit of the budget of Irish economy increased to 32% of Gross Domestic Product(GDP).The key reason was the fact that the total bailout cost of a particular bank, (Anglo Irish Bank) which passed into public hands in January 2009, was higher than the initial estimates and could reach €34.3 billion

November 2010

Ireland

- The Irish Government asked for a bailout package from IMF and the European Union. Subsequently, a financial package of €85 billion was endorsed.

2011

February 2011

- The European Stability Mechanism (ESM) was established by the European ministers of Economy. That mechanism possessed the role of the last resort lender and possessed €500 billion.

March 2011

Portugal

- The resignation of the Portuguese Prime Minster Socrates contributed to a vast increase of the government bond yields. Portuguese Prime Minister was forced to ask for a financial package from the European Union and the IMF the following month. After 2 months the two parties approved the package (€78 billion) on condition that Portugal would perform specific austerity measures.

June 2011

Greece

- Credit agency Standard and Poor's downgraded the credit quality of Greece government bonds to CCC.

July 2011

Greece

- An additional financial package of €109 billion was approved for Greece. A restructure of the loans of Greece moved the weights to individual bondholders. (On the basis of the characterization 'selective default' made by the Fitch credit agency, this nomination led to the first euro zone government default.

September 2011

Switzerland

- The National Bank of Switzerland proceeded to the devaluation of the Swiss Franc along with pegging its value with euro.

Italy

- Standard and Poor's credit agency downgraded the credit rating of Italy.

October 2011

- Accessional rescue package for the European bank's recapitalization along with the extension of the European Financial Stability Facility (were €1 trillion) regulated by the Euro-zone leaders.

Greece

- The political declarations of the Greek Prime Minister for a referendum majorly affected the markets.

November 2011

Greece

- The resignation of the Greek Prime Minister occurred. As a result, the creation of a caretaker government came up and Lucas Papademos was the interim Prime Minster.

Italy

- The resignation of the Italian Prime Minister Silvio Berlusconi led to this position Mario Monti.

Spain

- Another change of a European country's government occurred in a very short time period.

2012

January 2012

- Nine countries of the euro zone were downgraded by the credit agency Standard and Poor's.

Portugal

- The yields of the 10-year sovereign bonds of Portugal performed a tremendous increase and reached 18.29%.

February 2012

- A large number of European banks exploited a long-term refinancing opportunity from European Central Bank (ECB).In this period of time ECB intensified its efforts in order to provide liquidity to private banks.

March 2012

- 10-year sovereign bond yields of Spain and Italy decreased to 5%.
- The unemployment rates in Greece and Spain exceeded the limit of 20%. It is noteworthy that the people included in the age group under 25 were majorly affected.
- The ministers of economy in Euro-zone agreed with an extension of the European Financial Stability Facility (EFSF) and the European Stability Mechanism (ESM).

April 2012

Spain

- Spanish Government failed to reach its target in a bond auction.
- Despite the fact that the Spanish Government proceeded to additional budget cuts, the yields of the Spanish bonds increased steadily.

May 2012

Greece

- A potential Greek exit from the Euro zone led to massive drawings in Greek banks. The culmination of the drawing occurred to the Greek banks on 14 May 2012 when approximately €700 million were withdrawn by depositors.

Spain

- The Spanish government nationalized the Spanish bank Bankia through a bailout of €23.5 billion.

June 2012

- A demand of the Spanish government for bank recapitalization (€100 billion) emerged on 9 June 2012.
- The shares benchmark stock market index of Spain (IBEX) showed a large deduction.

Cyprus

- Cyprus requested for a financial package in order to deal with capitalization problems in the banking system

July 2012

- On the one hand, yields of the 10-year sovereign bond exceed the limit of 7%. On the other hand in countries like Germany and Austria yields decreased in such an extent that they became negative. The lookout of safe investment options resulted in extremely low borrowing costs for these 2 countries.

Chapter 3

1. Data

The data that are used in this master thesis came from Bloomberg Database. The variables that are included in our projects for both the U.S and the European crisis are:

- 10-year government bonds
- Stock Price index

The countries that are selected in the scheme are:

United States, Germany, Greece, Ireland, Italy, Spain, Portugal (daily data).

Our aim is to examine the existence of contagion in the European sovereign debt crisis. However, in order to ascertain a potential origin of the European crisis, we will examine a possible existence of contagion during a pre-crisis period of European crisis that has the United States subprime mortgage crisis as a benchmark.

More specifically, two periods of time were created (pre-crisis and post-crisis). For the U.S Crisis, our sample started from 29/01/2007(start of pre-crisis period) until 30/04/2010(end of post-crisis period). More specifically Lehman brothers collapse (15th of September 2008) is considered to be the trigger event and therefore, our data has the same number of observations for the pre-crisis period and the post-crisis period. In other words the pre-crisis, which started from 29/01/2007, ended 3 days before the collapse of Lehman Brothers (last Friday before the collapse that occurred on Monday) and the post-crisis period that started after the collapse of Lehman brothers ended one day before the IMF bailout for Greece which is considered to be the triggering event for the European Crisis.

For the European Crisis, our sample started from 16/09/2008(start of pre-crisis period) until 19/12/2011(end of post-crisis period). More specifically the Greek bailout from IMF (2nd of May 2010) is considered to be the trigger event and consequently, we have the same amount of data for the pre-crisis period and the post-crisis period. In other words the pre-crisis that started from 16/09/2008, one day after the collapse of Lehman Brothers and ended two days before the bailout(last Friday before the occurrence of bailout on Sunday). In

addition, the post-crisis period started after the Greek bailout that is considered to be the beginning of the European Crisis until 19/12/2011.

The selected data have a daily frequency.

Table 1

Index	Source	Symbol(Appendix)
German 10 year government bonds	**Bloomberg(GDBR10YR)**	**GE BON**
Greek 10 year government bonds	**Bloomberg(GGGB10YR)**	**GR BON**
Irish 10 year government bonds	**Bloomberg(GIGB10YR)**	**IR BON**
Spanish 10 year government bonds	**Bloomberg(GSPG10YR)**	**SP BON**
Portuguese 10 year government bonds	**Bloomberg(GSPT10YR)**	**PO BON**
Italian 10 year government bonds	**Bloomberg(GBTPGR10YR)**	**IT BON**
U.S 10 year government bonds	**Bloomberg(USGG10YR)**	**US BON**
German Stock Price Index	**Bloomberg(DAX)**	**GE STO**
Greek Stock Price Index	**Bloomberg(ASE)**	**GR STO**
Irish Stock Price Index	**Bloomberg(ISEQ)**	**IR STO**
Spanish Stock Price Index	**Bloomberg(IBEX)**	**SP STO**
Portuguese Stock Price Index	**Bloomberg(PSI 20)**	**PO STO**
Italian Stock Price Index	**Bloomberg(FTSE MIB)**	**IT STO**
U.S Stock Price Index	**Bloomberg(SPX)**	**US STO**

The table above lists the number of variables that were included in this thesis along with the tickers and the symbols that were used in the Appendix.

2. Methodology

The tests that are included in this thesis in order to examine the existence of contagion among the selected variables are:

- Forbes-Rigobon Test
- Coskewness Test
- Cokurtosis Test

These aforementioned tests will check the potential existence of a significant increase that appeared in cross-market linkages since a shock has happened to a specific market.

The statistic examines if a shock in the returns of the generator market was transmitted to the returns of the recipient market

An econometric test that needed to be included in this project is:

- Unit root test

A unit root test examines the potential existence of non-stationarity of a time series variable with the use of an autoregressive model (AR). In case that there is existence of non-stationarity the major issue has to do with the biased standard errors that are produced. More specifically, the findings might reveal the existence of a causal relationship among the included variables that will be invalid.

A well-known test that is valid in large samples is the augmented Dickey–Fuller test. The test uses has as a null hypothesis the existence of a unit root.

H_0: existence of unit root

H_1: non-existence of unit root

1st differences will be used in order to confront this problem. Therefore, the returns of the aforementioned variables will be included, in order to achieve stationarity.

1. Forbes-Rigobon test

The first test (**Forbes and Rigobon test (2012)**) examines the contingent subsistence of contagion, in case that an important raise in cross-correlation has occurred between a pre-crisis and a post-crisis period, on the basis of a Pearson correlation coefficient.

Through this test, an analysis of cross-market correlation coefficients will be made. In particular, through the Forbes Rigobon test, we will examine not only the potential existence of contagion from one country to another for one variable (e.g. contagion from the 10-year government bond returns of Germany to 10-year government bond returns of Greece but also the potential existence of contagion from one category of variables to another (e.g. from the 10-year government bond returns of Germany to ASE returns.

The authors examined the occurrence of contagion from one market to another (from i market to j market). Through the assumptions of non-existing endogeneity and omitted variables, they proceed to the following separation. More specifically, they sunder the initial sample into two sub-categories, in order to accomplish that the variance of the first category is lower than that of the second category.

It has to be noted that the heteroskedasticity bias occurs to these tests of contagion that are based on the Pearson correlation coefficient. Thus, the absence of adjustment in order to encounter this econometric problem, may lead to erroneous existence of contagion due to the fact that volatility increases can affect the outcome that comes from these coefficients.

Through the Forbes-Rigobon test, the aforementioned effect is revealed, analyzed and corrected by the authors. More specifically, they examine the potential existence of contagion among two markets (from the 1st market i to the 2nd market j). In addition, they proceed to a division of their data in order to create two categories, x and y with different variances. More specifically, they adjust the two groups in a way that the first group has lower variance that the second one ($\sigma_x^2 < \sigma_y^2$). The relevance of this classification with the existence of contagion comes from the fact that the first group is considered to be the pre-crisis period, whereas the

second group the post-crisis period. This linkage indicates higher level of variance after the beginning of the crisis.

However, due to the fact that variance raises could reveal the existence of contagion without an actual subsistence of contagion spillover through the transmission mechanism, they diversified the existence of contagion from these variance increases. In order to adjust the bias of the cross-correlation coefficient, they modified the definition of contagion. In particular, contagion as defined as a raise of the unconditional correlation coefficient. This unconditional correlation coefficient was provided by the following equation:

$$v_y = \frac{\rho_y}{\sqrt{1 + (\frac{\sigma^2_{y,i} - \sigma^2_{x,i}}{\sigma^2_{x,i}})(1 - \rho^2_y)}} \quad (1)$$

where:

ρ_x is the correlation during the pre-crisis period

ρ_y is the correlation during the post-crisis period

The difference of unconditional correlation (v_y) is the adjustment made by the nonlinear function δ. This function expresses the existence of relative shifts in the variance returns of the country that was the generator of the crisis. It can be expressed as:

$$\delta = \frac{\sigma^2_{y,\mathrm{i}} - \sigma^2_{x,\mathrm{i}}}{\sigma^2_{x,\mathrm{i}}} \quad (2)$$

Despite the fact that there was adjustment for the issue of heteroskedasticity, there was no adjustment for the issues of a potential occurrence of endogeneity and omitted variables.

Through an estimation of a VAR model they estimate the cross-correlation coefficient among the initial shock generator market as well as each one of the other included markets. It is achieved via the use of the variance-covariance estimates on the basis of the aforementioned unconditional correlation coefficient.

The null hypothesis H_0 as well as the alternative hypothesis H_1were set as:

$$H_0 : v_y = \rho_x$$
$$H_1 : v_y > \rho_x \quad (3)$$

where

H_0: no contagion

H_1: contagion

They use *t*-tests to examine if there is a significant increase in any of the correlation coefficients during the crisis period.

For these hypotheses the t-statistic occurs as:

$$FR_1(i \to j) = \frac{\hat{v}_y - \hat{\rho}_x}{\sqrt{\frac{1}{T_y} - \frac{1}{T_x}}}, \quad (4)$$

where

T_y and T_x indicate the size of the sample for crisis period y and pre-crisis period x

The standard error is drawn from the assumption that the samples occur from independent normal distributions. The Fisher transformation $FR_2(i \to j)$ (2^{nd} version) was used so that it could ameliorate the properties of the finite sample of test statistic through the following equation:

$$\mathrm{FR}_2(\mathrm{i} \to \mathrm{j}) = \frac{\frac{1}{2}\ln\left(\frac{1+\hat{\mathrm{v}}_\mathrm{y}}{1-\hat{\mathrm{v}}_\mathrm{y}}\right) - \frac{1}{2}\ln\left(\frac{1+\hat{\rho}_\mathrm{x}}{1-\hat{\rho}_\mathrm{x}}\right)}{\sqrt{\frac{1}{\mathrm{T_y}-3} + \frac{1}{\mathrm{T_x}-3}}} \quad (5)$$

Under the null hypothesis of no contagion, Forbes and Rigobon assume that:

$$FR(i \to j) \xrightarrow{d} X_1^2$$

As it was reported above, the problems of endogeneity and omitted variable bias have not been addressed.

The other two tests check for the existence of contagion as far as higher order moments are concerned.

2. Coskewness test (Fry, Martin and Tang)

The above mentioned analysis of the Forbes-Rigobon test might not achieve to track the subsistence of contagion between two markets. Consequently, through this asymmetric dependence test, the implementation of this test includes higher order moments (coskewness) so that they can locate contagion more effectively.

The authors examined the occurrence of a significant increase through coskewness among two periods (pre-crisis period and post-crisis period).

More specifically, the second test (coskewness test) developed by **Fry, Martin and Tang (2010)** examines the existence of contagion among the returns of one specific market to the volatility (through squared returns) of another market (second order moments).Therefore, through the coskewness test we will check the potential existence of contagion from one variable returns to another variable returns squared and vice versa. Moreover, it will not only examine the potential subsistence of contagion from one country to another for the same financial market returns, but also the potential existence of contagion from the returns of one financial market to another. In this case, the null hypothesis is no contagion.

Through a similar way, they examine potential occurrence of contagion from the 1st market (market i) to the 2nd market (market j). Moreover, they progressed to a classification of their data sets so that they could end up with two categories, x and y with different variances. More specifically, they divide the two groups in a way that the first group has lower volatility that the second one ($\sigma_x^2 < \sigma_y^2$). The relevance of this classification with the existence of contagion occurs from the fact that the first group is the pre-crisis period (sedate period), whereas the second group the post-crisis period (period after the shock). This linkage implies higher levels of variance after the beginning of the crisis. Likewise with the above test, T_y and T_x represent the size of the sample for crisis period y and pre-crisis period x

respectively. Moreover, the returns of the assets for the markets i and j are r_i and r_j respectively. The correlation among the returns of the two groups was expressed as ρ_x for the period with the lower variance period and ρ_y for the period with the higher variance.

The implementation of the test included two different versions of coskewness. In particular, on the basis of the previous test, CS_{12} examined if the returns of the underlying assets in the market that generated the crisis are expressed in terms of squared returns (returns on the 2nd degree) in order to calculate coskewness.

Therefore, the statistics that were used in order to examine the existence of contagion through the coskewness test can be defined as:

$$CS_{12}\left(i \to j; r_i^1, r_j^2\right) = \left(\frac{\hat{\psi}_y\left(r_i^1, r_j^2\right) - \hat{\psi}_x\left(r_i^1, r_j^2\right)}{\sqrt{\frac{4\hat{v}^2_{y|x_i} + 2}{T_y} + \frac{4\hat{\rho}_x^2 + 2}{T_x}}} \right)^2 \quad (6)$$

More specifically, the authors implement a test for contagion from market i(1st market) to the volatility of the market j(2nd market).

In other words, the above mentioned test, check if there is an important reduction of the returns in the market i that generated the crisis, as well as an increase of the volatility in the second market (market j). As a result, these two shifts were expressed through a different way in these two markets. In particular, the occurrence of positive skewness appeared in the market that generated the crisis, whereas higher volatility appears to be the outcome as far as the recipient market is concerned.

The second version operates through a reverse way via the following equation:

$$CS_{21}\left(i \to j; r_i^2, r_j^1\right) = \left(\frac{\hat{\psi}_y\left(r_i^2, r_j^1\right) - \hat{\psi}_x\left(r_i^2, r_j^1\right)}{\sqrt{\frac{4\hat{v}^2_{y|x_i} + 2}{T_y} + \frac{4\hat{\rho}_x^2 + 2}{T_x}}} \right)^2 \quad (7)$$

In this case, the CS_{21} checks if there is an important increase of volatility in the market i that generated the crisis, as well as an important reduction of the returns in the second market (market j).

More specifically, the increase of volatility in the 1st market influences the 2nd market in a way that the investors pursuit positive skewness. From the equation (7), the numerator occurs as:

$$\widehat{\psi}_{y}\left(r_{i}^{m}, r_{j}^{n}\right)=\frac{1}{T_{y}} \sum_{t=1}^{T_{y}}\left(\frac{y_{i,t}-\hat{\mu}_{y,i}}{\widehat{\sigma}_{y,i}}\right)^{m}\left(\frac{y_{j,t}-\hat{\mu}_{y,j}}{\widehat{\sigma}_{y,j}}\right)^{n} \tag{8}$$

$$\widehat{\psi}_{x}\left(r_{i}^{m}, r_{j}^{n}\right)=\frac{1}{T_{x}} \sum_{t=1}^{T_{x}}\left(\frac{x_{i,t}-\hat{\mu}_{x,i}}{\widehat{\sigma}_{x,i}}\right)^{m}\left(\frac{x_{j,t}-\hat{\mu}_{x,j}}{\widehat{\sigma}_{x,j}}\right)^{n} \tag{9}$$

Moreover, the $\hat{v}_y$ variable is the FR adjusted unconditional correlation coefficient and is defined as:

$$\hat{v}_{y|x_i}=\frac{\hat{\rho}_y}{\sqrt{1+(\frac{\sigma_{y,i}^2-\sigma_{x,i}^2}{\sigma_{x,i}^2})(1-\hat{\rho}_y^2)}} \tag{10}$$

The null hypothesis H_0 as well as the alternative hypothesis H_1 was set as:

$$\begin{aligned} H_0&: \psi_{y}\left(r_{i}^{m}, r_{j}^{n}\right)=\psi_{x}\left(r_{i}^{m}, r_{j}^{n}\right) \\ H_1&: \psi_{y}\left(r_{i}^{m}, r_{j}^{n}\right) \neq \psi_{x}\left(r_{i}^{m}, r_{j}^{n}\right) \end{aligned} \tag{11}$$

where

H_0: no contagion

H_1: contagion

Through the null hypothesis (H_0) of no contagion both of the above mentioned the coskewness tests (CS_{12}, CS_{21}) are asymptotically distributed as

$$CS_{12}, CS_{21}(i \rightarrow j) \xrightarrow{d} X_1^2$$

3. Cokurtosis test

The third test (cokurtosis test) developed by Hsiao (2012) examines the contagion among the returns of one market to the cubed returns (third-degree returns) of another market.

The previous analysis of the Forbes-Rigobon test as well as coskewness may not manage to trail the subsistence of contagion between two markets. Consequently, through this asymmetric dependence test (Hsiao (2012), Hsiao and Fry-McKibbin (2014)), the implementation of this test includes higher co-moments (cokurtosis) in order to manage to capture contagion more effectively.

The authors examined the occurrence of a significant increase through cokurtosis among two periods (pre-crisis period and post-crisis period). In particular, they checked for potential occurrence of contagion from the 1st market (market i) to the 2nd market (market j). Through a similar way, they divided the data sets in two categories, x and y with different variances. These two groups were classified in a way that the first group has lower volatility that the second one ($\sigma_x^2 < \sigma_y^2$), Ion other words, the first group is the pre-crisis period (sedate period), whereas the second group the post-crisis period (period after the shock). This linkage implies higher levels of variance after the beginning of the crisis. Moreover, T_y and T_x represent the size of the sample for crisis period y and pre-crisis period x respectively. The returns of the assets for the markets i and j are r_i and r_j (respectively). Finally, the correlation between the two asset returns is denoted as ρ_x (pre-crisis period) and ρ_y (crisis period).

On the basis of the framework of Fry, Martin and Tang, two different types of cokurtosis tests were presented. In particular, on the basis of the previous test, CK_{13} examined if the returns of the underlying assets in the market that generated the crisis (market i) are expressed in terms of cubed returns (returns on the 3rd degree) to the market that was the recipient of the crisis in order to reckon cokurtosis.

In the same way, CK_{31} checked whether a potential transmission of the shocks from the cubed asset returns of the source market i (1st market) occurred to the returns of market j (2nd market).

These two statistics for the cokurtosis test among the two markets are expressed on the following equations:

$$CK_{13}\left(i \to j; r_i^1, r_j^3\right) = \left(\frac{\hat{\xi}_y\left(r_i^1, r_j^3\right) - \hat{\xi}_x\left(r_i^1, r_j^3\right)}{\sqrt{\frac{18\hat{v}_{y|x_i}^2 + 6}{T_y} + \frac{18\hat{\rho}_y^2 + 6}{T_x}}} \right)^2 \tag{12}$$

and

$$CK_{31}\left(i \to j; r_i^3, r_j^1\right) = \left(\frac{\hat{\xi}_y\left(r_i^3, r_j^1\right) - \hat{\xi}_x\left(r_i^3, r_j^1\right)}{\sqrt{\frac{18\hat{v}_{y|x_i}^2 + 6}{T_y} + \frac{18\hat{\rho}_y^2 + 6}{T_x}}} \right)^2 \tag{13}$$

From the equations (18) and (19), the numerator occurs as:

$$\hat{\xi}_y\left(r_i^m, r_j^n\right) = \frac{1}{T_y}\sum_{t=1}^{T_y}\left(\frac{y_{i,t} - \hat{\mu}_{y,i}}{\hat{\sigma}_{y,i}}\right)^m \left(\frac{y_{j,t} - \hat{\mu}_{y,j}}{\hat{\sigma}_{y,j}}\right)^n - (3\hat{v}_y|x_i), \tag{14}$$

$$\hat{\xi}_x\left(r_i^m, r_j^n\right) = \frac{1}{T_x}\sum_{t=1}^{T_x}\left(\frac{x_{i,t} - \hat{\mu}_{x,i}}{\hat{\sigma}_{x,i}}\right)^m \left(\frac{x_{j,t} - \hat{\mu}_{x,j}}{\hat{\sigma}_{x,j}}\right)^n - (3\hat{\rho}_x) \tag{15}$$

Moreover, the $\hat{v}_y$ variable is the FR adjusted unconditional correlation coefficient that was reported above(equation 10).

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Moreover, the null hypothesis (H_0) and the alternative hypothesis H_1 were set as:

$$H_0: \xi_y\left(r_i^m, r_j^n\right) \leq \xi_x\left(r_i^m, r_j^n\right) \tag{16}$$
$$H_1: \xi_y\left(r_i^m, r_j^n\right) > \xi_x\left(r_i^m, r_j^n\right)$$

where

H_0: no contagion

H_1: contagion

Through the null hypothesis (H_0) of no contagion both of the above mentioned the cokurtosis tests (CK_{13}, CK_{31}) are asymptotically distributed as

$$CK_{13}, CK_{31}(i \to j) \xrightarrow{d} X_1^2$$

As far as the 3 aforementioned tests are concerned, it can be mentioned that the Forbes-Rigobon test occurred before the others and is characterized by the above mentioned econometric issues, while the coskewness and the cokurtosis tests focus on the existence of contagion based on the squared returns and the cubed returns respectively.

4. Triggering events

4.1 U.S Crisis

On September 15, 2008 Lehman Brothers filed for bankruptcy and nearly caused a collapse of the financial system. The financial impact of the Lehman Brothers collapsed was approximately 10 trillion dollars erosion in market capitalization. This bankruptcy ($613 billion bankruptcy which was the largest ever in U.S. history) appeared to have direct and indirect effects. At an international level, there were about 80 Lehman subsidiaries that had close ties with the parent company. Source of information from the bankruptcy case indicated that this collapse led to losses on a global framework.

Consequently, the Lehman Brothers bankruptcy was a key trigger for the global financial crisis. Due to the fact that it was the 4th largest investment bank by asset size, severe losses in the subprime market were the outcome of this event. As far as the evolution of the financial crisis is concerned, that bankruptcy is broadly considered to be the key event that led to a transformation of the subprime mortgage crisis into a global financial crisis phenomenon.

Therefore, this specific event that appeared during September 2008 constitutes an important circumstance that led to increased market volatility and important losses as it was the largest bankruptcy of a financial institution in the U.S history.

From the scope of the existing literature review, a number of empirical studies (Fry, Martin and Tang), (Hui and Chan(2014)) marked the bankruptcy of Lehman Brothers as a

major event. Therefore, this event is considered as an important fact in the timeline of the U.S subprime mortgage crisis and the global financial crisis. For these reasons, it is included as a triggering event of the spread of the financial crisis as far the U.S crisis period is concerned.

4.2 European Crisis

Greek sovereign debt crisis, which started during the end of 2009 and was highlighted by the IMF bailout (2nd May 2010), is considered to be the key event of the European sovereign debt crisis. More specifically, on 2 May 2010, the European Central Bank (ECB), the International Monetary Fund (IMF) and the Eurozone countries, launched a €110 billion bailout loan to rescue Greece from sovereign default. It was the largest assembled bailout for a country with the participation of the 3 aforementioned institutions. This was the beginning of the implementation of fiscal adjustment programs in Greece in order to reduce the twin deficits.

The debt crisis in the market for Greek government bonds proved to be the first major test of the Eurozone. On the 23rd of April 2010 Greek authorities formally requested the activation of the EU/IMF rescue mechanism. As far as the previous events before the bailout were concerned, it has to be noted that the deterioration of the Greek fundamentals played a key role in the timeline of these events. More specifically, a crisis of confidence in November 2009, and then subsequently this crisis of confidence were combined with an inability for Greece to service its public debt the following months (February and Marcy 2010). As far as the existing literature review is concerned, a number of working papers and publications focused on the Greek crisis.

More specifically, the empirical studies of Philippas, Siriopoulos (2013), Arghyrou and Tsoukalas, 2010 and Mink, Haan (2013) had focused on the Greek Sovereign debt crisis as a noteworthy crisis period of the Eurozone that majorly affected the financial markets of the European markets. Their concluding remarks indicated the spillover and the transmission of contagion to European countries due to the occurrence of that aforementioned Greek crisis.

Consequently, the fact that the IMF in cooperation with the European Institutions offered the largest bailout through financial aid, constitute an event that marked the timeline of the

European debt crisis and , therefore, it is considered as the triggering event for the European period of this project.

3. Thesis results

The implementation of these 3 tests, aimed to track potential linkages which appeared during the U.S and the European financial crisis.

The detailed results are presented in the Appendix. The probability values are in brackets (p-values) and the test statistics are above them. The null hypothesis (H_0) is 'No Contagion' and the significant level is 5%.the rejection of H_0 means that contagion has occurred.

1. U.S Crisis

1.1 Forbes and Rigobon (FR) test

Through the Table 2 of the Appendix, the results of Forbes and Rigobon test are presented. More specifically, the results reveal the potential existence of a shock transmission from the returns of the 1st market to the returns of the 2nd market. This is achieved if there is an important uplift in the cross-correlation.

On the basis of the probability values, it is found that the rejection of null hypothesis occurred to 59 out of 182 cases. In these cases, the probability values did not exceed the 5% significance level.

The main results of the table indicate that contagion in the EU region appeared among different financial markets. It has to be noted that no contagion was transmitted from the U.S bonds returns.

As far as the bond returns are concerned, existence of contagion from the German bond returns to most of the European stock returns was tracked based on the results. Moreover, shocks from the returns of the Irish bond markets, were conveyed to the U.S and European stock returns.

Finally, on the basis of the stock returns, the main evidence indicates the occurrence of contagion from the U.S stock returns to most of the European returns of the stock markets (Germany, Greece, Ireland and Spain)

1.2 Coskewness test

The authors (Fry,Martin,Tang(2010)) of this test considered that the aforementioned tests fails to track the complete existence of contagion. Therefore they presented two different versions CS_{12} and CS_{21} that were analyzed in the previous chapter. In brief, the 1st version checks the occurrence of contagion from the returns of the generator market to the volatility of the receiver market. The 2nd version examines the aforementioned existence from the volatility of the 1st market to the returns of the 2nd market.

On the basis of the probability values, the rejection of null hypothesis occurred to 69 out of 182 cases for the 1st type (CS_{12}) and 36 out of 182 cases for the 2nd type (CS_{21}). The significance level was 5%.

The results of the tests revealed that these higher order moments can capture extra existence of contagion for CS_{12} among different financial markets. More specifically, for the 1st type (CS_{12}), contagion appeared from the returns of the Spanish bonds to all the returns of equity markets that were included in this project except Italy. In addition, spillover from the returns of the Greek bonds transmitted to the returns of the German, Greek, Spanish and Portuguese stock markets. Finally, contagion from U.S bonds appeared to most of the European stock indexes apart from Italy.

On the other hand, for the 2nd type (CS_{21}), contagion appeared to a lesser extent. A noteworthy evidence of that case was the transmission of contagion from the returns of the Greek stock market to Italian and U.S bond markets, as well as to most of the European and

U.S stock markets. Moreover, contagion appeared from U.S bonds to all the other bond markets apart from Portugal.

1.3 Cokurtosis test

This test was developed in order to track the existence of contagion through higher order moments. The authors (Hsiao (2012), Hsiao and Fry-McKibbin (2014)) presented two different versions of cokurtosis were included CK_{13} and CK_{31} that were analyzed in the previous chapter. In brief, the 1st version CK_{13} checks the occurrence of contagion from the returns of the source market to the skewness of the receiver market through cubed returns. The 2nd version examines the aforementioned existence from the returns of the 1st market to the returns of the 2nd market.

Based on the probability values, the rejection of null hypothesis occurred to 103 out of 182 cases for the 1st type (CK_{13}) and 93 out of 182 cases for the 2nd type (CK_{31}). The significance level was 5%.

The results of the tests revealed that these higher order moments can track the existence of contagion among different financial markets than the two aforementioned tests.

In particular, for the 1st type (CK_{13}), contagion appeared from the returns of the German Greek, Spanish and Portuguese markets to all the returns of the other stock markets that were included in this project(except for Italy). It has to be noted that contagion from the Irish stock market appeared to all the other stock markets apart from Italy.

Finally, on the basis of the U.S stock returns, evidence of contagion was revealed to all the stock markets.

For the second type of cokurtosis (CK_{31}), the results revealed a smaller number of transmissions of contagion. In particular, conveyance of contagion appeared from the Spanish and Portuguese stock market to all the stock markets. Furthermore, transmission occurred from the U.S stock market to all the stock markets, except for Italy.

In addition, existence of contagion was revealed from the U.S bonds to all the other bond markets with the exception of Portugal.

2. European crisis

2.1 Forbes and Rigobon (FR) test

The detailed results of Forbes and Rigobon test are reported in the table 7 of the Appendix. These results reveal the existence of a shock transmission from the returns of the 1st market to the returns of the 2nd market. Through the probability values, it is found that the rejection of null hypothesis occurred to 28 out of 182 cases. In other words, the probability values did not exceed the 5% significance level.

The main results of the table indicate that existence contagion in the EU region appeared in only a few cases. It is noteworthy that contagion appeared not only from the Greek bonds to all the stock markets except for Portugal, but also from the Greek bonds market to most of the bond markets apart from Germany and Portugal. In general, the main recipients of the transmission of contagion were the Spanish and the Greek bond markets. Finally, the Irish bond market and the Irish stock market were the source markets for the conveyance to the Greek bond markets.

2.2 Coskewness test

The small number of contagion transmission between financial markets that was reported through the previous test, highlight the fact that higher order moments aim to track the existence of contagion more effectively. As it was recorded above, the authors presented two different versions CS_{12} and CS_{21} of the coskewness test. The 1st version checks the occurrence of contagion from the returns of the source market to the volatility of the receiver market while the 2nd version examines the aforementioned existence from the volatility of the 1st market to the returns of the 2nd market.

The probability values indicated that the rejection of null hypothesis occurred to 45 out of 182 cases for the 1st type (CS_{12}) and 56 out of 182 cases for the 2nd type (CS_{21}). The significance level was 5%.

The results of the tests indicated that these higher order moments can track extra existence of contagion among different financial markets. More specifically, for the 1st type (CS_{12}), contagion appeared from the returns of Greek bond market to all the returns of the equity markets that were included in this project except for Spain. In addition, contagion from Italian bonds was transmitted to the returns of the stock markets of Germany, Greece, Spain and Portugal. Moreover, transmission occurred from Italian stocks to Irish, Spanish, Portuguese and German stock returns.

Finally, on the basis of the stock returns, conveyance of contagion occurred from Greek stock returns to the Spanish, Portuguese, German and U.S stock markets.

For the 2nd type (CS_{21}) of coskewness test, contagion appeared to a larger extent. Spillover appeared from the returns of the Greek stock market to all the stock markets apart from Germany. Moreover, transmission of contagion occurred from U.S stock market to all the bond markets apart from Spain and from the U.S bond market to all the stock markets except for Greece. Finally, conveyance of contagion was reported from the Portuguese stock market to all the stock markets except for Italy and U.S and from the German bonds to all the other stock markets apart from Germany and Greece.

2.3 Cokurtosis test

The authors (Hsiao (2012), Hsiao and Fry-McKibbin (2014)) of this test tried to capture the existence of contagion through higher order moments. In particular, they presented two different types of cokurtosis (CK_{13} and CK_{31}). The 1st version CK_{13} examines the subsistence of contagion from the returns of the generator market to the skewness of the receiver market through cubed returns. The 2nd version, through the opposite way, examines the aforementioned existence from the returns of the 1st market to the returns of the 2nd market.

The rejection of null hypothesis occurred to 61 out of 182 cases for the 1st type (CK_{13}) and 86 out of 182 cases for the 2nd type (CK_{31}). The significance level was 5%.

The results of the tests showed that these higher order moments can capture more effectively the existence of contagion among different financial markets than the two aforementioned tests.

In particular, for the 1st type (CK_{13}), contagion appeared from the returns of the Portuguese bond market to all the returns of the equity markets apart from Spain and U.S. Transmission of contagion occurred from the Italian bond market to all the other stock markets except for Ireland and U.S.

Moreover, conveyance of contagion occurred from the Greek stock market to all the bond markets apart from Greece and Ireland. Finally, it has to be noted that the Italian stocks market was the recipient of contagion from all the other stock markets.

For the second type of cokurtosis (CK_{31}), the results indicated a larger number of transmissions of contagion. More specifically, conveyance of contagion appeared from the German bond market to all the stock markets apart from Greece. Furthermore, transmission occurred from the Portuguese stock market to all the bond and stock markets except for the Italian stock market. Moreover, transmission of contagion appeared from the U.S bonds to all the Stock markets (apart from Greece)

Finally, existence of contagion was revealed from the U.S stocks to all the other bond markets with the exception of Portugal and Italy.

4. Thesis results and literature review

The above results will be compared in relation to the existing literature review.

Kohonen (2012)

This test examined the euro-zone government bond data during the period 2009-2010.The evidence of contagion coincides with the above mentioned results of the thesis. More specifically, the empirical results of this study match those that were revealed in Kohonen (2012) that there was not one particular country that led to the start of the spread of contagion.

Philippas, Siriopoulos (2013)

This study tested contagion for the Greek debt crisis through six EMU bond markets. The evidence revealed a contagion that transmitted from the country hit by the crisis to the other European Monetary Union countries. In the framework of the countries that coincide to this master thesis, the existence of contagion from Greece to other European crisis that was affected from the debt crisis appeared.

Peter Clayes and Borek Vasicek (2014)

The results of this paper showed the existence of substantial spillover especially between EMU countries as well as this thesis presented. Furthermore it was revealed that despite the fact that the aggregate spillover among the European Union has always been substantial, it raised and remained to a higher level since the beginning of the financial crisis. However, in contrast to this thesis, the study presented that the countries of Belgium, Italy and Spain proved to be key markets during the financial crisis.

Kenourgios (2013)

This empirical study examined volatility contagion across U.S. and European stock markets during the Global Financial Crisis and the Eurozone Sovereign Debt Crisis. The time difference among the Global Financial Crisis and the Eurozone Sovereign Debt Crisis revealed that the implied volatility markets recognized and reacted to these two incidents in a different way.

It was indicated that during the crisis phase level the uncertainty of the stock market, in conjunction the risk aversion of the investors, rose dramatically at the early stages of the Global Financial Crisis. Like the above mentioned results of our thesis, this empirical study showed strong findings of contagion during the last phase of the European Sovereign Debt Crisis

Marta Gómez-Puig, Simón Sosvilla-Rivero (2014)

This study showed that about two thirds of the total endogenously defined breakpoints happened after November 2009. This research indicated that during the crisis period evidence was revealed for 101 causal relationships. More specifically, 41 demonstrate the existence of new causality connections and 60 of them were patterns that pre-existed in the relatively calm period (pre-crisis period).This thesis presented the existence of contagion both in the pre-crisis period (U.S Subprime mortgage crisis) and in the crisis period.

Mink, Haan (2013)

This research tested the effect on the negative news about Greece and the potential bailout through European Banks in 2010. The results were contradictory. More specifically, the news concerning Greece appeared not to lead to abnormal returns, while the news related with a potential bailout seemed to lead to unusual returns. This thesis through the results indicated that Greek news influenced not only the other European countries that were majorly affected by the European sovereign debt crisis, but also countries like Germany and United States.

Beirne, Fratzscher (2013)

This study revealed that the sensitivity was more intense for European countries that were majorly affected during crisis (Ireland, Italy, Greece, Spain and Portugal). Furthermore, it was found that herding contagion occurred in sovereign debt markets during the crisis in specific time periods and geographic regions.

The results of the thesis indicated that during the European debt crisis, countries that were importantly influenced during the crisis period were more sensitive to these period news and events.

5. Conclusion

In conclusion, the results of the thesis indicated the existence of contagion for several cases for the two crises periods (U.S and European) that were included in this project.

Moreover the results revealed that tests which include higher order moments (e.g. coskewness, cokurtosis) managed to capture the existence of contagion more efficiently. Furthermore, the findings indicated that the contagion of transmission was not limited within one financial market since there was evidence of contagion from the returns of the bonds market to the returns of the stocks market and vice versa. Finally, this empirical study demonstrated that market contagion was not limited between the countries that were influenced by the European crisis.

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7. Appendix

Important notes

Through the tables 2-6, the existence of contagion is tested for the U.S crisis period.

Forbes Rigobon test, coskewness and cokurtosis test are included in this study.

The null hypothesis H_0 is 'No Contagion'**.**

The values in the brackets are probability values (p-values) and above them are the test statistics.

In the cases that the null hypothesis is rejected, it is highlighted in bold.

The significance level is **5%**

Through the tables 7-11, the existence of contagion is tested for the European crisis period.

Forbes Rigobon test, coskewness and cokurtosis test are included in this study.

The null hypothesis H_0 is 'No Contagion'**.**

The values in the brackets are probability values (p-values) and above them are the test statistics.

If the null hypothesis is rejected, it is highlighted in bold.

The significance level is **5%**.

1. American crisis

1.1 Forbes-Rigobon table 2 (Checks for contagion from market generator i(1st vertical column) to the receiver market j(1st horizontal row))

	GE BON	GR BON	IR BON	SP BON	PO BON	IT BON	US BON	GE STO	GR STO	IR STO	SP STO	PO STO	IT STO	US STO
GE BON	GE BON	1.4731 (0.9296)	**-4.5874 (0)**	0.9864 (0.8380)	-0.9163 (0.1797)	**-2.0276 (0.0213)**	-0.3565 (0.3607)	**-2.1667 (0.0151)**	**-2.5135 (0.0060)**	**-3.6461 (0.0001)**	**-1.6793 (0.0466)**	**-2.0910 (0.0183)**	2.4078 (0.9920)	**-2.3541 (0.0093)**
GR BON	0.8745 (0.8091)	GR BON	2.2112 (0.9865)	0.7953 (0.7868)	-0.2908 (0.3856)	0.5437 (0.7067)	0.4501 (0.6737)	0.2906 (0.6143)	3.8804 (0.9999)	3.7187 (0.9999)	-0.6029 (0.2733)	2.2728 (0.9885)	**-1.7138 (0.0433)**	1.8294 (0.9663)
IR BON	**-4.4964 (0)**	2.5752 (0.9950)	IR BON	-0.6542 (0.2565)	-0.5716 (0.2838)	**-1.7418 (0.0408)**	0.3932 (0.6929)	**-1.8166 (0.0346)**	**-3.4944 (0.0002)**	**-2.7368 (0.0031)**	**-3.2847 (0.0005)**	**-2.6351 (0.0042)**	-0.9483 (0.1715)	**-3.2686 (0.0005)**
SP BON	1.3757 (0.9155)	0.6690 (0.7483)	-0.8470 (0.1985)	SP BON	-1.6106 (0.0536)	0.3366 (0.6318)	2.4509 (0.9929)	-0.1407 (0.4440)	0.5812 (0.7194)	0.5983 (0.7252)	**-1.6634 (0.0481)**	0.1487 (0.5591)	**-1.7527 (0.0398)**	0.1232 (0.5490)
PO BON	-0.9468 (0.1719)	-0.0854 (0.4660)	-0.5870 (0.2786)	-1.0410 (0.1489)	PO BON	0.0159 (0.5063)	0.3773 (0.6470)	-0.4437 (0.3286)	1.0410 (0.8511)	-0.1659 (0.4341)	0.3759 (0.6465)	0.4201 (0.6628)	2.3154 (0.9897)	0.5943 (0.7238)
IT BON	**-2.1232 (0.0169)**	1.3476 (0.9111)	**-1.7758 (0.0379)**	0.1822 (0.5723)	0.0588 (0.5235)	IT BON	1.4990 (0.9331)	-0.7290 (0.2330)	**-2.1004 (0.0178)**	**-3.2128 (0.0007)**	**-1.9190 (0.0275)**	-0.7049 (0.2404)	0.4578 (0.6765)	-0.7337 (0.2316)
US BON	-0.1988 (0.4212)	0.5271 (0.7009)	0.8093 (0.7908)	2.4449 (0.9928)	0.7173 (0.7634)	2.2638 (0.9882)	US BON	1.6000 (0.9452)	0.5967 (0.7246)	0.3699 (0.6443)	-1.4919 (0.0679)	2.7372 (0.9969)	-1.1111 (0.1333)	1.4265 (0.9231)
GE STO	**-1.6526 (0.0492)**	0.1202 (0.5478)	-1.0272 (0.1522)	-0.1499 (0.4404)	-0.3413 (0.3664)	0.5405 (0.7056)	2.0739 (0.9810)	GE STO	**-3.4871 (0.0002)**	**-4.4164 (0)**	**-1.9999 (0.0228)**	-1.8303 (0.0636)	0.4072 (0.6581)	**-2.2766 (0.0114)**
GR STO	**-1.9708 (0.0244)**	3.9800 (1)	**-3.8821 (0.0001)**	0.7398 (0.7703)	2.4718 (0.9933)	**-1.7352 (0.0414)**	1.0206 (0.8463)	**-3.4946 (0.0002)**	GR STO	-0.1616 (0.4358)	**-3.7255 (0.0001)**	-0.7587 (0.2240)	1.2509 (0.8945)	-1.6014 (0.0546)
IR STO	**-3.6825 (0.0001)**	3.8630 (0.9999)	**-2.4725 (0.0067)**	0.8949 (0.8146)	0.6325 (0.7365)	**-3.2507 (0.0006)**	0.7063 (0.7600)	**-4.4561 (0)**	-0.1282 (0.4490)	IR STO	**-4.8572 (0)**	**-1.7994 (0.0360)**	0.1405 (0.5559)	**-2.8575 (0.0021)**
SP STO	-1.3571 (0.0874)	-0.1673 (0.4336)	**-3.3541 (0.0004)**	-1.5991 (0.0549)	0.9021 (0.8165)	**-1.6610 (0.0484)**	-1.4704 (0.0707)	**-2.3665 (0.0090)**	**-3.7475 (0.0001)**	**-4.5609 (0)**	SP STO	**-3.4559 (0.0003)**	2.9794 (0.9986)	**-2.1586 (0.0154)**
PO STO	**-1.9043 (0.0284)**	2.4146 (0.9921)	**-2.5399 (0.0055)**	0.0873 (0.5348)	0.8766 (0.8096)	-0.1667 (0.4338)	2.4881 (0.9936)	**-2.3786 (0.0087)**	-1.5022 (0.0665)	**-2.3699 (0.0089)**	**-3.4797 (0.0003)**	PO STO	0.3945 (0.6534)	-0.9388 (0.1739)
IT STO	2.1749 (0.9852)	-1.1821 (0.1186)	-0.6453 (0.2594)	-1.1830 (0.1184)	2.2869 (0.9889)	0.5754 (0.7175)	-0.4056 (0.3425)	0.6186 (0.7319)	1.1053 (0.8655)	0.7840 (0.7835)	2.2204 (0.9868)	0.5857 (0.7210)	IT STO	0.8520 (0.8029)
US STO	**-2.1285 (0.0166)**	2.1746 (0.9852)	**-3.1940 (0.0007)**	0.0855 (0.5341)	1.0821 (0.8604)	-0.2098 (0.4169)	1.1995 (0.8848)	**-2.8276 (0.0023)**	**-2.2748 (0.0115)**	**-3.1589 (0.0008)**	**-2.2802 (0.0113)**	-0.9786 (0.1639)	0.7774 (0.7815)	US STO

1.2 Coskewness Test Table 3 (Checks for contagion from the returns of the market generator i(1st vertical column) to the volatility of the receiver market j(1st horizontal row))

	GE BON	GR BON	IR BON	SP BON	PO BON	IT BON	US BON	GE STO	GR STO	IR STO	SP STO	PO STO	IT STO	US STO
GE BON	GE BON	1.0052 (0.4120)	0.0647 (0.1931)	0.0857 (0.9427)	**0.0002 (0.0203)**	**0.9674 (0.0111)**	1.0857 (0.8805)	0.0241 (0.7169)	0.0352 (0.1166)	0.0524 (0.6995)	0.0624 (0.1925)	**0.0000 (0.0475)**	0.0241 (0.9354)	**0.0000 (0.0310)**
GR BON	0.0000 (0.6017)	GR BON	**0.0000 (0.0425)**	0.8514 (0.9195)	0.0274 (0.8229)	**0.0024 (0.0338)**	0.0404 (0.8695)	**0.0025 (0.0428)**	**0.0410 (0.0002)**	0.0274 (0.5213)	**0.0572 (0.0366)**	**0.0341 (0.0018)**	0.0025 (0.9411)	0.0063 (0.0775)
IR BON	0.0271 (0.2735)	0.0274 (0.8143)	IR BON	0.0341 (0.9998)	**0.0645 (0.0470)**	0.0524 (0.9308)	0.0642 (0.9772)	0.0052 (0.8931)	**0.0240 (0.0499)**	0.4074 (0.8686)	**0.0036 (0.0332)**	0.0024 (0.7822)	0.0025 (0.9839)	0.0102 (0.8234)
SP BON	0.0524 (0.8078)	0.0125 (0.6173)	0.0024 (0.9740)	SP BON	0.0035 (0.9287)	**0.1010 (0.0023)**	**0.0204 (0.0001)**	**0.0247 (0.0042)**	**0.0634 (0.0014)**	**0.0274 (0.0041)**	**0.1001 (0.0047)**	**0.0021 (0.0003)**	0.0052 (0.5562)	**0.0034 (0.0043)**
PO BON	0.0340 (0.8711)	0.00570 (0.4336)	0.0152 (0.9580)	0.7568 (0.2712)	PO BON	0.4846 (0.7615)	0.0858 (0.9226)	0.0675 (0.8784)	**0.0207 (0.0345)**	0.0374 (0.9178)	0.0475 (0.9819)	**0.0052 (0.0443)**	0.0035 (0.9854)	0.0140 (0.1082)
IT BON	0.0050 (0.8308)	2.5344 (0.2414)	0.0005 (0.9797)	0.0030 (0.4763)	**0.0084 (0.0314)**	IT BON	**0.0750 (0.0133)**	0.0057 (0.3891)	**0.0005 (0.0019)**	0.0024 (0.9346)	0.0410 (0.5656)	0.0030 (0.3065)	0.0068 (0.9729)	**0.0003 (0.0347)**
US BON	0.4200 (0.7847)	0.0005 (0.0573)	0.0024 (0.9715)	**0.0074 (0.0142)**	0.0024 (0.8775)	0.3520 (0.8837)	US BON	**0.0241 (0.0075)**	**0.0001 (0.0036)**	**0.0274 (0)**	**0.0001 (0.0003)**	**0.2400 (0.0415)**	0.0000 (0.8195)	**0.3500 (0.0001)**
GE STO	0.0012 (0.6021)	0.0003 (0.1924)	0.0042 (0.8615)	**0.0009 (0.0009)**	0.0000 (0.6348)	0.0084 (0.6694)	**0.0047 (0.0021)**	GE STO	**0.0024 (0.0036)**	0.0520 (0.9699)	0.0361 (0.6805)	**0.0034 (0.0001)**	0.0052 (0.9854)	**0.0042 (0.0001)**
GR STO	0.0043 (0.5732)	**0.0001 (0.0096)**	0.150 (0.9087)	**0.0005 (0.0042)**	0.0050 (0.7165)	1.6353 (0.3853)	**0.0013 (0.0074)**	**0.0004 (0.0351)**	GR STO	0.0453 (0.7610)	0.0142 (0.4828)	**0.0022 (0.0053)**	0.0042 (0.9804)	0.0024 (0.0754)
IR STO	0.0356 (0.9854)	0.0765 (0.9858)	0.0476 (0.8613)	**0.0030 (0)**	0.0785 (0.7833)	0.0364 (0.7593)	**0.0052 (0.0052)**	**0.2364 (0.0027)**	0.0647 (0.0642)	IR STO	**0.0003 (0.0002)**	**0.0857 (0.0003)**	0.0347 (0.8627)	**0.0001 (0.0005)**
SP STO	**0.0000 (0.0104)**	0.0412 (0.6218)	0.00012 (0.9093)	**0.0002 (0.0001)**	0.0002 (0.4789)	0.0003 (0.2533)	**0.0000 (0.0003)**	**0.0000 (0.0002)**	0.0024 (0.0604)	**0.0006 (0.0047)**	SP STO	2.3524 (0.5111)	0.0471 (0.9883)	0.0574 (0.7050)
PO STO	**0.0000 (0.0245)**	0.0001 (0.0542)	0.0002 (0.7896)	**0.0001 (0.0003)**	0.374 (0.5570)	1.8746 (0.6882)	**0.0278 (0.0001)**	**0.1274 (0.0005)**	**0.0001 (0.0002)**	0.0271 (0.8051)	0.0241 (0.8569)	PO STO	0.0574 (0.9842)	0.0352 (0.6917)
IT STO	0.0006 (0.9263)	0.0070 (0.8773)	0.0005 (0.9281)	**0.0006 (0.0024)**	0.2041 (0.9777)	0.2758 (0.9430)	**0.7420 (0.0344)**	0.0352 (0.6253)	0.0287 (0.4283)	**0.0724 (0.0407)**	0.0025 (0.9014)	0.0638 (0.9980)	IT STO	**0.0000 (0.0375)**
US STO	**0.0000 (0.0186)**	0.0032 (0.4573)	0.0096 (0.9743)	**0.0000 (0.0005)**	0.0027 (0.6944)	0.0001 (0.6449)	**0.0051 (0.0041)**	**0.0052 (0.0003)**	**0.0096 (0.0075)**	0.0750 (0.8773)	0.0035 (0.9913)	0.0024 (0.6991)	0.8412 (0.8794)	US STO

1.3 Coskewness Test Table 4 (Checks for contagion from the volatility of the market generator i(1st vertical column) to the returns of the receiver market j(1st horizontal row))

	GE BON	GR BON	IR BON	SP BON	PO BON	IT BON	US BON	GE STO	GR STO	IR STO	SP STO	PO STO	IT STO	US STO
GE BON	GE BON	0.0437 (0.4911)	0.0561 (0.8468)	**0.0327 (0.0001)**	0.0341 (0.5536)	0.2410 (0.8380)	**0.0352 (0.0041)**	0.0745 (0.3124)	0.0326 (0.7394)	0.0024 (0.9461)	0.0652 (0.9968)	0.0352 (0.9164)	0.0745 (0.4547)	0.0628 (0.9661)
GR BON	0.0001 (0.2792)	GR BON	0.0035 (0.9760)	**0.0250 (0.0036)**	0.0002 (0.4660)	0.0362 (0.3885)	**0.0254 (0.0425)**	**0.0025 (0.0249)**	0.0035 (0.2558)	0.0035 (0.0722)	0.0025 (0.9524)	1.2504 (0.7976)	0.0324 (0.3560)	0.0021 (0.7906)
IR BON	0.0025 (0.8184)	0.0745 (0.9497)	IR BON	**0.0373 (0.0041)**	0.0215 (0.2710)	0.0475 (0.8892)	**0.0874 (0.0023)**	**0.0475 (0.0251)**	0.0352 (0.6912)	**0.0425 (0.0003)**	0.0742 (0.9130)	0.0052 (0.7778)	**0.0032 (0.0001)**	0.0241 (0.9290)
SP BON	**0.0082 (0)**	**0.0015 (0.0074)**	1.2374 (0.8592)	SP BON	0.0201 (0.9738)	0.0031 (0.9959)	**0.0081 (0.0159)**	0.0011 (0.9516)	0.0619 (0.9092)	0.0106 (0.7860)	0.0320 (0.9819)	0.0045 (0.9925)	0.0420 (0.9704)	0.0012 (0.9899)
PO BON	0.0052 (0.8559)	**0.0035 (0.0395)**	0.0042 (0.5682)	0.0062 (0.9979)	PO BON	0.0035 (0.5235)	0.0041 (0.1498)	1.5327 (0.7516)	0.0085 (0.9556)	0.0062 (0.8036)	0.0024 (0.9760)	0.0035 (0.9777)	0.0075 (0.9520)	0.0068 (0.9617)
IT BON	0.0725 (0.9144)	0.0417 (0.5646)	0.0635 (0.6346)	1.2369 (0.8719)	0.0041 (0.9397)	IT BON	**0.0041 (0.0007)**	0.0035 (0.3880)	0.4025 (0.5808)	2.8312 (0.2355)	0.0024 (0.8442)	0.0035 (0.9397)	0.0058 (0.5301)	0.0075 (0.8193)
US BON	**0.0028 (0.0034)**	**0.0018 (0.0478)**	**0.0030 (0.0025)**	**0.0013 (0.0003)**	0.0001 (0.3638)	**0.0012 (0.0007)**	US BON	0.088 (0.5359)	0.0105 (0.8644)	0.0361 (0.4439)	0.0141 (0.9758)	0.0188 (0.9424)	0.0104 (0.8854)	0.0129 (0.8739)
GE STO	0.0001 (0.4018)	**0.0008 (0.0039)**	0.0003 (0.0844)	0.0000 (0.6763)	0.0104 (0.9181)	**0.0004 (0.0397)**	**0.0005 (0.0268)**	GE STO	**0.0066 (0.0375)**	**0.0009 (0.0021)**	0.0014 (0.7875)	0.5527 (0.6773)	0.0512 (0.1114)	0.0313 (0.4534)
GR STO	0.0002 (0.1359)	**0.0005 (0.0228)**	0.0002 (0.1161)	0.0172 (0.9828)	0.0863 (0.9736)	**0.0004 (0.0351)**	**0.0004 (0.0437)**	**0.0015 (0.0001)**	GR STO	**0.0003 (0.0004)**	0.0004 (0.6131)	0.0014 (0.2514)	**0.0001 (0.0025)**	**0.0007 (0.0280)**
IR STO	0.0002 (0.1543)	0.0003 (0.0981)	**0.0012 (0.0006)**	0.0330 (0.7601)	0.0015 (0.9257)	0.0020 (0.7506)	**0.0015 (0.0001)**	0.0520 (0.9546)	0.0403 (0.0723)	IR STO	0.0071 (0.6923)	0.0638 (0.9895)	0.0724 (0.3973)	0.3527 (0.9834)
SP STO	0.0000 (0.8326)	0.0754 (0.8005)	0.0085 (0.5108)	0.0052 (0.9029)	0.0063 (0.9992)	0.0095 (0.9213)	**0.0009 (0.0391)**	0.0417 (0.9765)	0.0528 (0.8501)	0.0637 (0.5849)	SP STO	0.0857 (0.8418)	**0.0020 (0.0002)**	0.0052 (0.9746)
PO STO	0.986 (0.9455)	0.0010 (0.6782)	0.0410 (0.7699)	0.0340 (0.8763)	0.0740 (0.9567)	0.0620 (0.8471)	0.0510 (0.7325)	0.0420 (0.5588)	0.0031 (0.3866)	0.0052 (0.7227)	0.0001 (0.5287)	PO STO	0.0765 (0.9160)	0.0035 (0.3122)
IT STO	0.6637 (0.5125)	0.0524 (0.6586)	0.0124 (0.3479)	0.0323 (0.9699)	0.0427 (0.9686)	0.0634 (0.7767)	0.0127 (0.9556)	0.0036 (0.9525)	0.0314 (0.7560)	0.0274 (0.6910)	0.4101 (0.4511)	0.0001 (0.3943)	IT STO	0.0024 (0.9925)
US STO	0.0028 (0.7027)	0.0001 (0.5282)	0.0074 (0.5369)	0.0014 (0.8295)	0.0034 (0.8417)	0.0104 (0.5642)	0.0400 (0.5409)	0.5001 (0.4091)	0.1002 (0.1440)	0.0232 (0.5492)	0.0001 (0.2684)	0.0001 (0.2999)	0.0004 (0.8980)	US STO

1.4 Cokurtosis Test Table 5 (Checks for contagion from the returns of the market generator i(1st vertical column) to the skewness of the receiver market j(1st horizontal row))

	GE BON	GR BON	IR BON	SP BON	PO BON	IT BON	US BON	GE STO	GR STO	IR STO	SP STO	PO STO	IT STO	US STO
GE BON	GE BON	**0.0052 (0)**	0.0124 (0.6527)	0.0323 (0.9953)	0.0052 (0.9868)	0.0088 (0.4554)	0.0003 (0.9396)	**0.0634 (0.0023)**	**0.0724 (0.0003)**	**0.0754 (0.0005)**	**0.0052 (0.0002)**	**0.0033 (0.0052)**	0.0060 (0.9950)	**0.6249 (0.0004)**
GR BON	**0.0000 (0.0021)**	GR BON	**0.0001 (0.0241)**	0.5636 (0.9866)	0.0647 (0.9969)	0.0463 (0.2373)	0.0637 (0.8390)	**0.0637 (0)**	**0.8746 (0.0274)**	**0.0479 (0.0357)**	**0.0858 (0.0041)**	**0.0858 (0.0005)**	0.0150 (0.9824)	**0.5742 (0.0021)**
IR BON	2.6482 (0.1278)	**0.0038 (0)**	IR BON	0.0046 (0.9998)	0.0063 (0.9998)	0.0074 (0.9351)	0.0078 (0.9958)	0.0053 (0.4567)	**0.0046 (0.0013)**	0.0056 (0.4847)	**0.0062 (0.0001)**	**0.0075 (0.0211)**	0.00754 (0.9943)	0.0003 (0.2819)
SP BON	0.0001 (0.9100)	0.0022 (0.4704)	0.0003 (0.9692)	SP BON	0.0003 (0.0600)	**0.0065 (0.0021)**	**2.0736 (0.0384)**	**0.0583 (0.0363)**	**0.0093 (0.0342)**	**0.0858 (0.0012)**	**0.7580 (0.0102)**	**0.0658 (0.0362)**	0.1040 (0.1004)	**0.6854 (0.0032)**
PO BON	0.0002 (0.7566)	0.0074 (0.8423)	0.0024 (0.9574)	0.0021 (0.0774)	PO BON	0.0042 (0.3422)	0.0053 (0.9296)	**0.0002 (0.0021)**	**0.0032 (0.0020)**	**0.0005 (0.0035)**	**0.0012 (0.0155)**	**0.0746 (0.0221)**	0.0274 (0.9783)	**0.3524 (0.0042)**
IT BON	0.0041 (0.1666)	**0.0002 (0.0322)**	0.0003 (0.7240)	**0.0005 (0.0160)**	0.0016 (0.9615)	IT BON	0.0035 (0.9822)	**0.0004 (0.0122)**	**0.0027 (0.0472)**	**0.0052 (0.0201)**	**0.0012 (0.0112)**	**0.0005 (0.0121)**	0.352 (0.9787)	**0.7421 (0.0014)**
US BON	0.0027 (0.7303)	0.0042 (0.0620)	0.0005 (0.8776)	**0.0001 (0.0041)**	0.0074 (0.9875)	0.0052 (0.8349)	US BON	0.0050 (0.0512)	**0.0027 (0.0034)**	**0.0052 (0.0012)**	**0.0057 (0.0025)**	**0.0007 (0.0207)**	0.0627 (0.2932)	**0.0015 (0.0021)**
GE STO	**0.0005 (0.0133)**	**0.0003 (0.0200)**	0.0000 (0.4875)	**0.0002 (0.0354)**	0.0042 (0.9790)	0.0004 (0.3372)	**0.0524 (0.0274)**	GE STO	**2.3410 (0)**	**1.1400 (0.0021)**	**0.0415 (0.0032)**	**0.0427 (0.0041)**	0.5740 (0.9246)	**0.0052 (0.0032)**
GR STO	**0.4648 (0.0032)**	**0.0857 (0.0021)**	0.0086 (0.3664)	**0.0274 (0.0318)**	0.0000 (0.7588)	0.0000 (0.1292)	**0.0362 (0.0474)**	**0.857 (0.0024)**	GR STO	**0.0040 (0.0036)**	**0.0201 (0.0001)**	**0.0241 (0.0074)**	0.0274 (0.9854)	**0.0204 (0.0025)**
IR STO	**0.0074 (0.0040)**	**0.0057 (0.0024)**	0.0052 (0.5679)	**0.0000 (0.0357)**	0.0074 (0.8905)	0.0047 (0.4126)	**0.0001 (0.0021)**	**0.0341 (0.0242)**	**0.0742 (0.0235)**	IR STO	**0.0247 (0.0241)**	**0.0374 (0.0142)**	0.0041 (0.7127)	**0.0025 (0.0036)**
SP STO	**0.0574 (0.0011)**	**0.0772 (0.0352)**	0.0035 (0.5522)	**1.0420 (0.0274)**	0.0020 (0.7446)	0.0051 (0.1079)	**0.0057 (0.0224)**	**0.0084 (0.0135)**	**0.0000 (0.0271)**	**0.0074 (0.0132)**	SP STO	**0.0648 (0.0204)**	0.0034 (1)	0.0030 (0.1190)
PO STO	**0.0241 (0)**	**0.0958 (0.0374)**	0.0473 (0.3003)	**0.0574 (0.0352)**	0.0847 (0.7943)	0.0637 (0.1220)	**0.0074 (0.0074)**	**0.0047 (0.0354)**	**0.0034 (0.0400)**	**0.0014 (0.0210)**	**0.0020 (0.0421)**	PO STO	0.0021 (0.9951)	0.0057 (0.1167)
IT STO	0.0005 (0.8870)	0.0057 (0.8610)	0.0050 (0.8660)	0.0024 (0.3563)	0.00075 (0.9953)	0.0034 (0.8980)	**0.0002 (0.0038)**	**0.0024 (0.0419)**	0.0785 (0.0774)	0.0754 (0.8865)	0.0057 (0.8296)	0.0074 (0.7882)	IT STO	**0.5841 (0.0021)**
US STO	**0.0000 (0.0045)**	**0.0001 (0.0035)**	0.0025 (0.5382)	**0.0002 (0.0021)**	0.0036 (0.8051)	0.0353 (0.2507)	**0.3342 (0.0005)**	**2.1220 (0.0021)**	**0.0675 (0.0004)**	**0.0275 (0.0074)**	**0.4250 (0.0004)**	**0.6752 (0.0076)**	**0.3675 (0.0113)**	US STO

1.5 Cokurtosis Test Table 6 (Checks for contagion from the skewness of the market generator i(1st vertical column) to the returns of the receiver market j(1st horizontal row))

	GE BON	GR BON	IR BON	SP BON	PO BON	IT BON	US BON	GE STO	GR STO	IR STO	SP STO	PO STO	IT STO	US STO
GE BON	GE BON	**0.0001 (0.0002)**	0.0024 (0.8773)	**0.0421 (0.0011)**	**0.0036 (0.0103)**	0.0074 (0.1857)	**0.0274 (0.0025)**	**0.0001 (0)**	**0.0002 (0.0476)**	**0.0001 (0.0063)**	0.0203 (0.6674)	0.0014 (0.6863)	**0.0052 (0.0012)**	0.0051 (0.2386)
GR BON	**0.0006 (0.0001)**	GR BON	0.1017 (0.2925)	**0.0024 (0.0002)**	0.0052 (0.1922)	**0.0203 (0.0003)**	**0.0410 (0.0041)**	**0.0021 (0.0245)**	**0.0051 (0.0365)**	**0.0012 (0.0024)**	0.0303 (0.1482)	0.0402 (0.0908)	**0.0041 (0.0024)**	**0.0022 (0.0035)**
IR BON	0.0024 (0.9636)	0.4100 (0.5326)	IR BON	**0.2400 (0.0010)**	**0.2400 (0.0007)**	**0.0052 (0.0008)**	**0.0035 (0.0006)**	**0.4100 (0.0047)**	**0.0050 (0.0003)**	**0.0001 (0.0036)**	0.0053 (0.6365)	0.0050 (0.3298)	**0.0100 (0.0041)**	**0.0003 (0.0351)**
SP BON	**0.0001 (0.0010)**	**0.0006 (0.0024)**	0.0420 (0.2262)	SP BON	0.0410 (0.9788)	0.0001 (0.9968)	0.0013 (0.0505)	0.0003 (0.9798)	0.0001 (0.9982)	0.0004 (0.9642)	0.0041 (0.9983)	0.0024 (0.9980)	0.0002 (0.9339)	0.0003 (0.9973)
PO BON	0.0410 (0.8915)	0.0240 (0.9798)	0.0041 (0.9832)	0.0340 (0.9774)	PO BON	0.7500 (0.9956)	0.0240 (0.8544)	0.6200 (0.1276)	1.2340 (0.9878)	2.0240 (0.9449)	1.0023 (0.9976)	0.0243 (0.9977)	0.0347 (0.9719)	0.0727 (0.9920)
IT BON	0.0034 (0.4751)	0.0052 (0.3545)	1.2014 (0.4413)	2.2410 (0.9928)	0.0247 (0.9132)	IT BON	**0.0047 (0)**	**0.0524 (0.0094)**	0.0342 (0.5137)	**0.0021 (0.0001)**	0.0417 (0.8943)	0.0027 (0.8774)	**0.0045 (0.0002)**	0.0410 (0.6763)
US BON	**0.0006 (0.0032)**	**0.0026 (0.0047)**	**0.0003 (0.0024)**	**0.0005 (0.0036)**	0.0042 (0.3013)	**0.0001 (0.0202)**	US BON	0.0102 (0.9114)	0.0050 (0.9269)	0.0007 (0.7205)	0.0754 (0.9817)	0.0100 (0.9969)	0.0074 (0.1304)	0.0001 (0.9903)
GE STO	**0.0021 (0.0024)**	**0.0056 (0.0004)**	**0.0033 (0.0003)**	0.0050 (0.7502)	0.0400 (0.9370)	**0.0010 (0.0023)**	**0.0002 (0.0001)**	GE STO	**0.0162 (0.0008)**	**0.0038 (0.0041)**	0.0082 (0.2500)	0.0022 (0.2186)	**0.0003 (0.0007)**	**0.0060 (0.0007)**
GR STO	**0.0011 (0.0041)**	**0.0023 (0.0004)**	**0.0017 (0.0003)**	0.0020 (0.9846)	0.0410 (0.1105)	**0.0005 (0.0002)**	**0.0001 (0.0091)**	**0.0028 (0.0003)**	GR STO	**0.0019 (0.0021)**	**0.0131 (0.0036)**	**0.0106 (0.0201)**	**0.0075 (0.0002)**	**0.0028 (0.0035)**
IR STO	**0.0075 (0.0021)**	**0.0084 (0.0365)**	**0.0093 (0.0052)**	0.0007 (0.8790)	**0.0002 (0.0047)**	**0.0033 (0.0001)**	**0.0001 (0.0024)**	**0.0099 (0.0021)**	**0.0288 (0.0045)**	IR STO	0.0368 (0.2641)	0.0234 (0.2856)	**0.0037 (0.0002)**	**0.0155 (0.0018)**
SP STO	**0.0000 (0.0280)**	0.0001 (0.1200)	**0.0463 (0.0024)**	0.0340 (0.9963)	0.4100 (0.7245)	0.0012 (0.1375)	0.0020 (0.7955)	**0.0001 (0.0015)**	**0.0033 (0.0021)**	**0.0051 (0.0017)**	SP STO	**0.0123 (0.0001)**	**0.0202 (0.0021)**	**0.0301 (0.0035)**
PO STO	0.0024 (0.1041)	**0.0001 (0.0091)**	**0.0412 (0.0300)**	0.0010 (0.9428)	0.0023 (0.8331)	0.0064 (0.2511)	0.0013 (0.6966)	**0.0401 (0.0147)**	**0.0401 (0.0041)**	**0.0086 (0.0307)**	**0.0002 (0.0249)**	PO STO	**0.0506 (0.0365)**	**0.0401 (0.0247)**
IT STO	0.0034 (0.7553)	0.0041 (0.3696)	**0.0002 (0.0004)**	0.5848 (0.8825)	0.0747 (0.8713)	0.0957 (0.1625)	0.0054 (0.5833)	0.0078 (0.0711)	0.0092 (0.0317)	0.0046 (0.0963)	0.0056 (0.9763)	**0.0001 (0.0014)**	IT STO	0.064 (0.9910)
US STO	**0.0001 (0.0056)**	**0.0002 (0.0001)**	**0.0001 (0.0003)**	0.0456 (0.9774)	0.0875 (0.6174)	0.0086 (0.0585)	0.064 (0.5067)	**0.0002 (0.0001)**	**0.0004 (0.0002)**	**0.0001 (0.0001)**	**0.0005 (0.0041)**	**0.0003 (0.0003)**	0.0064 (0.6520)	US STO

2. European crisis

2.1 Forbes-Rigobon Test table 7 (Checks for contagion from market generator i(1st vertical column) to the receiver market j(1st horizontal row))

	GE BON	GR BON	IR BON	SP BON	PO BON	IT BON	US BON	GE STO	GR STO	IR STO	SP STO	PO STO	IT STO	US STO
GE BON	GE BON	-1.5166 (0.0647)	-0.8750 (0.1908)	**-2.3476 (0.0094)**	-0.8517 (0.1972)	1.2488 (0.8941)	-0.4652 (0.3209)	-1.3039 (0.0961)	0.1022 (0.5407)	-0.7746 (0.2193)	1.3960 (0.9186)	2.1790 (0.9853)	-1.0785 (0.1404)	1.6898 (0.9545)
GR BON	-1.5135 (0.0651)	GR BON	**-2.1503 (0.0158)**	**-2.2284 (0.0129)**	0.1859 (0.5737)	**-1.1876 (0.0175)**	**0.9066 (0.0177)**	**-1.0777 (0.0406)**	**-1.6440 (0.0401)**	**-2.7275 (0.0032)**	**-1.3933 (0.0318)**	-0.6899 (0.2451)	**-1.4881 (0.0384)**	**2.0397 (0.0493)**
IR BON	-0.8490 (0.1979)	**-2.2367 (0.0127)**	IR BON	-1.0312 (0.1512)	-0.6617 (0.2541)	0.7796 (0.7822)	-0.6772 (0.2491)	-0.4166 (0.3385)	0.6772 (0.7509)	-0.1707 (0.4322)	1.5835 (0.9434)	1.9476 (0.9473)	-0.1326 (0.4473)	0.4011 (0.6558)
SP BON	**-2.2527 (0.0121)**	**-2.1978 (0.0140)**	-1.1094 (0.1336)	SP BON	**-2.0929 (0.0182)**	-0.0314 (0.4875)	-0.7063 (0.2400)	-1.2298 (0.1094)	0.2135 (0.5845)	1.0008 (0.8415)	1.5789 (0.9428)	0.0418 (0.5167)	-1.1657 (0.1219)	-0.7455 (0.2280)
PO BON	-1.1358 (0.1280)	0.0435 (0.5174)	-0.7301 (0.2327)	**-1.8826 (0.0299)**	PO BON	0.5522 (0.7096)	-0.8125 (0.2082)	0.5285 (0.7014)	-0.0255 (0.4898)	-0.6573 (0.5455)	0.7492 (0.7731)	0.5641 (0.7137)	-0.8075 (0.2097)	0.8728 (0.8086)
IT BON	0.6515 (0.7426)	-1.1414 (0.1269)	0.5138 (0.6963)	0.0091 (0.5036)	0.4224 (0.6636)	IT BON	0.5836 (0.7203)	1.0155 (0.8451)	-0.0097 (0.4961)	**0.0986 (0.0393)**	0.6738 (0.7498)	1.0881 (0.8617)	-0.3137 (0.3769)	0.6345 (0.7371)
US BON	-0.5519 (0.2905)	0.8432 (0.8004)	-0.6914 (0.2447)	-0.7057 (0.2402)	-0.5074 (0.3060)	1.0676 (0.8571)	US BON	-0.2252 (0.4109)	-0.4352 (0.3317)	-0.6766 (0.2493)	-0.1657 (0.4342)	0.1621 (0.5644)	-1.4254 (0.0770)	0.0774 (0.5308)
GE STO	-0.6119 (0.2703)	-1.2690 (0.1022)	-0.1780 (0.4294)	**-1.6735 (0.0471)**	1.8482 (0.9677)	2.5067 (0.9939)	2.6399 (0.7389)	GE STO	1.9596 (0.9750)	0.4916 (0.6885)	1.4678 (0.9289)	**2.4327 (0.0425)**	0.9431 (0.8272)	2.5625 (0.9948)
GR STO	0.1489 (0.5592)	**-1.6997 (0.0446)**	0.6541 (0.7435)	0.1846 (0.5732)	0.3136 (0.6231)	2.6813 (0.7522)	-0.3123 (0.3774)	1.2544 (0.8952)	GR STO	1.0377 (0.8503)	0.2946 (0.6159)	1.5066 (0.9340)	1.0681 (0.5271)	**1.0633 (0.0262)**
IR STO	-0.5548 (0.2895)	**-3.6806 (0.0001)**	1.1763 (0.5700)	1.2486 (0.8941)	-0.6760 (0.2495)	0.7653 (0.7780)	-0.8612 (0.1946)	1.5513 (0.7093)	1.6831 (0.9538)	IR STO	2.8235 (0.9976)	2.3666 (0.9910)	1.6082 (0.9461)	-0.5610 (0.2874)
SP STO	0.8948 (0.8146)	-0.4977 (0.3094)	0.7537 (0.7745)	1.5017 (0.9334)	0.6294 (0.7355)	0.4935 (0.6892)	-0.2674 (0.3946)	0.2474 (0.5977)	-0.3458 (0.3648)	0.9141 (0.8197)	SP STO	0.0169 (0.5067)	0.4416 (0.5006)	-0.3751 (0.3538)
PO STO	1.1927 (0.8835)	0.1007 (0.5401)	1.2810 (0.8999)	0.3461 (0.6354)	0.2988 (0.6175)	1.4751 (0.6827)	**-0.1569 (0.0376)**	0.9870 (0.8382)	0.2422 (0.5957)	1.0915 (0.8625)	-0.2286 (0.4096)	PO STO	-0.5716 (0.2838)	-0.5529 (0.2901)
IT STO	-0.9248 (0.1775)	**-2.0398 (0.0207)**	-0.0543 (0.4783)	-1.6297 (0.0516)	-0.0518 (0.4793)	0.1710 (0.5679)	**-1.2812 (0.0001)**	1.9451 (0.8277)	0.6724 (0.7493)	1.5468 (0.9390)	1.1964 (0.8842)	1.0057 (0.8427)	IT STO	**0.6140 (0.0304)**
US STO	2.2566 (0.9880)	2.0832 (0.9814)	**0.3699 (0.0443)**	**-1.6034 (0.0044)**	1.8666 (0.9690)	1.1913 (0.8832)	0.3544 (0.6385)	2.5005 (0.9938)	1.3914 (0.9180)	-0.6119 (0.2703)	0.1114 (0.5443)	-0.1457 (0.4421)	0.5833 (0.7201)	US STO

2.2 Coskewness Test Table 8 (Checks for contagion from the returns of the market generator i(1st vertical column) to the volatility of the receiver market j(1st horizontal row))

	GE BON	GR BON	IR BON	SP BON	PO BON	IT BON	US BON	GE STO	GR STO	IR STO	SP STO	PO STO	IT STO	US STO
GE BON	GE BON	0.0345 (0.9259)	0.0052 (0.9935)	0.0003 (0.9999)	0.0010 (0.9958)	0.0027 (0.9995)	2.0041 (0.9338)	0.0003 (0.9984)	0.0052 (0.9506)	0.0052 (0.9897)	0.0001 (0.9783)	0.0409 (0.9906)	0.0212 (0.9874)	0.0365 (0.9955)
GR BON	0.0003 (0.9848)	GR BON	**0.0001 (0.0047)**	0.0003 (0.9871)	**0.0053 (0.0196)**	0.0003 (0.9799)	**0.0012 (0.0106)**	0.0008 (0.9715)	**0.0041 (0.0428)**	**0.0075 (0.0497)**	0.0084 (0.9779)	**0.0057 (0.0447)**	**0.0405 (0.0029)**	**0.0752 (0.0376)**
IR BON	0.0006 (0.9921)	0.0074 (0.9629)	IR BON	**0.0009 (0.0315)**	0.0410 (0.8941)	0.0052 (0.9780)	0.4721 (0.6408)	1.6741 (0.7604)	1.0741 (0.1558)	0.0000 (0.7904)	0.0005 (0.9401)	0.0034 (0.9618)	0.0002 (0.7088)	0.0212 (0.9747)
SP BON	0.0124 (0.9725)	0.0002 (0.9957)	0.0001 (0.8674)	SP BON	0.0005 (0.9834)	0.0003 (0.9824)	0.0041 (1.2336)	0.0035 (0.8900)	0.0062 (0.1326)	0.0047 (0.9767)	**0.0085 (0.0470)**	0.0062 (0.9687)	**0.0063 (0.0419)**	0.2100 (0.9905)
PO BON	0.0120 (0.9932)	0.0074 (0.9920)	0.0034 (0.9291)	0.0025 (0.9875)	PO BON	0.0527 (0.6640)	**0.0003 (0.0002)**	**0.0032 (0.0313)**	**0.0021 (0.0352)**	2.0041 (0.5891)	1.0034 (0.8721)	0.0003 (0.9133)	**0.0021 (0.0009)**	0.0035 (0.6823)
IT BON	0.0241 (0.9910)	1.0401 (0.9586)	0.4020 (0.8075)	0.0012 (0.9662)	0.0058 (1.6532)	IT BON	**0.0002 (0.0023)**	**0.0240 (0.0310)**	**0.0410 (0.0001)**	1.0001 (0.8154)	**0.0024 (0.0151)**	**2.4175 (0.0158)**	0.0001 (0.5223)	0.0062 (0.5558)
US BON	0.0041 (0.9607)	2.0057 (0.9682)	0.0084 (0.9373)	0.0067 (0.8319)	1.0087 (0.1728)	**0.0055 (0.0001)**	US BON	0.0240 (0.9986)	1.0005 (0.9931)	0.0240 (0.9996)	1.0475 (0.9998)	**0.0057 (0.0083)**	1.0006 (0.9907)	0.0041 (0.9979)
GE STO	0.0032 (0.9954)	1.0310 (0.9460)	1.0200 (1.9951)	2.0120 (0.9469)	0.0034 (0.7766)	0.0470 (0.2199)	0.0020 (0.9870)	GE STO	0.0024 (0.5012)	1.0013 (0.6727)	2.0002 (0.9024)	1.0240 (0.7743)	**0.0410 (0.0155)**	0.0020 (0.8792)
GR STO	0.0410 (0.9440)	**0.0247 (0.0240)**	1.0024 (0.2671)	**0.0024 (0.0346)**	1.0475 (0.5714)	**0.0007 (0.0033)**	**0.0124 (0.0172)**	**0.0006 (0.0180)**	GR STO	0.0041 (0.9956)	**0.0003 (0.0406)**	**0.0055 (0.0370)**	1.0003 (0.9480)	**0.0041 (0.0384)**
IR STO	0.0030 (0.9880)	0.0054 (0.9934)	0.0007 (0.9126)	0.0006 (0.9611)	0.0002 (0.5607)	0.0001 (0.9409)	0.0127 (0.9912)	0.0005 (1.5889)	0.0021 (0.9776)	IR STO	0.0075 (0.3083)	1.0024 (0.1078)	**0.0012 (0.0001)**	1.0024 (0.8892)
SP STO	0.0471 (0.9724)	0.7540 (0.9729)	1.0520 (0.8529)	**0.5700 (0.0041)**	1.4100 (0.7712)	0.0020 (1.1914)	0.0741 (0.9892)	0.0842 (0.8388)	2.0540 (1.9901)	0.0634 (0.8994)	SP STO	0.0074 (0.0877)	**0.0002 (0.0021)**	1.0063 (0.8313)
PO STO	0.0002 (0.9727)	0.0000 (0.9799)	0.0001 (0.8219)	0.0241 (0.9972)	1.0320 (0.7560)	.0041 (0.4862)	**1.0200 (0.0142)**	0.0024 (0.9750)	1.0012 (0.9970)	2.0404 (1.0917)	2.0024 (0.3034)	PO STO	**0.0001 (0.0042)**	2.1021 (0.4150)
IT STO	0.0002 (0.9372)	0.0214 (0.8855)	**0.0451 (0.0388)**	0.0241 (0.9403)	0.4710 (0.9957)	0.1047 (0.4934)	0.0741 (0.9734)	**0.0274 (0.0431)**	2.0052 (0.8911)	**0.0214 (0.0415)**	**1.0012 (0.0333)**	**0.0005 (0.0036)**	IT STO	1.0047 (0.9884)
US STO	0.0001 (0.9917)	0.0012 (0.9972)	0.0274 (0.9108)	0.0000 (0.9945)	1.0020 (0.8857)	**0.0340 (0.0160)**	0.4002 (0.9943)	0.0002 (0.5308)	0.0018 (0.9665)	**1.0240 (0.0240)**	0.0024 (0.6215)	**1.0410 (0.0392)**	**0.0005 (0.0036)**	US STO

2.3 Coskewness Test Table 9 (Checks for contagion from the volatility of the market generator i(1st vertical column) to the returns of the receiver market j(1st horizontal row))

	GE BON	GR BON	IR BON	SP BON	PO BON	IT BON	US BON	GE STO	GR STO	IR STO	SP STO	PO STO	IT STO	US STO
GE BON	GE BON	0.0023 (0.9232)	0.0502 (0.7201)	0.0341 (0.3806)	**0.0052 (0.0049)**	**0.0020 (0.0012)**	0.0067 (0.9851)	0.0041 (0.6011)	0.0027 (0.9594)	**0.0074 (0.0024)**	**0.7426 (0.0001)**	**0.0526 (0.0021)**	**0.0520 (0.0009)**	**0.0030 (0.0032)**
GR BON	0.0074 (0.6386)	GR BON	0.0068 (0.7396)	0.0024 (0.9785)	0.0014 (0.5163)	**0.0020 (0)**	0.0631 (0.9976)	0.0248 (0.2142)	0.0214 (0.9891)	0.0415 (0.4824)	0.0008 (0.0733)	**0.0010 (0.0041)**	0.0005 (0.2524)	0.0420 (0.0983)
IR BON	0.0071 (0.7679)	0.0024 (0.7582)	IR BON	0.0284 (0.9079)	0.0051 (0.4301)	**0.0025 (0.0028)**	0.0030 (0.9994)	0.0024 (0.9877)	0.0001 (0.9823)	0.0041 (0.1896)	0.0035 (0.1704)	**0.0024 (0.0036)**	0.0074 (0.8589)	**0.0027 (0.0025)**
SP BON	0.0074 (0.9981)	0.0041 (0.9356)	0.0024 (0.9803)	SP BON	0.0524 (0.8365)	0.4200 (0.4622)	0.0522 (0.9975)	0.1425 (0.8135)	0.0510 (0.9940)	0.0434 (0.3894)	0.0520 (0.6604)	0.0041 (0.8831)	0.0052 (0.9044)	0.0096 (0.5298)
PO BON	0.0003 (0.0789)	0.0001 (0.3995)	0.0401 (0.2374)	0.4175 (0.7842)	PO BON	0.0352 (0.5379)	0.0002 (0.9988)	0.0002 (0.9381)	0.0005 (0.9990)	1.1024 (0.4152)	0.0801 (0.8249)	0.4010 (0.3186)	0.0425 (0.9933)	0.0022 (0.3340)
IT BON	0.0002 (0.7937)	**0.0005 (0.0294)**	0.0417 (0.7356)	0.4210 (0.7021)	0.0247 (0.5516)	IT BON	0.0015 (0.9974)	0.0002 (0.8086)	0.0009 (0.9963)	0.0035 (0.9431)	0.0417 (0.4556)	0.0248 (0.0798)	0.0627 (0.9489)	**0.0384 (0.0028)**
US BON	0.0041 (0.9748)	0.0024 (0.9940)	0.0010 (0.9831)	0.0274 (0.9858)	0.0571 (0.9951)	0.5278 (0.9885)	US BON	**0.0008 (0.0001)**	1.0012 (0.8425)	**0.0052 (0.0063)**	**0.0475 (0.0024)**	**0.0210 (0.0002)**	**0.0041 (0.0012)**	**0.0371 (0.0024)**
GE STO	0.0021 (0.8591)	0.0012 (0.5127)	0.0008 (0.4428)	0.0021 (0.6240)	0.0467 (0.8951)	0.0058 (0.6703)	0.0057 (0.6823)	GE STO	0.0022 (0.9977)	**0.0000 (0.0097)**	0.0035 (0.5434)	0.0320 (0.6877)	0.0277 (0.9879)	**0.0207 (0.0032)**
GR STO	0.0475 (0.9642)	0.0024 (0.9918)	0.0052 (0.9773)	0.0074 (0.9653)	0.0435 (0.9882)	0.0057 (0.9952)	0.0058 (0.9869)	0.0096 (0.9791)	GR STO	**0.0012 (0.0035)**	**0.2456 (0.0021)**	**0.0271 (0.0025)**	**0.0041 (0.0021)**	**0.0249 (0.0032)**
IR STO	**0.0033 (0.0015)**	0.0001 (0.2686)	**0.0010 (0.0015)**	0.0540 (0.6058)	0.2400 (0.4493)	0.4100 (0.8221)	0.0241 (0.5196)	**1.0004 (0.0431)**	**0.0010 (0.0015)**	IR STO	0.0001 (0.9377)	**1.0003 (0.0041)**	2.0004 (0.8464)	**0.0001 (0.0091)**
SP STO	**0.0049 (0.0041)**	0.0002 (0.1441)	0.0410 (0.5786)	0.0024 (0.5177)	0.0021 (0.9025)	0.0010 (0.8938)	0.0447 (0.8630)	0.0024 (0.7140)	**0.0018 (0)**	0.0001 (0.5287)	SP STO	**0.0001 (0.0035)**	0.41025 (0.7322)	**0.0204 (0.0041)**
PO STO	**0.0183 (0.0035)**	**0.0018 (0.0021)**	0.0002 (0.1541)	0.0012 (0.1057)	0.0241 (0.7266)	**0.0004 (0.0406)**	**0.0235 (0.0314)**	**0.0014 (0.0042)**	**1.0037 (0.0052)**	**2.0017 (0.0041)**	**0.0053 (0.0024)**	PO STO	0.1020 (0.8721)	0.0042 (0.2142)
IT STO	0.0012 (0.5028)	0.0101 (0.2878)	0.0210 (0.6633)	0.0201 (0.3278)	0.0410 (0.6836)	0.0741 (0.9523)	0.0302 (0.1872)	0.4201 (0.2712)	**0.0013 (0.0003)**	0.0401 (0.3032)	0.0021 (0.4499)	0.2012 (0.6308)	IT STO	**0.0002 (0.0001)**
US STO	**0.0160 (0.0001)**	**0.0054 (0.0050)**	**0.0004 (0.0377)**	0.0001 (0.2822)	**0.0008 (0.0059)**	**0.4009 (0.0023)**	**0.0275 (0.0007)**	**0.0015 (0.0001)**	**0.0041 (0.0002)**	1.0001 (0.4585)	**2.0004 (0.0442)**	0.0204 (0.0608)	0.0001 (0.4120)	US STO

2.4. Cokurtosis Test Table 10 (Checks for contagion from the returns of the market generator i(1st vertical column) to the skewness of the receiver market j(1st horizontal row))

	GE BON	GR BON	IR BON	SP BON	PO BON	IT BON	US BON	GE STO	GR STO	IR STO	SP STO	PO STO	IT STO	US STO
GE BON	GE BON	0.0071 (0.9704)	0.0041 (0.9960)	0.0007 (0.9997)	0.3574 (0.9984)	0.0348 (0.9975)	0.0085 (0.8034)	0.0069 (0.9811)	**0.0574 (0.0078)**	0.0034 (0.9940)	0.0021 (0.9928)	**0.0454 (0.0242)**	0.4005 (0.9388)	0.0027 (0.9999)
GR BON	**0.0024 (0.0332)**	GR BON	0.0035 (0.9911)	**0.0005 (0.0050)**	0.0320 (0.9971)	**0.0410 (0.0090)**	**0.0248 (0.0492)**	0.0052 (0.9951)	0.7400 (0.5039)	**0.0450 (0.0354)**	0.0074 (0.9575)	**0.0214 (0.0094)**	0.024 (0.9792)	**0.2775 (0.0072)**
IR BON	0.0120 (0.9827)	0.7034 (0.9756)	IR BON	0.0240 (0.9358)	2.0044 (0.9670)	0.0415 (0.9264)	**0.2020 (0.0074)**	0.0052 (0.4414)	**0.4041 (0.0038)**	0.0247 (0.8416)	0.0674 (0.9141)	0.05147 (0.8477)	0.0140 (0.2316)	0.1024 (0.9900)
SP BON	0.0410 (0.9886)	0.0041 (0.9829)	0.8801 (0.7733)	SP BON	0.2003 (0.9682)	0.4031 (0.9549)	**0.0020 (1)**	1.4100 (0.7578)	**0.0814 (0.0005)**	1.0074 (0.9729)	0.0320 (0.8272)	0.0274 (0.9141)	0.417 (0.6934)	0.6867 (0.9619)
PO BON	0.2051 (0.9599)	0.1031 (0.9465)	0.2009 (0.9602)	0.4074 (0.9993)	PO BON	2.0021 (0.2259)	**0.0054 (0.0025)**	**1.0063 (0.0076)**	**2.0214 (0.0009)**	**0.0548 (0.0281)**	1.0057 (0.4208)	**0.0052 (0.0241)**	**0.0430 (0.0024)**	2.3472 (0.8774)
IT BON	0.1041 (0.9604)	**0.0024 (0.0408)**	0.0234 (0.9087)	0.0051 (0.9804)	1.0030 (0.4583)	IT BON	**0.0024 (0.0085)**	**0.0041 (0.0047)**	**1.0025 (0.0041)**	0.0420 (0.1382)	**0.0031 (0.0052)**	**2.0051 (0.0041)**	**0.0001 (0.0063)**	1.4074 (0.9067)
US BON	0.0024 (0.8394)	0.0012 (0.7787)	**0.9052 (0.0009)**	1.0235 (0.9118)	**2.0010 (0.0038)**	**0.0005 (0.0005)**	US BON	0.0014 (0.9869)	0.1024 (0.6991)	0.0634 (0.9981)	0.1421 (0.9980)	1.0410 (0.9972)	0.0201 (0.9608)	0.7024 (0.9999)
GE STO	0.0120 (0.9135)	0.0985 (0.9197)	**0.8745 (0.0465)**	1.0005 (0.9848)	0.0140 (0.0533)	**0.0012 (0.0004)**	0.0005 (0.9378)	GE STO	**0.0305 (0.0037)**	0.0527 (0.5058)	0.4010 (0.4344)	0.2024 (0.5138)	**0.0420 (0.0025)**	0.0134 (0.9968)
GR STO	**0.0002 (0.0475)**	0.0010 (0.9088)	0.4100 (0.7564)	**0.0240 (0.0291)**	**0.0501 (0.0002)**	**0.4003 (0.0004)**	1.0420 (0.8607)	**0.3002 (0.0007)**	GR STO	0.0242 (0.9986)	0.0024 (0.9965)	1.3042 (0.9946)	**0.0007 (0.0388)**	**0.0024 (0.0499)**
IR STO	0.0005 (0.9737)	0.0748 (0.9549)	**0.8005 (0.0450)**	0.0007 (0.9769)	**0.0058 (0.0323)**	0.0067 (0.1988)	0.0741 (0.9983)	0.0201 (0.3570)	0.0341 (0.9526)	IR STO	**0.0201 (0.0003)**	**1.7020 (0.0176)**	**0.0205 (0.0041)**	0.0005 (0.5056)
SP STO	0.0229 (0.9766)	0.0002 (0.8947)	0.0022 (0.8956)	0.0003 (0.9611)	0.0021 (0.7245)	**0.0201 (0.0013)**	0.0205 (0.9945)	0.0102 (0.2821)	0.0420 (0.9359)	**0.4200 (0.0161)**	SP STO	**0.5420 (0.0024)**	**0.1021 (0.0006)**	0.4057 (0.9705)
PO STO	0.0415 (0.9746)	**0.0625 (0.0418)**	0.0036 (0.9525)	0.00074 (0.9355)	1.8054 (0.9451)	**0.0024 (0.0008)**	0.5708 (0.9920)	0.2409 (0.8706)	**0.2005 (0.0354)**	0.1010 (0.4828)	**0.0574 (0.0075)**	PO STO	**0.1403 (0.0358)**	0.0417 (0.7570)
IT STO	0.5041 (0.9313)	0.7024 (0.9646)	0.8014 (0.8988)	0.0030 (0.9180)	**1.0010 (0.0470)**	0.0015 (0.0651)	0.0024 (0.9431)	**0.2001 (0.0084)**	0.0021 (0.8159)	**0.0305 (0.0036)**	0.0714 (0.1120)	**0.4024 (0.0021)**	IT STO	0.0347 (0.9996)
US STO	**0.0042 (0.0011)**	0.0214 (0.9794)	0.0351 (0.9377)	**0.0085 (0.0355)**	0.0457 (0.5143)	0.0742 (0.8298)	0.0341 (0.9207)	0.2014 (0.7912)	0.744 (0.9950)	0.0284 (0.0516)	0.2034 (0.7659)	0.0096 (0.2995)	**0.4024 (0.0045)**	US STO

2.5 Cokurtosis Test Table 11 (Checks for contagion from the skewness of the market generator i(1st vertical column) to the returns of the receiver market j(1st horizontal row))

	GE BON	GR BON	IR BON	SP BON	PO BON	IT BON	US BON	GE STO	GR STO	IR STO	SP STO	PO STO	IT STO	US STO
GE BON	GE BON	0.0042 (0.5880)	**0.0204 (0.0251)**	**0.0057 (0.0026)**	**0.0257 (0)**	**0.0031 (0)**	0.0074 (0.8913)	**0.0021 (0.0052)**	0.0274 (0.9223)	**0.4100 (0.0041)**	**0.0520 (0.0032)**	**0.0074 (0.0065)**	**0.0427 (0.0035)**	**0.3514 (0.0006)**
GR BON	0.0341 (0.7321)	GR BON	0.0420 (0.7337)	0.0421 (0.6262)	**0.0002 (0.0005)**	**0.0024 (0.0065)**	0.0210 (0.9836)	0.0221 (0.8681)	0.7248 (0.9942)	**1.0003 (0.0036)**	**0.0024 (0.0024)**	**0.0036 (0.0047)**	1.0003 (0.6814)	**0.0415 (0.0077)**
IR BON	0.2400 (0.6042)	0.0410 (0.9017)	IR BON	1.4105 (0.5580)	0.2410 (0.3741)	**0.0005 (0.0078)**	0.0032 (0.9987)	1.4102 (0.7535)	0.0421 (0.9986)	**0.0024 (0.0123)**	0.0041 (0.2176)	**1.0022 (0.0009)**	0.7540 (0.9133)	**0.0062 (0.0004)**
SP BON	0.0234 (0.9278)	0.0724 (0.8865)	1.0134 (0.8699)	SP BON	1.0074 (0.9939)	0.0024 (0.7824)	0.0074 (0.9997)	0.0235 (0.9822)	0.4025 (1)	1.0351 (0.7835)	1.0574 (0.8314)	**0.0378 (0.0310)**	0.0274 (0.9666)	**0.0724 (0.0025)**
PO BON	**0.0014 (0.0002)**	0.4001 (0.4587)	0.0201 (0.4613)	0.0410 (0.7219)	PO BON	0.0201 (0.3384)	0.0019 (0.9987)	0.4204 (0.7909)	0.7017 (0.9990)	0.0101 (0.2861)	0.0401 (0.8601)	0.2142 (0.8342)	0.2474 (0.9273)	**0.0064 (0.0041)**
IT BON	**0.1055 (0.0001)**	0.0025 (0.7394)	**0.0005 (0.0321)**	0.4034 (0.5260)	1.0412 (0.1180)	IT BON	1.0106 (0.9977)	0.7020 (0.6340)	0.4238 (0.9970)	2.1042 (0.2965)	0.4210 (0.2047)	**0.0011 (0)**	0.4043 (0.9464)	0.0017 (0.0894)
US BON	0.0406 (0.8667)	0.0012 (0.9488)	0.0003 (0.9744)	0.2012 (0.9818)	2.0356 (0.9719)	0.1042 (0.9694)	US BON	**0.4100 (0.0003)**	1.0500 (0.8790)	**0.2010 (0.0038)**	**0.0420 (0.0225)**	**0.0348 (0.0013)**	**0.0475 (0.0035)**	**0.0067 (0.0124)**
GE STO	**0.0035 (0.0003)**	**0.0240 (0.0061)**	0.0403 (0.0631)	0.0404 (0.7188)	1.0002 (0.2008)	0.0701 (0.4380)	**0.0037 (0.0001)**	GE STO	0.0043 (0.9878)	**0.0021 (0.0024)**	**0.0301 (0.0063)**	**0.0024 (0.0001)**	0.0007 (0.3577)	**0.0057 (0.0005)**
GR STO	0.0021 (0.7514)	0.0201 (0.9663)	2.0027 (0.9203)	0.1074 (0.9922)	0.0057 (0.9460)	0.0056 (0.9273)	0.0005 (0.7374)	1.0004 (0.8481)	GR STO	**0.0047 (0.0042)**	**0.0068 (0.0024)**	**0.0087 (0.0007)**	**0.0014 (0.0011)**	**0.0035 (0.0074)**
IR STO	**0.0224 (0.0059)**	0.0402 (0.2076)	**0.0014 (0.0001)**	2.4100 (0.7466)	**0.0406 (0.0157)**	1.0001 (0.2283)	**0.0149 (0.0004)**	**0.0028 (0.0049)**	**0.4034 (0.0052)**	IR STO	0.0006 (0.2574)	**0.0240 (0.0360)**	0.0008 (0.8977)	**0.0404 (0.0036)**
SP STO	**0.0075 (0)**	**0.0030 (0.0041)**	0.0201 (0.3107)	0.4001 (0.3402)	2.4100 (0.6935)	**1.0004 (0.0425)**	**0.0011 (0.0007)**	**1.0009 (0.0022)**	**0.0053 (0.0036)**	**1.0007 (0.0065)**	SP STO	**0.0007 (0.0021)**	0.0103 (0.8849)	**0.0200 (0.0025)**
PO STO	**0.1858 (0.0025)**	**0.0269 (0.0063)**	**0.0115 (0.0011)**	**0.0108 (0.0040)**	**0.0047 (0.0365)**	**0.0194 (0.0425)**	**0.0831 (0.0052)**	**0.0248 (0.0002)**	**0.4647 (0.0003)**	**0.1051 (0.0004)**	**0.0346 (0.0092)**	PO STO	0.0427 (0.7621)	**0.4001 (0.0083)**
IT STO	**0.0046 (0)**	0.0410 (0.8096)	0.0301 (0.3056)	0.0472 (0.8725)	0.4002 (0.1942)	0.4101 (0.5439)	**0.0042 (0.0021)**	**0.0015 (0.0001)**	**0.0130 (0)**	1.0501 (0.2218)	0.0002 (0.2069)	0.0022 (0.2055)	IT STO	**0.0021 (0.0024)**
US STO	**0.0004 (0.0349)**	**0.0056 (0)**	**0.0006 (0.0188)**	**0.0019 (0.0007)**	0.0002 (0.1175)	0.0021 (0.3544)	**0.0021 (0.0021)**	0.0440 (0.7551)	**0.0021 (0.0032)**	**0.0041 (0.0241)**	0.0881 (0.4451)	0.0881 (0.2818)	0.0188 (0.9194)	US STO