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‘’Volatility spillover between stock and bond markets’’

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Abstract

We study the phenomenon of volatility spillover between equity and bond markets. We use two methodologies Hong's volatility spillover test and Yin-Wong Cheung and Lilian K. Ng's causality in variance test. We use eleven bond markets and eleven stock markets, which form eleven countries. Our analysis has two stages; at first we check for causality with both methodologies among the above mentioned markets. Second we check for causality exclusively in the bond markets. At first we found almost no causality among markets in both methodologies. As for the second analysis we found strong causality relations among bond markets. Also we check if an investor can have a diversified portfolio by shifting funds from a bond market to a stock market and vice versa.

Key words: volatility spillover, bond market, stock market, equity, causality test, portfolio diversification.

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Introduction

The purpose of the essay is to examine the existence of volatility spillover between equity and bond markets and value as well the results that come from this effect. The evaluation of the results is necessary to point out the use of the particular essay, because of the growing integration between financial markets the need of better understanding about the co-movements of assets is crucial. Investors who invest in different markets are exposed to more than one kind of market volatility risk, so examining the correlation of market volatility is important to investment and risk management. Investment management firms have long used models that account for common factors in return to develop systematic approaches for allocating fund across asset classes. For example, portfolio managers often shift funds from stock to bonds when they expect stock market volatility to increase, but the risk reduction achieved by this shift depends on the degree of the volatility linkage that occurs between stock and bond markets. If volatility in the stock and bond markets is highly correlated, bonds may not provide the safe haven that managers are seeking. It is also important for derivative dealers, because when the dealer's operation is exposed in more than one market then the net volatility exposure depends on the cross-market correlation of volatility changes. So the need of the information about the co-movements of asset is crucial for dealer because he must incorporate it in his risk measurement systems and set aggregate position limits across trading desks. Furthermore, accounting for volatility correlation is important for valuing derivative securities whose payoffs depend on multiple asset prices. The use of knowing the relation between markets volatilities is essential for setting regulatory policy, market regulators should consider volatility correlation across markets when evaluating the effects of proposed police changes. In general, monetary authorities across the globe have always relied on the knowledge of correlation between financial markets in setting their policies. The increasing popularity of risk management techniques, such as value at risk and portfolio optimization strategies, like tactical asset allocation, that attempt to exploit predictable variation in volatility and returns have also make the understanding of correlation between the assets urgent.

It can't be unseen the fact that examining the volatility spillover between assets isn't easy. The nature of stock-bond market co-movements has perplexed researchers in financial economics for years and there have been many attempts to understand their fundamental relationship. Among other factors, an important factor is the substantial variation the stock-bond return displays as we see it in the paper of Lieven Baele, Green Bekaert ,Koen Inghelbrecht (2007). The three authors mention the substantial time variation as a puzzling empirical phenomenon and give a strong example from their study, over their sample period they identified one 5-year episode in which the stock-bond return correlation was high as 75 percent, and one in which dropped to lower than minus 60 percent. For better explanation about the spillover effect we will describe and analyze sources and types of equity-bond market spillover based upon the paper of Warren G. Dean, Robert W. Faff and Geoffrey F. Loudon (2010). Dean, Faff and Loudon use the following labels to identify the existence of spillover effect in return and volatility within the stock and bond markets-1)asset substitution, 2)financial contagion, 3)hedging demand shifts ,4)news specificity, 5)news decomposition and 6)asymmetric price adjustment. The following analysis for the above labels is from the same paper (Dean, Faff and Loudon 2010).

Asset substitution views equities and bonds as competing assets. Information disclosures affect the perceived attractiveness of these asset classes to investors. News that favors bonds over stocks motivates investors to buy bonds and sell stocks whereas news favoring stocks means investors switch into equities. The asset substitution hypothesis therefore predicts that positive return shocks in one market will spillover as negative return shocks in the other. For example, bond market returns should fall subsequent to good news being released in the equity market. Moreover, the effect is symmetric.

Financial contagion refers to the propagation of return shocks across markets in the absence of any information releases, or as an overreaction to news disclosures or noise. The financial contagion hypothesis therefore predicts that bad news in either market is transmitted to the other market, regardless of economic fundamentals. Hence spillovers can occur in either direction but will be asymmetric in the sign of the return stock. To this conclusion the authors were driven by three papers, first from King and Wadhwai (1990) that show that financial contagion occurs in a partially revealing equilibrium in which prices in one market respond not only to fundamental information but also to price changes per se in other markets. The second was from Ito and Lin (1994) who describe contagion as the situation in which prices in one market are affected by price changes in some other market beyond that which is justifiable by economic fundamentals. The third was from Bae et al. (2003) who emphasize that contagion is most likely to occur when news is extremely bad.

Hedging demand shifts occur when price changes in one market cause hedgers to change their positions in the other market simply to maintain their target hedge ratio. Higher Stock prices cause hedgers to sell bonds into stock and vice versa. For instance, a rise in equity prices induces an active hedger to shift funds from bond to equities. In this setting, demand for bonds falls even in the absence of information flow or financial contagion .The hedging demand hypothesis, like the asset substitution hypothesis, predicts that good news in the stock market will depress bond prices and vice versa.

News specificity refers to the idea that the news conveyed by price changes in stock and bonds differ on terms of the degree to which they provide information of a specific nature about the respective asset classes. Price changes in government bonds convey news about general economic conditions and broad shifts in corporate profitability. Stock price changes more directly reflect revisions to corporate valuations arising from both aggregate and individual fundamental factors. If information originating in the stock market is dominated by equity specific news, then equity shocks are more likely to have a substitution effect as they signal changes in the relative attractiveness of equity investment compared to bonds. However, if news sourced in the bond market is primarily informative about broad economic conditions, then this should affect stocks and bonds in the same direction. The news specificity hypothesis predicts that equity return shocks spillover into bond returns with the opposite sign whereas bond return shocks spillover into equity returns with the same sign.

News decomposition is the partitioning of news into two distinct, 1)news about future cash flows and 2) news about discount rates. The significance of this distinguish is supported both from the authors who mentioned above and from the authors of another paper, Campbell and Vuolteenaho. In their model, stock prices unexpectedly rise with positive news about future cash flows and fall when the discount rate rises. However, an immediate discount rise also suggests that the future returns will be higher. Therefore, unexpected return shocks due to revisions in discount in discount rate expectations are partly reversed by future return. In contrast , return shocks caused by future cash flows news are permanent. As a consequence, investors react more strongly to news about future cash flows news than they do to news about discount rates. If bond market return shocks primarily convey information about future cash flows, then the news decomposition hypothesis predicts that cash flow news in bond returns will spillover into equity returns with the same sign. However, if bond market news is predominantly related to discount rates, then the news decomposition hypothesis predicts that bond returns will spillover into equity returns in the opposite direction but with less strength than in the case of cash flows news.

Finally, asymmetric price adjustment occurs where news is impounded into market prices at different rates depending on the sign of the return shock. This can be due to asymmetric costs. Koutmos (1999) estimates an asymmetric partial adjustment price model which shows that prices impound bad news faster than good news. The asymmetric price adjustment hypothesis therefore suggests that bad news spills oer between bond and equity markets more quickly than good news.

From the above analysis, which based on the paper of Warren Dean, Robert Faff and Geoffrey Loundon (2010), is shown how difficult is to examine and predict the spillover effect between equity and bond markets due to the many and changeable factors that are related with it.

As a result the literature for volatility spillover is limited, we will focus in six articles related to the above subject. In the paper of Dean, Faff and Loudon (2010) is document the asymmetry in return and the volatility spillover between equity and bond markets in Australia. The model that they are using is a bivariate GARCH model with spillover and asymmetric effects. Specific it identifies asymmetries in the nature of return and volatility spillovers between the equity market and the government bond market in Australia, the data that their using are continuously compounded daily returns which they computed from the ASX All ordinaries Total return Index and the All Lives Government Total return sourced from datastream. The authors find in their study that the stock bond spillover dynamics are strongly asymmetric. In respect of return volatility, bad news sourced from the bond market spills over into lower equity returns while good news from equity market leads to lower bond returns. Spillovers flow from the bond market into the equity market volatility at various rates dependent upon the respective signs of the return shocks in both markets. Conversely, bond market volatility does not appear to be affected by conditions in the equity market. The question that arises from this paper is whether the results can apply for the rest of the countries. The authors replay to this question as follow ‘’the first point to make is that it is inadvisable to apply our results to emerging markets, even in those few cases where some type of debt market exist. However, it is by no means safe to assume broad applicability to all developed markets. One way of gaining an indicative feel for likely answers to this question is to identify those aspects of the Australian setting that would be common and/or natural points of linkage to other markets. Most notably, similarity to Canada (in size/industrial composition) the US (general market development) and New Zealand (traditional close economy/cultural ties and geographic proximity) would suggest that our findings would be largely transportable to these countries. On the other hand, the contrasting settings of countries like Japan would suggest that due caution are applied with regard to spillover asymmetry characteristics that we document. Of course, these comments are purely speculative.’’

The second paper that we examine comes from Vincent Bodart and Paul Reding (1999). The paper examines the behavior of domestic daily returns on bond and stock markets trying to identify whether there exist differences in the patterns of volatilities and international correlations between ERM and non-ERM countries and across alternative episodes of ERM exchange rate variability. Their analysis is focused on the experience of the Exchange Rate Mechanism of the European Monetary System over the period from January 2 1989 to December 19 1994, the methodology that was used was to isolate the effect of the exchange rate regime on the volatilities and on international correlations of bond and stock returns by comparing the systematic patterns of those volatilities and correlations across different European countries and EMS episodes. The authors from their empirical investigation indicate that the exchange rate is a factor that affects the volatility of assets. More specific, the results of their empirical investigation point in the same direction and indicate that the reduced exchange rate volatility enjoyed during the credible EMS period has been associated with lower volatility in bond and stock returns. In other words when you set the right exchange rate you dampen the volatility asset prices, especially when domestic and foreign money demand shocks dominate, because in the opposite case when foreign real shocks prevail the net come is ambiguous. In addition, as we quote from the paper, the degree of credibility of the peg matters: an imperfectly credible exchange rate may result in higher volatility of domestic interest rates and asset prices than what would be the case in a permanently fixed credible regime. The authors in the conclusion conclude some important insights of their analysis. First their analysis detects a considerable linkage between the patterns of volatilities on the bond market and the foreign exchange market, but it was unable to detect any similar linkage on the stock market. These results, as the authors say, confirms the presumption that the uncertainty surrounding the conduct of domestic monetary policy is a crucial determinant of the volatility of bond prices, whereas the volatility of stock prices is more related to the overall underlying macroeconomic uncertainty. Second their analysis shows that the degree of exchange rate variability exerts an influence on international bond and stock correlation. In general, one can conclude from the particular paper that changes in the pattern of volatilities and international correlations on bond and stock markets can be, at least partially, attributed to an exchange regime effect.

In the paper of James M. Steely (2005) a two-factor no arbitrage model is used to provide a theoretical link between stock and bond market volatility, the results of the paper aren't based only to the above model but also to the empirical evidence that examined in it. The data that used the author were the daily closing observations on the FTSE-100 share price index, to represent stock returns and the index of prices of long term Government Stocks (FTLG), to represent the return on long term bonds. Also is used the index of prices short term government stock (FTSG) to represent short term risk free yields. It is important to notice that through the literature, that stands for this field of finance, few authors have distinguish the bonds between short term risk free yields and long term bonds. The period is twenty years, from June 1984 to June 2004. The author with his analysis found that the correlation between short-term yield shocks and long term bond yield shocks was relatively stable during the sample period, while the correlation between each of these markets and the equity market reversed sign. An example is given by the author for better understanding of the results, over the period October 1 to November 30,1987, prices in the equity market fell at an annualized rate of nearly 600%, while prices in the gilt-edged market rose at an annualized rate of nearly 40%. With this observation is suggested a clear link between the behavior of the two markets at that time. A finally observation is that, according to the author, despite the fact that this paper has considered only one country, it could easily be applied to other countries, and across countries, where modeling time varying correlation structures is also likely to be a key factor.

We also study the paper from the authors, Jeff Fleming, Chris Kirby and Barbara Ostdiek (1998). The particular paper investigates the nature of volatility linkages in the stock, bond and money markets, estimating a stochastic volatility representation of the trading model, purposed by authors, using GMM. For data they use daily returns on the S&P 500 stock index futures, T-bond futures and T-bill futures for the period January 1983-August 1995. More specific their analysis of the volatility linkages across markets is based on the relation between volatility and information flow. The authors start their analysis by developing a model of speculative trading that formalizes this relation and generates predictions about how information creates cross market linkages. Based on their model we observe that linkages arise from two distinct sources. The first is information that simultaneously affects expectations in more than one market because each of these is influenced by macroeconomic news. The second source is information spillover caused by cross market hedging and that's where the authors based their analysis. The intuition behind hedging as a source of market linkage is straightforward. For example, consider a trader who operates in both the stock and bond markets, an information event that alters his expectations about stock returns directly affects his demand for stocks. This event may not consider only his demand for stocks but also for bonds even if it does not alter his expectations about interest rates, the reason behind this is that the trader considers the correlation between stock and bond returns when he rebalances his portfolio. Overall the information event changes trader's demand for both stocks and bonds, with result that an information spillover occurs, generating trading and volatility in both markets. The results of their analysis are given below, the correlation estimates are 69% for the stock and bond markets, 67% for the stock and money markets and 64% for the bond and money markets, these results indicate that there indeed strong linkages between these markets. However, according to the authors, we can accept the hypothesis that the correlations are perfect, because the result indicates that the markets do not share the same information flow. In conclusion the information spillover caused by cross-market hedging is incomplete.

In addition to the above paper we introduce the paper from Kent Wang, this study proposes a simple way for examining volatility linkages between S&P 500, Eurodollar futures and 30-years Treasury bond futures markets using implied volatility. The data, that paper used, are four year correlation between daily implied volatilities in the three markets. An important observation for the analysis is that this paper considered and controlled measurement biases and spurious correlation effect. It is found that there is relatively high and robust correlation between equity and money market, but the linkages between the other market pairs are weak and spurious.

Finally we have the paper of Andrew Duncan and Alain Kabundi (2012), this paper investigates domestic and foreign sources of volatility transmission for South Africa asset classes. The important thing about this paper is that introduce foreign sources of volatility spillover to domestic assets, with the hypothesis however that spillovers are not permitted to flow the opposite direction. This hypothesis is based on the assumption that whilst small open economies, such south Africa, may be highly sensitive to international events, financial shocks originating in these economies are idiosyncratic to the global financial system. The methodology and the results of the paper are given below. Based on generalized variance decompositions of a vector autoregressive model, this approach combines bidirectional spillovers exchanged by domestic assets with volatility injections imported from shocks to the global finance system. The analysis relates a sample of daily observations ranging from October 1996 to June 2010. The estimated spillover levels are time varying and increase during domestic and foreign crisis. More specific average domestic spillovers of 38% exceed average foreign spillovers of 4,7% and maximum domestic spillovers estimated for the US for a similar sample period. These findings, according to authors, suggest a high degree of systemic risk in South Africa and, furthermore, that this risk is predominantly related to country-specific factors. Commodity and equity shocks are identified as the primary sources of spillovers to the other asset classes.

However for better understanding about the spillover effect between assets we expand our study field and move on to spillover between stocks and bonds returns. In the paper of Lieven Baele, Geert Bekaert and Koen Inghelbrech (2007) are being examined the economic sources of stock-bond return comovement and its time variation using a dynamic factor model. The authors identify the economic factors employing structural and non structural vector autoregressive models for economic variables such as interest rates, expected inflation, output growth and dividend payouts. They also view risk aversion, and uncertainty about inflation and output as additional potential factors. To estimate various candidate models they obtained daily and quarterly US data over the period 1968Q4-2004Q4 form CRSP. The motivation behind this study is that in standard rational pricing models, the fundamental factors driving stock and bond returns either affect cash flows or discount rates which are important factors of stock and bond consistent. In their analysis, the authors, find that the fundamental factor models fail to fit the extreme range of conditional stock-bond returns correlations, so they try to explore some alternative non fundamental determinants of stock and bond return correlations. At first, according to the authors, we have the flight to safety phenomenon, where investors switch from risky asset, stocks, to a safe heaven, bonds, in times of increased stock market uncertainty. This implies a negative correlation between stock and bond returns. Second they stressed the importance of liquidity effects in stock and bond pricing, there is no reason for these liquidity shocks to be perfectly correlated across two markets and hence the liquidity risk may be an important omitted variable. Liquidity effects have also a negative impact on the correlation between equity and bond returns. The authors conclude that they fail to find a satisfactory fit with stock-bond return correlations, in other words using fundamentals only is unable to match both the timing and the magnitude of the correlation movements.

In addition to the above paper, the paper from Tarun Chordia, Asani Sarkar and Avanidhar Subrahmanyam (2003) argue about the importance of liquidity in the relation between stock and bond returns. Liquidity can be defined as the ability to buy or sell large quantities of an asset quickly and at low cost, despite the fact that the majority of the pricing models don't include trading, and thus ignore the time and the cost of transforming cash into financial assets, recent financial crisis indicate that when the market conditions are severe liquidity can decline of even disappear. Such liquidity shocks are a possible channel through which asset prices are influenced by liquidity. Other reasons that liquidity plays an important role in the correlation between stock and bond markets follow; first we know, from previous studies, that there are strong volatility linkages between the two markets which can affect liquidity in both markets by altering the inventory risk borne by market making agents.

Second, stock and bond market liquidity may correlated via trading activity, in practice with asset allocation strategies is observed shift wealth between stock and bond markets. For example, a negative information shock in stocks causes outflows from stocks into Treasury bonds and thus causes price pressures and also has impact in stock and bond liquidity. In the other hand stock and bond order flows may be complementary sometimes. For example, if the Federal Reserve pursues an expansionary monetary police, the increase in funds could cause higher order flows into both stocks and bond and possible changes in their liquidity. Overall the above reasons imply that liquidity can exhibit co movement across asset classes and also can be driven by common factors such as monetary shocks. The cross dynamics in liquidity are examined by estimating a vector autoregressive model for liquidity, returns, volatility and order flow in the stock and bond markets. Before analyze the conclusion of the above paper we will discuss the impact of the monetary policy in the financial market liquidity. When the authors place the monetary variables first in ordering in their model they found that monetary easing forecasts increased stock and bond market liquidity during crisis period, also while volatility in both stock and bond markets responds positively to positive federal funds surprise the effect on stock market volatility is larger. Overall monetary police appears to have a timid relation with financial market liquidity and only during crisis period. It is also important to mention the economic significance of the monetary policy, the authors find that a one standard deviation shock to net borrowed reserves during crisis period has an annualized impact of about 70000$ on trading costs for a daily trade of two million shares in the basket of NYSE-listed common stocks, while the impact of a one standard deviation negative Federal Funds rate surprise is about 20000$. On the other hand the economic significance of bond fund flows on liquidity is small, a one standard deviation shock to bond flows has an annualized effect only 7500$ on the cost of trading two millions dollars worth of Treasury Bonds per day. The conclusion of the paper follow: first, weekly regularities in stock and bond market liquidities closely mimic each other, second daily innovations in volatility and liquidity explain a large fraction of the error variance in forecasting liquidity, mentioning that past volatility and liquidity are the most important variables in forecasting future liquidity. Third liquidity and volatility shocks are positively and significantly correlated across stock and bond market at daily horizons and also at longer horizons. Fourth an unexpected loosening of monetary policy, which measured as a decrease in net borrowed reserves, is associated with an increase in stock liquidity and has a modest ability to forecast liquidity during crises and finaly innovations to bond fund flows are informative in forecasting both stock and bond market liquidity.

Another paper that investigates the spillover effect between stock and bond returns based on economic fundamentals is from Stefano d'Addona and Axel H. Kind (2006). They use an affine asset pricing model to jointly value stocks and bonds, this model is implemented for G7 post war economies and its in sample and out sample performance is assessed by comparing the correlations generated by the model with convectional statistical measures. They conclude that their model implies that the volatility of the real interest rate increases the correlation between stocks and bonds. This result, however, is intuitive given that the real interest rate discounts both future dividends and cash flows deriving from fixed income securities. Inflation shocks, however, tend to reduce correlation between stocks and bonds, which reflects the fact that in the model of the authors stocks provide complete insurance with respect to future inflation . As we compare the two above papers with see that in the same subject they introduce different results, another indication of how puzzling is to understand the spillover effect between the assets.

As we continue examining the literature, we will focus now to the correlation between stock and bond returns in international level. At first we have the paper of Rene Garcia and Georges Tsafack (2011). They use a regime switching copula model to investigate the dependence structure between international equity and bond market. The model allows for a switching between a normal state where markets will be linearly and symmetrically correlated and an asymmetric dependence state to capture common crashes. In a normal regime it is difficult to make a difference between the level of dependence for joint positive moves and joint negative moves. When the economy is in the asymmetric regime, even with a stable correlation, a downside move in one market will increase the probability of a similar event in another market. The data and the results of the paper are analyzed below. The authors separately analyze dependence between two leading markets in North America (US and Canada) and two major markets of the Euro zone (France and Germany). Their empirical analysis shows that dependence between international assets of the same type is strong in both the symmetric and the asymmetric regimes, while dependence between equities and bonds is low even in the same country. Another important result is that exchange rate volatility seems to contribute to asymmetric dependence.

In the paper of Lorenzo Cappiello, Robert F. Engle and Kevin Sheppard it is crucial to mark the role of euro on the correlation between the assets. Generally this paper investigates the presence of asymmetric conditional second moments in international equity and bond returns, the analysis is carried out through an asymmetric version of the Dynamic Conditional Correlation model of Engle (2002). The authors use the Financial Time All World indices for international equity markets and datastream which constructed bond indices as a measure of bond performance. With the introduction of euro the correlations between assets have change, both cross country and cross market. EMU bond returns are relatively high correlated with EMU equity returns while correlation between EMU bond returns and American and Australian equity returns is typically near zero and often negative. These results applied, analogous, for the Australia and America. In addition to the above results the paper notes that conditional correlation between equity and bond returns typically declines when stock markets suffer from financial turmoil, an indication of a flight to quality phenomenon.

In addition to the above paper, the paper of Suk Joong Kim, Fariborz Moshirian and Eliza Wu (2005) examine the influence of the European Monetary Union in evolution of international stock and bond market integration. The authors use a two step procedure: First they document the downward trends in time varying conditional correlations between stock and bond market returns in European countries, Japan and US. Second they investigate the causality and determinants of this interdependent relationship. Their main hypothesis is that economic policies directed at achieving convergence in exchange rates, monetary stance and the real economy have been relevant and critical common influences on the extent of systemic stock and bond market integration in Europe and the rest of the world. Their empirical analysis is conducted for a sample set of countries that fall into two distinct groups: 1) Euro zone members (France, Germany, Italy and Spain) and 2) non Euro zone countries (UK, Japan, US) and the model is a bivariate EGARCH model. The paper concludes 4 results: 1) intra-stock and bond market integration with in EMU has strengthened in the sample period as inter stock-bond market integration has trended downwards to zero and even negative mean levels in most European countries, Japan and the US, consistent with a flight to quality phenomena in international financial markets 2) cross market volatilities have overall stabilizing effects but bond market return shock have more influence 3) the EMU has caused the inter stock-bond market segmentation dynamics only in European countries and 4) real economic integration with the EMU and reduction in currency risk with the introduction of the Euro have generally stimulated inter financial market integration but increasing monetary policy convergence with the EMU may have created uncertain investor sentiments in the international financial system. To this end, the EMU has increased benefits of diversification across stocks and government bonds at the country level.

The paper of John Y. Campbell and John Ammer makes a strong difference in comparison with the above papers. The authors argue that postwar excess stock and bond returns have been almost uncorrelated. The paper uses a log linear asset pricing framework and a vector autoregressive model, using data from NYSE and AMEX. The authors argue that mainstream research treated the variances and covariance of assets returns are being exogenous, which, according to the authors, is mistake. The arguments, of the authors, are based on previous studies that find 1) a less than 40% of the variance of price changes is typically explained by exogenous factors, in particular by contemporaneous news events (Roll, 1988) and 2) that almost two thirds of the variance of aggregate stock price movements can be accounted for by innovations in variable proxying for corporate cash flows and investors' discount rates, which are fundamental determinants of assets (Eugene Fama (1990). In their analysis found that in case of stocks, the components are changing expectations of future real dividends, future real interest rates and future excess returns on stocks. In case of long term nominal bonds, on the other hand, the components are changing expectations of future inflation rates, future real interest rates and future excess returns on long bonds. These results make the authors to explain why bond and stock returns are practically uncorrelated. They give 3 reasons: 1)the only component which is common is the news about real interest rates, but this component has relatively little variability, 2)There is a positive correlation between news about future excess returns on bonds and stocks but the correlation never exceeds 0,4 (3) there is a weak positive correlation between stock return and news about long term future inflation that make bond and stock returns covary negatively, offsetting the positive covariance coming from the real interest rate and expected excess return effects.

As we continue to examining the literature on the spillover effect between stock and bond returns, we focus to the paper of Shane Underwood (2008) who tests the hypothesis that trading activity in the stock and bond markets contains important market wide pricing information. The data that he is using are from GovPX Treasury and NYSE TAQ. The paper conclude as follows, aggregate Treasury order imbalances are strongly related to intraday equity returns, with the effect being most pronounced when equity market uncertainty is relatively low or high. These results also show that during high VIX periods are associated with a stronger relation between buying and selling pressure in Treasuries and returns on equities. Equity order flow, while statistically significant in some cases, plays a smaller role in explaining returns on Treasuries. These results indicating that aggregate order flow contains information that is distinct from that reflected in return series. All the above suggest that aggregate trading activity in the stock and bond markets does contain that type of private information about macroeconomic factors.

In the paper of John T. Scruggs and Paskalis Glabadanidis (1999), are being investigated two topics, the first is the nature of the dynamic covariance matrix of stock and bond returns and second the intertemporal relation between risk and return. The authors estimates a conditional two factor version of the ICAMP in which stock and bond risk premia are linear functions of an asymmetric dynamic covariance matrix of stock and bond returns, using data from NYSE AMEX and Ibbotson Associates. The authors find that stock market variance is affected asymmetrically by both stock and bond return shocks. The asymmetric response of conditional stock market variance to past bond return shocks is even more dramatic than the asymmetric response to stock return shocks. As for the bond market variance the authors find that responds symmetrically to bond return shocks, but is relatively unresponsive to stock return shocks.

The paper of Dirk G. Baur (2009) introduces, on our study, two meanings cross country and cross asset. The main objective of this paper is to re examine the trend of the stock bond correlations (cross asset) towards zero and to investigate the reason for the decline in stock bond comovements despite the increased interdependence among assets (cross country) caused by globalization and the integration of securities markets in general. First the author present a theoretical framework with a simple model that links cross country and cross asset co movements and shows that lower levels of stock bond co-movements can be explained with higher cross country stock-stock or bond-bond co-movement levels. This finding is important because is consistent with economic intuition suggesting that cross country contagion and flight to quality occur at the same time. Second he examine the dynamics of stock bond correlations for a relatively long sample period of 20 years for eight developed markets and show that there is a negative trend in stock bond correlations. Thirdly he shows empirically that the negative trend coincides with a positive trend in cross country stock-stock and bond-bond co-movements and argues that this link is due to increased portfolio rebalancing of investors in order to compensate for lower benefits of diversification across same assets. Finally he concludes that periods of extreme negative shocks better explain the variation in stock bond linkages than period of high volatility.

We now focus in a paper that examines the spillover effect between assets from a specific aspect, that is how behaves the above effect in crisis periods. The paper is from H. Hartmann, S. Straetmans and C.G. Vries (2001). The authors use, for describing the linkage between the assets, an extremal dependence measure and stand for it because can account for non linear relationships in contrast to correlation analysis. The data come from datastream and referred to G-5 countries. The paper concludes that linkage between assets markets in periods of crisis are characterized by their asymptotic tail dependence. This measure allows the authors to derive non parametric estimates for the expected number of market crashes given that at least one market crashes. More specific they found that stock market receive a co crash in about one of out of five crashes. On the other hand the number that is given for bond is lower and stills less for a co crash between stock and bond market. An important result that is driven by the authors is that national borders, due to free capital flows and financial integration, do not seem to matter very much. As a comment to this result the authors suggest that domestic financial stability cannot stop at national borders.

At this point we'll analyze a particular section of literature on spillover between assets' returns, and that is the correlation between stock market uncertainty and stock-bond co-movements. At first we have the paper of Robert Connolly, Chris Stivers and Licheng Sun. The paper examine stock index returns and long-term government bond returns for the U.S. and European countries (German and U.K,) over 1992 to 2002, using a two state regime switching analysis which describes a commonality in the co-movement variations over time, both across countries and across assets. As for the measure of stock market uncertainty, is used the implied volatility (IV) from equity index options. The paper is structured as follows; first the authors show how cross country stock return comovements vary with IV, second they contribute by extending the stock bond comevement work. More particular they analyze countries over a more recent period and also evaluate stock bond comovemets for stock portfolios of different systematic risk. They found that cross country return comovements tend to be stronger following high IV days and on days with large changes in IV. About the stock bond return comovements, they conclude that they tend to be substantially positive following low IV days and on days with small changes in IV.

Second, at the paper of Robert Connolly, Chris Stivers and Lincheng Sun (2003) is examined if time variation in the co movements of daily stock and Treasury bond returns can be related to non return based measures of stock market uncertainty. Their sample period is from 1986 to 2000 and the measures of stock uncertainty that use are the implied volatility from equity index options, specifically the Chicago Board Option Exchange's Volatility Index and the abnormal stock turnover. Their results are; first they find a negative relation between their uncertainty measures, which described above, and the future correlation between stock and bond returns, second the bond returns tend to be high, relative to stocks, during periods when VIX increases and during periods when unexpected stock turnover is high. Overall their findings suggest that stock market uncertainty has cross market pricing influences in joint stock bond price formation. Also in their analysis conclude that in times of high stock uncertainty are also times with more revisions in investors' assessments of both stock risk and the relative attractiveness of stocks versus bonds, in a way that the negative correlation in stable inflationary times can be described by the above argument. It is important to mention two observations that arise from this paper, first that the time variation in the stock bond return relation is international phenomenon. Second the authors wonder whether longer horizon returns exhibit patterns that are qualitatively similar to their daily return findings. They find that the magnitude and reliability of the time variations would be less for longer horizons because 1) fewer observations are available for measuring time varying correlations and 2) the specification of expected returns becomes important for longer horizon returns, which would complicate the empirical testing and is out of the analysis of the particular paper.

The final paper, in our study, that investigates the relation between stock market uncertainty and the stock bond co movements comes from Chris Stivers and Licheng Sun (2002). The method of analyzing the above relation are based on 1) a simple correlation analysis, 2) A GARCH that allow the relation between stock and bonds to vary directly and continuously with the lagged VIX and 3) a regime-shifting model that allows the relation between stocks and bonds to vary across regimes. The sample period is from 1988 to 2000. The authors find a relative positive relation between daily bond returns and the contemporaneous change in VIX, which contracted to the very large negative relation between stock returns and contemporaneous changes in VIX. More specific they found that stock and bond returns tend to move substantially together during periods of lower stock market uncertainty, in contrast during periods of high stock market uncertainty stock and bond returns tend to exhibit little relation or even negative relation.

The rest of the papers, contribute to our study by analyzing the spillover effect between assets' return each one based on a different factor. The paper from Nektarios Aslanidis and Charlotte Christiansen (2012), in contrast to the above literature, examines other parts of the stock bond distribution beside mean and variance. Specifically analyzes the tails of the distribution. The tails of the distribution, according to the authors, are important when considering optimal portfolio allocation. For example, the diversification benefits of combined stock bond holdings are particular high during times of extreme negative correlations. The paper adopts quantile regressions to scrutinize the realized stock bond correlation based upon high frequency returns, also provides in sample and out sample analysis and considers a large number of macro-finance predictors well know from the return predictability literature. In sample results show that macro finance variables are significant at the lower quantiles of the realized correlation, even better results are obtained by using a factor model. The in-sample predictability is strongest at the lower median quantiles and in the out of sample analysis the factor model delivers more accurate forecasts than individual macro-finance predictors, particularly at the upper and median quantiles.

The paper of Marcelo Bianconi, Joe A. Yoshino and Mariana O. Machado de Sousa (2013) investigate the effect of an external factor to the correlation between stock and bond returns. In this particular paper is examined how the U.S. financial crisis affect the assets of the BRIC countries. The authors, in their analysis, use daily data from January 2003 to July 2010, at first they examine unconditional volatility measure of BRIC and U.S. markets using the heat map tool developed by the IMF to understand how volatility spreads across the BRIC nations over time. Second they use Johansen's cointegration framework to examine long term relationships among the BRIC countries and the U.S. financial stress measure. Finally they use multivariate GARCH methods and dynamic conditional correlations of Engle (2002) to examine conditional dynamic volatility and correlations of the BRIC market returns, distinguishing between own autocorrelations and news effect. The results of the paper follow below, the authors mention negligible effect of the U.S. financial crisis on the Chinese stock market, in contrast the particular effect on the returns in Brazil and Russia is negative and relatively larger than the effect in the India stock market. Moreover the EMBI-India returns are insulated from the U.S. financial crisis and exhibit no conditional volatility news effect, also the effects on the EMBI returns for Brazil, Russia and China are positive and the correlations are also positive and increase after the September 2008 events. As for the correlations between assets inside the BRIC countries, are negative for Brazil and Russia and India shows no significant correlations between bond and stock markets. Also for China the conditional correlation is negative. Across the BRIC countries, the stock and bond market correlations for Brazil and China are negative but much less significant with India and China and among China and India. The joint dynamics of the stocks and bonds show short term negative correlations with the stock responding negatively and bonds positively to the U.S. financial crisis. For the long term the previous dynamics display one long run relationship between the U.S. financial crisis and the BRIC bond returns only ,and another for the stock and bonds of the BRIC countries only, independent of the U.S. financial crisis. From the above results the authors try to investigate whether the BRIC countries can provide diversification opportunities. Their observations indicate that BRIC bond markets respond positive in the very short term to the U.S.

financial crisis but the bond market in India seems more detached from the other BRIC bond markets. Also the stock market of China responded much less to the U.S. financial crisis relative to the other countries in this period.

The paper of Robert J. Shiller and Andrea E. Beltratti examine the spillover effect from a different angle that is used to be, they analyze the co-movements of stock prices and bond yields and not stock and bond returns. At first they controvert the argument that the relationship between these two assets must be negative, as they say the argument is true only if certain implicit assumptions about stochastic properties of relevant variables are valid. The latter isn't valid because the dividend stream that is discounted for stocks is different than the stream of coupons that is discounted for bonds, so the implied differences in the stochastic properties of the two assets can be a problem for the relation between them. For instance if there is a substantial inflation then these two streams can be dramatically different, in a way that only changes in nominal long term bond yields reflect inflationary expectations so these changes should have a little effect on stock prices. Moreover movements in long term interest rates might be related to information about the future dividend stream on stocks, sometimes when there is a stock market crisis there isn't always follows a rise in the long term interest rates because in some cases the fall of interest rates are interpreted as adverse information about the outlook for economic profits. This positive relation between stock prices and long term assets shows that changes in long term interest rates might carry information about changes in future dividends, offsetting the negative relation between stock prices and bond yields. The authors try to found the information that carry both stock prices and bond yields with a vector autoregressive forecasting models for dividends and interest rates. Also they estimate a VAR which is used to test the restrictions imposed on the VAR by the present value relations and to estimate what the dividend-price ratio on stocks and bonds should be if prices were set according to fundamentals. The authors conclude that despite their objections, the correlation between stock prices and bond yields is slight negative and also found that excess return in the stock market covary strongly with excess returns in the bond market when compared with what the correlation should be in the terms defined in their paper.

The final paper, in our study, is from Ronald Bewley, David Rees and Paul Berg. The paper examines the impact of stock market volatility on spreads of corporate bond credit spreads using two measures. The first is based on volatility implied from option prices and the second is derived from a conditional heteroscedastic volatility model of changes in stock market index. The credit spread is the additional yield that is priced into a bond as compensation for various risks and for illiquidity. The authors found that implied stock market volatility has no significant impact on these spreads on a day to day basis, but a measure of market volatility, from a GARCH model, has a significant negative effect on these spreads. In other words an increase in market volatility causes a narrowing of spreads to Government securities.

Methodology

Below we will introduce two tests, from which we will compute our results for the volatility spillover effect.

- Yin-Wong Cheung and Lilian K. Ng test

In the paper of Yin-Wong Cheung and Lilian K. Ng is introduced a test which is based on the residual cross-correlation function (CCF) and investigate the causality in variance. The model is tested for its empirical size and the probability of having power properties by a Monte Carlo simulation, the latter shows that the model has good empirical size and power properties. The test includes two stages; first the authors estimate univariate time-series models that permit time variation in both conditional means and variances and second construct series of squared residuals, standardized by conditional variances. The two stage method is an extension on the procedures developed in Haugh (1976) and McLeod and Li (1983). Suppose, according to authors, two stationary and ergordic time series X_t,Y_t and two information sets $I_t = \{X_{t-j}, j \geq 0\}$ and $J_t=\{X_{t-j}, Y_{t-j}, J\geq 0\}$. So Y_t causes X_{t+1} in variance if:

$$\mathbf{E\{(X_{t+1} - \mu_{x,t+1})^2|I_t\} \neq E\{(X_{t+1} - \mu_{x,t+1})^2|J_t\}}$$

Where $\mu_{x,t+1}$ is the mean of X_{t+1} .

In this term the time series are too general for empirically testable, so they must be constructed in a way that will be applicable in practice (stage one) . In that case consider X_t and Y_t as:

$$\mathbf{X_t=\mu_{x,t} + h_{x,t}^{0,5} *\varepsilon_t} \qquad \mathbf{(1)}$$

$$\mathbf{Y_t=\mu_{y,t} + \boldsymbol{h_{y,t}^{0.5}} *\zeta_t} \qquad \mathbf{(2)}$$

Where $\{\varepsilon_t\}$ and $\{\zeta_t\}$ are two independent white noise processes with zero mean and unit variance.$\{ h_{i,t}\}$, i=x,y is the conditional variance for each model.

Then the authors construct the series of squared residuals (stage two).Let U_t and V_t be the squares of standardized innovations:

$$\mathbf{U_t = ((X_t-\mu_{x,t})^2/h_{x,t})=\boldsymbol{\varepsilon_t^2}}$$

$$\mathbf{V_t = ((Y_t-\mu_{y,t})^2/h_{y,t})=\boldsymbol{\zeta_t^2}}$$

So, $r_{uv}(k)$ be the sample cross correlation at lag k:

$$r_{uv}(k)=c_{uv}(k)(c_{uu}(0)c_{vv}(0))^{-1/2}$$

where $c_{uv}(k)$ is the kth lag sample cross covariance given by

$$\mathbf{c_{uv}(k)= T^{-1}\Sigma(U_t-\bar{\mathit{U}})(V_{t-k}-\bar{\mathit{V}}),}\ k=0,\pm1,\pm2,\ldots,$$

and $c_{uu}(0)$ and $c_{vv}(0)$ are the sample variances of U and V respectively.

In order to test the hypothesis of no causality in variance authors use estimators of U_t and V_t since both of them are unobservable.

So

$$\hat{\boldsymbol{r}}_{\mathbf{uv}}\mathbf{(k)=r_{uv}(k)|_{\theta=\hat{\theta}}}$$

$\hat{\theta}$ is set to be, by the authors, a consistent estimator of the true parameter vector θ^o , which is a vector of the parameters of the model given at Eq.(1) and Eq. (2). The sample cross covariance and the sample variances are similarly defined.

For the test authors use two ways; first, given the asymptotic behavior of $\hat{\boldsymbol{r}}_{\mathbf{uv}}\mathbf{(k)}$, they compare $\sqrt{T}\hat{\boldsymbol{r}}_{\mathbf{uv}}\mathbf{(k)}$ with the standard normal distribution, second a chi-square test statistic

$$S=T\sum_{i=j}^{k}\ \hat{r}_{uv}(i)^2$$

Which has a chi-square distribution with (k-j+1) degrees of freedom also used to test the given hypothesis.

Some information about the model, that already explained, is given below. The CCF model has some advantages over some alternative tests for causality in variance. For example, compared with a multivariate method, the CCF does not include contemporaneous modeling of both intra and inter series in both the first and second moment dynamics, which that make it easier to implement. Also, the uncertainty in both the first and second moment dynamics and the possible correlation between the series would complicate the formulation of a multivariate GARCH model. Furthermore CCF test is useful when the number of series under investigation is large and long lags are expected, in addition the above test has a well-defined asymptotic distribution and is asymptotically robust to distributional assumptions.

However, CCF method has certain limitations. For example, CCF is not formulated to detect causation patterns that yield zero cross correlations

➢ Hong-Causality in volatility test

In his paper, Hong, test for causality in variance based on Granger (1969, 1980). Ganger introduces the causality in terms of incremental predictive ability of one time series for another. Hong's test includes a properly standardized version of a weighted sum of squared sample cross correlations between standardized residuals and has a null asymptotic N (0, 1) distribution. As for the weighting in sum of squared sample cross correlations, the author uses a flexible weighting scheme at each lag. The latter method is expected to give better power against the alternatives whose cross correlations decay to zero as the lag order increases. We will try to explain the Hong's model by describing each step that has taken to formulate his model.

1. At first he estimates $\{\hat{\varepsilon}_{1t}\}$ and $\{\hat{\varepsilon}_{2t}\}$ using univariate GARCH(p, q) models for each one, using QMLE method, and save the conditional variance estimators $\{\hat{h}_{1t},\hat{h}_{2t}\}$

In order to begin with the above step, author at first, introduces the causality in variance hypothesis. He focuses on Granger causalities between time varying conditional variances of Y_{1t} and Y_{2t}, whose unconditional variances may not exist.

$$\mathbf{H_0: E\,\{Var(Y_{1t}|I_{t-1})|I_{1t-1}\}= Var(Y_{1t}|I_{t-1})}$$

$$\mathbf{H_A: E\,\{Var(Y_{1t}|I_{t-1})|I_{1t-1}\}\neq Var(Y_{1t}|I_{t-1})}$$

We say that Y_{2t} does not Granger-cause Y_{1t} in variance with respect to I_{t-1} if H_0 holds and Y_{2t} Granger causes Y_{1t} in variance with respect to I_{t-1} if H_A holds.

A note that should be taken seriously is that if there isn't causality in mean and variance does not imply absence of general causality, but if a relation is found in mean or variance then the general causation has been found. From econometric perspective detection of causality in variance is particularly important when the test for causality in mean fails to reject the null hypothesis, because it is possible that the general causality exists but there is no causality in mean.

To test the null hypothesis, the author, consider these disturbance processes:

$$\varepsilon_{it}= Y_{it}-\mu_{it}^{0}, \quad i=1, 2$$

where μ_{it}^{0} = $E(Y_{it}|I_{t-1})$. In addition Hong specify the following processes

$$\varepsilon_{it}=\xi_{it}(h_{it}^{0})^{1/2}$$

where h_{it}^{0} is a positive time varying measurable function with respect to I_{it-1} and $\{\xi_{it}\}$ is an innovation process with

$$E(\xi_{it}|I_{1t-1})=0 \qquad E(\xi_{it}^2|I_{1t-1})=1$$

Then by construction, $E(\varepsilon_{it}|I_{1t-1})=0$ and $E(\varepsilon_{it}^2|I_{1t-1})= h_{it}^0$.So the hypotheses H_o and H_A can be written as follows

$$H_o: Var(\xi_{1t}|I_{1t-1})= Var(\xi_{1t}|I_{t-1})$$

$$H_A: Var(\xi_{1t}|I_{1t-1})\neq Var(\xi_{1t}|I_{t-1})$$

Since squared innovation $\{\xi_{it}^2\}$ are unobservable the authors uses squared residuals, standardized by their conditional variance, to estimate them. If θ_i^0 is a vector of parameters of the given model then the author permit $\hat{\theta}_1$ to be a QMLE of θ_i^0. In that case the centered squared standardized residuals can be obtained as

$$\hat{u}_t=u_t(\hat{\theta}_1)=\hat{\varepsilon}_{1t}^2/\hat{h}_{1t}-1, \quad \hat{v}_t=v_t(\hat{\theta}_2)= \hat{\varepsilon}_{2t}^2/\hat{h}_{2t}-1$$

Where $\hat{h}_{it}=h_{it}(\hat{\theta}_i)$ with: $h_{it}=\omega_i + \sum_{j=1}^{q} a_{ij}\varepsilon_{it-j}^2(\theta_i) + \sum_{j=1}^{p} \beta_{ij}h_{it-j}(\theta_i)$ (The conditional variance follows a GARCH (p,q) process).

2. <u>Computes the sample cross-correlation function $\hat{p}_{uv}(j)$ between the centered squared standardized residuals.</u>

The below function is based on Cheung and Ng (1996) proposition for testing the null hypothesis by using the sample cross correlation function between $\hat{u}_t$ and $\hat{v}_t$.

$$\hat{p}_{uv}(j)=\{\hat{C}_{uu}(o)\hat{C}_{vv}(0)\}^{-1/2}\hat{C}_{uv}(j)$$

3. <u>Chooses a weighting function k(.) and an integer M and computes $C_{1T}(k)$ and D_{1T}.</u>

Cheung and Ng, who proposed the model that we describe in step2, introduce a statistic test for the null hypothesis, which is based on the sum of the first M cross correlations:

$$S=T\sum_{j=1}^{M} \rho_{uv}^2(j).$$

Below, and based on the author, we discuss that the given model from Cheung and Ng isn’t always efficient and a new model is necessary to be formulated.

A significant observation is that a high volatility today tends to be followed by another high volatility tomorrow and a low volatility today tends to be followed by another low volatility tomorrow. Also recent past volatility has greater impact on current volatility than distant past volatility. In terms of volatility spillover this should mean that the current volatility of an asset is more affected by the recent volatility of the other asset than by the past volatility of that asset. Empirically we can see that cross correlations between assets generally decay to zero as the lag order j increases. So, in a case that a large M is being used the S test may not be fully efficient because it gives equal weighting to each of the M sample cross correlations. Therefore for large M, a more efficient test may be introduced by giving a larger weight to a lower lag order j. Based on the above considerations, Hong suggests a class of new tests, which essentially generalized the Cheung and Ng statistic test:

$$T\sum_{j=1}^{T-1} k^2(j/M)\, \rho_{uv}^2(j). \qquad (A)$$

Hong, finally, introduce the test statistic of this paper which is a standardized version of the above model(A):

$$\mathbf{Q_1=\{T\sum_{j=1}^{T-1} k^2(j/M)\, \rho_{uv}^2(j)-C_{1T}(k)\}/\{2D_{1T}(k)\}^{1/2}}$$

Where

$$C_{1T}(k)= \sum_{j=1}^{T-1} (1-j/T)k^2(j/M)$$

$$D_{1T}(k)= \sum_{j=1}^{T-1} (1-j/T)\{1-(j+1)/T\}k^4(j/M)$$

C_{1T} and D_{1T} are the mean and the variance of (A) respectively. The factors (1-j/T) and {1-(j+1)/T} are finite sample correlations. For the selection of k(.) and M, Hong study the sensitivity of the size and the power of the model due to these selections. He found that the choice of k(.) has little impact on the size and power as long as it is non-uniform. The selection of M has little impact on the size but has some impact on power. As a general rule, Hong says, if we use non uniform k(.) then we will have not significant problems, despite the size of M, because even if it's large the k(.) will alleviate the loss of power. More specific k(.) is a weighting function such as truncated and Bartlett kernels. In our analysis we use six kernels, the two that we have already introduced and additional the Daniell, Parzen, quadratic-spectral and Tukey-Hanning kernels. The formulations of the above kernels are presented below:

Truncated

$$k(z)=\begin{cases} 1, & |z| \le 1 \\ 0, & otherwise \end{cases}$$

Bartlett

$$K(z)=\begin{cases} 1-|z|, |z| \le 1 \\ 0,\ otherwise \end{cases}$$

Daniell

$k(z)=siz(\pi z)/\pi z,\ -\infty<z<\infty$

Parzen

$$K(z)=\begin{cases} 1-6z^2+6|z|^3, |z| \le 0,5 \\ 2(1-|z|)^3, \ 0,5<|z|\le 1 \\ 0, otherwise \end{cases}$$

<u>QS</u>

$$k(z)=\frac{3}{\sqrt{5}\,(\pi z)^2}\{\sin(\pi z)/\pi z-\cos(\pi z)\},\ -\infty<z<\infty$$

<u>Tuckey-Hanning</u>

$$k(z)=\begin{cases} \frac{1}{2}(1+\cos(\pi z)), |z| \le 1 \\ 0, \ otherwise \end{cases}$$

In addition to Q_1 test statistics we will introduce, from the paper, the Q_2 test which tests the bidirectional hypothesis that neither Y_{2t} Granger causes Y_{1t} in variance nor Y_{1t} Granger causes Y_{2t} in variance. The particular test is effective when no prior information about the direction of causalities is available. The Q_2 test is given below:

$$\mathbf{Q_2=\{T\sum_{j=1-T}^{T-1} k^2(j/M)\, \rho_{uv}^2(j)-C_{2T}(k)\}/\{2D_{2T}(k)\}^{1/2}}$$

Where

$$C_{2T}(k)=\sum_{j=1-T}^{T-1}(1-|j|/T)k^2(j/M)$$

$$D_{2T}(k)=\sum_{j=1-T}^{T-1}(1-|j|/T)\{1-(|j|+1)/T\}k^4(j/M)$$

4. <u>Finally, computes the test statistic Q_1 and compares it to the upper tailed critical value of N(0,1) at an appropriate level and finds if the null hypothesis is accepted or rejected.</u>

At the end, author uses Monte Carlo stimulation to investigate the finite sample performance of the proposed tests. The results are given below:

The new tests have reasonable sizes at 10% level, but at 5% level tend to over reject. The reason behind this is that Q tests behave as a standardized version of $k^2(j/M)$ weighted sum of independent centered x_1^2. Such standardization converges to N(0,1) in distribution as $M \to \infty$,as a consequence in small M the above standardized version is right skewed in distribution and the N(0,1) approximation will result in over rejection under H_0

DATA

Our empirical analysis in conducted for a sample of twenty two markets, these markets consist eleven countries, two markets for each country (Bond market and Stock market).The countries are Austria, France ,German, Greece, Ireland, Italy, Netherlands, Portugal, Spain, UK and Us. The sample period is from 26/3/1998 to 31/10/2013, so we have a sample of 4071 observations. The performance of the stock market of each country is measured by the daily closed prices of the general stock index of each country. As for the bond markets we take as proxy for the performance the daily yields of the 10-year government bond, considering the latter as benchmark for all the government bonds. Before we put the data in use we conducted unit root tests to check if the observations are stationary. All the observations that referred to the government bonds are stationary in contrast with the observations for the stock markets. So we take logarithm differences to eliminate the particular problem. The daily closed prices of the stock indices were obtained from the Datastream and the yields of the 10-year government bonds from the Bloomberg.

Below we present a table with some of the statistical properties of our data. In order to make more understandable the table we must make some comments. The column that referred to **jbtest** contains the results of the particular test that tests if the time series have normal distribution, based on the values that take the *kurtosis* and the *skewness*. The test has two variables, h and the p-value, specifically the ***h*** takes only two values, zero and one. When the ***h*** is one then the null hypothesis is rejected and when is zero the exact opposite. The null hypothesis stands for the normal distribution. The p-value denotes the support of the value of ***h.*** The same philosophy stands for the unit root test but in the opposite way. In this case the null hypothesis is that the time series are stationary and the alternative is that have unit root. So we must observe in the unit root test all the ***h*** to be zeroes.

Statistical properties of daily bond and equity returns (%), 26/3/1998-31/10/2013

	Bond index return				jbtest		unit root test
	mean return	Variance	Skewness	Kurtosis	h	p-value	h
Greece	7,626641	38,05621	2,6323924	10,01921	1	0,001	0
Austria	3,941017	1,172423	-0,899211	4,349097	1	0,001	0
Ireland	4,256044	4,738728	0,1707586	5,331407	1	0,001	0
France	3,945331	0,827836	-0,419706	3,082868	1	0,001	0
German	3,713569	1,196236	-0,62962	2,625335	1	0,001	0
Italy	4,616824	0,505065	-0,25887	7,919005	1	0,001	0
Spain	4,581589	0,566093	0,2310741	4,131184	1	0,001	0
Portugal	5,217701	6,053438	1,2736393	6,271936	1	0,001	0
Netherlands	3,863057	1,132546	-0,717396	3,355142	1	0,001	0
UK	4,213845	1,14791	-0,974429	3,062127	1	0,001	0
US	3,954269	2,171001	-0,945028	3,800717	1	0,001	0

	Stock index return				jbtest		unit root test
	mean return	Variance	Skewness	Kurtosis	h	p-value	h
Greece	0,008669	1,5772362	0,128532	16,13146			0
Austria	0,010079	1,009146	-0,40911	19,77365	1	0,001	0
Ireland	0,01856	0,9361076	-0,74541	23,60221	1	0,001	0
France	0,007027	1,0280492	-0,17162	16,33066	1	0,001	0
German	0,021571	1,4598695	-0,25017	11,138	1	0,001	0
Italy	-0,00317	0,7524209	-0,14139	23,82811	1	0,001	0
Spain	0,010257	1,0308963	-0,09169	16,92016	1	0,001	0
Portugal	0,004959	0,5114308	-0,53125	29,36405	1	0,001	0
Netherlands	0,015815	1,1129628	-0,31662	18,60396	1	0,001	0
UK	0,020159	0,8788649	-0,59781	34,49438	1	0,001	0
US	0,023037	1,0449725	-1,0355	31,02023	1	0,001	0

Empirical results

Before we introduce our results, which have been computed by the two methodologies that we mentioned above, it is important to disclosure the definition of causality so the reader can easily understand the output of our analysis. In order to give a proper definition we quote the corresponding definition from the paper of Marta Gomez and Simon Sosvilla Rivero (Granger causality in peripheral EMU public markets: A dynamic approach, 2013): ‘’One variable Granger causes some other variable, given an information set, if past information about the former can improve the forecast of the latter based only in its past information. Therefore, the knowledge of one series evolution reduces the forecast errors of the other, suggesting that the latter does not evolve independently of the former’’.

- **Hong test**

We begin our presentation of the results by introduce the Hong’s first. The results of Hong’s test are too many to be presented as they were computed and one reason is that they will not be in a form easy to be understood by the reader, we create from the computed results a total of 363 tables.. This happens because the methodology of Hong contains three causality tests, two one way and one bilateral, and six kernel functions that are computed for each causality test. In order to make the presentation understandable and simplified we try to show all the given results in a single table. To do so, we introduce a ‘’heat map’’, which is a table that give us the results that concern the relation of two variables in a form of colors. Each color of the map, according to the definition that an analyst gives each time, shows the results aggregated and present the definition, which has been given by the analyst, as an explanation of the results. Based upon these we introduce the **Table 1**. In that table we show the causality between the stock and the bond market in one country or across the countries. Each column is the stock market of each country and each row is the bond market of each country. We use three colors to define the causality that arise from the analysis of results (**Table 1.1)**. We use black to mention that there is no causality in any of the causality tests meaning that the null hypothesis of Hong's test is strong in every bandwidth of the causality tests. We use orange to suggest that there is weak causality, meaning that the null hypothesis of no causality isn't strong in every bandwidth and there are bandwidths that accept the alternative hypothesis across the three causality tests. Finally we use red to support that there is causality in all bandwidths and at least in two causality tests. We remind that the causality tests are three, an one way causality that investigate if the past information of a bond market is improving the forecast of a stock market ,also an one way causality that investigate if the past information of a stock market is improving the forecast of a bond market and finally a bilateral causality test. In addition to the **table 1** we introduce the **table 1.2** which is more detailed about the causalities between the variables. We use arrows to denote the causality tests that have been developed among the variables; we use separate arrow for each causality test. The arrows (→) and (←) denote which of the two one-way causality tests is verified between two particular variables and points the direction of causality. For example we see that the bond market of Greece and the stock market of France have two arrows (←, ↔) meaning that between the above variables exists bilateral causality (↔) and is verified the one way causality test that check the hypothesis that the stock market of France granger causes the bond market of Greece (←).

Table 1

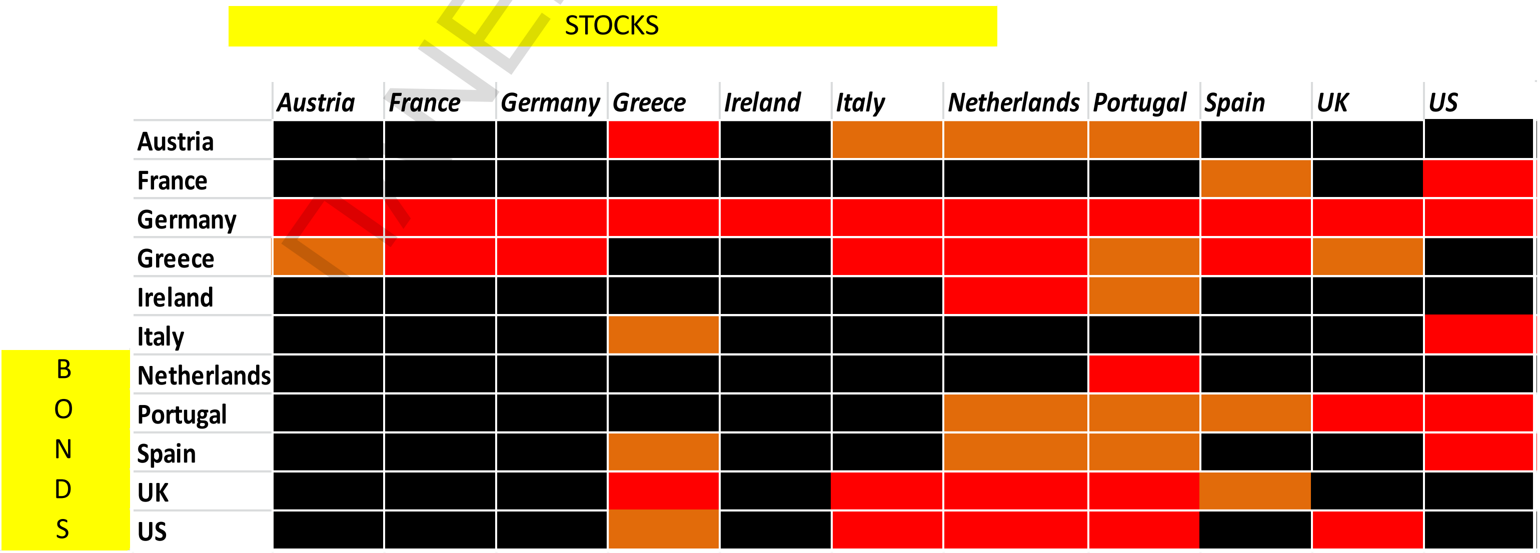

Table 1.1

	no causality
	weak causality
	strong causality

Table 1.2

						stocks						
		Greece	Austria	Ireland	France	Germany	Italy	Spain	Portugal	Netherlan	UK	US
	Greece	–	←	–	← ↔	← ↔	← ↔ →	←	←	← ↔	←	–
	Austria	← ↔	–	–	–	–	← →	–	←	→	–	–
b	Ireland	–	–	–	–	–	–	–	→	→ ↔	–	–
o	France	–	–	–	–	–	–	→	–	–	–	→ ↔ ←
n	Germany	↔	↔	↔	← ↔	↔	↔	↔	↔	↔	← ↔	→ ↔
d	Italy	→	–	–	–	–	–	–	–	–	–	→ ↔ ←
s	Spain	← ↔	–	–	–	–	–	–	→ ↔	→ ↔	–	→ ↔ ←
	Portugal	–	–	–	–	–	–	→ ↔	–	→ ↔	→ ↔	→ ↔
	Netherlan	–	–	–	–	–	–	–	→ ↔	–	–	–
	UK	→ ↔	–	–	–	–	→ ↔	→	→ ↔	→ ↔	–	–
	US	←	–	–	–	–	← ↔	–	← ↔	← ↔	← ↔	–

For example we see that the bond market of Austria didn't develop causality in variance with the stock market of the same country and didn't also with the France, Germany, Ireland, Spain, UK and US stock markets. Especially for the non causality between the markets within the country we can say that is verified the literature that supports the non causality effect between the markets within the country. As for the countries Italy, Netherlands and Portugal we see that has weak causality. More specific with Italy is developing a strong one way causality in bandwidths 5-13, the one way causality is referring to the hypothesis that the past information of the bond market of Austria can improve the forecast of the stock market of Italy. The stock market of Netherlands is affected by the causality of the bond market of Austria and this is showed in the bandwidths 3-20. Finally the stock market of Portugal Granger causes the bond market of Austria in the bandwidths 12-20.

As for the France bond market we see that almost hasn't any causality with the given stock markets. There are only two exceptions, the stock market of Spain and the stock market of US, that the France bond market developed causality with them. With Spain the causality is presented in a weak form and specifically in the test that investigate the hypothesis that past information of the France's bond market can improve the forecast of the Spain's stock market and, this hypothesis is strong in bandwidths one to two and six to twenty in all kernels functions. The stock market of US has causality in variance with the aforesaid bond market in all test and all kernels, meaning that the hypothesis is strong in all the bandwidths.

In contrast we see that the German bond market developed causality in variance with any given stock market, and this is presented especially in the bilateral test. The latter supports strong the hypothesis of causality between the German bond market and the stock markets of the other countries. In the case of the stock market of Austria the hypothesis is strong in the bilateral test and in all the bandwidths. As for the German stock market we see also the same activity, in addition with the test that verified the causality from stock market to bond market. With the Greek stock market we see strong support of the causality in the bilateral test as we do in the Irish stock market but in the latter country we see also a strong support in the test that shows German bond market helps improve the forecasting of the Irish stock market. Specifically the hypothesis of causality is strong is the bandwidths twelve to seventeen of the Q kernel function, nineteen to twenty in T-H kernel function, six to eleven in Truncated kernel function and sixteen to twenty in Daniel kernel function. The Italian stock market has almost the same conduct with the Irish stock as for the causality with the German bond market except that the former stock market in the one way test behaved differently. In Italian stock market we see that the one way causality test supports strong the hypothesis of causality in the bandwidths eleven to twenty in the Q kernel function, five to thirteen in truncated kernel function and fifteen to twenty in Daniel kernel function. The Netherland, Portuguese and Spanish stock market have causality with the German bond market and that is presented in the results of the bilateral test in all of the stock markets. As we continue analyzing the effect of the German bond market in the stock markets we see that UK stock market shows causality in bilateral and the hypothesis is supported strong because it is powerful in all bandwidths and in all kernels. Also in bandwidths six to thirteen in truncated kernel and ten to twenty in the rest of kernels the hypothesis that the UK stock market can improve the forecast of the German bond market has strong support. Finally the German bond market and the US stock market have strong causality in variance as it shown in the bilateral test but also in the test that study the hypothesis that German bond market granger causes the US stock market.

As we proceed to the rest of the countries we see that the Greek bond market has been granger caused by the stock market of Austria, in a weak form of causality, and that is shown in the corresponding causality test and especially in bandwidths four to twenty in all kernel functions. As for the behavior between the France stock market and the

Greek bond market we see that is being developed strong causality. More specific the bilateral test supports strong the hypothesis of causality between the two markets in bandwidths three to twenty and also in these bandwidths we have strong support of the hypothesis that France stock market granger causes the Greek bond market. The same results are given by the German stock market, namely has strong relation with the Greek bond market and that is shown in the bilateral test and in the one way test that investigate the hypothesis if past information about the German stock market can improve the forecast of the Greek bond market based only in German stock market past information. All the above are verified in the bandwidths two to twenty of the tests. As for the Greek and Irish stock markets we see no causality developed between them and the Greek bond market. In contrast Italian and Netherland stock markets have strong causality with the above mention bond market. More specific with the Italian stock market the bilateral test supports strong the hypothesis of causality in bandwidths three to twenty and in bandwidths six to twenty we have strong support of the hypothesis that the Italian stock market granger causes the Greek bond market. The Dutch stock market granger causes the Greek bond market as it shown in bandwidths four to twenty in the corresponding one way test and also we have strong support of the above mentioned hypothesis in the bilateral test (six to twenty bandwidths). As for Spanish and American stock markets we see no connection between them and the Greek bond market. For Portuguese and English stock markets we see that is being developed causality between them and the Greek bond market, in a weak form. Both markets granger cause the Greek bond market and that is shown in bandwidths four to twenty in their kernel functions of their corresponding tests.

The Irish bond market didn't develop causality almost with every given stock market. There are two exceptions however, with the stock market of Netherlands and the stock market of Portugal. The causality with the former is strong and focuses on the bilateral test in bandwidths ten to twenty and in the one way causality test, that investigate the hypothesis that the bond market granger causes the stock market of Netherlands, in bandwidths ten to twenty. As for the Portuguese stock market, the causality that arise is in a weak form and is shown only in the test that checks the hypothesis that the above mentioned bond market granger causes the specific stock market in bandwidths ten to twenty.

The same behavior with the above mentioned bond market presents the bond market of Italy. More specific the bond market of Italy didn't develop causality with the majority of the stock markets with the exceptions of two, the Greek and the American. With the Greek stock market we see causality in weak form in the test that verified that the bond market granger causes the stock market, especially in bandwidths twelve to twenty in Q kernel function and eight to twenty in Truncated kernel function.

The Netherland bond market developed causality only with the stock market of Portugal. More specific this relation, which is strong, is shown in the bilateral test in bandwidths sixteen to twenty and in the one way test that investigate the hypothesis that the stock market of Portugal Granger causes the bond market of Netherlands. That means that if the above is true then past information about the former can improve the forecast of the latter based only in its past information.

In contrast we see that the Portuguese bond market have causality with plenty stock markets. At first the causality presented with the stock market of Netherlands, in a weak form, which is shown in the test that checks if the bond market granger causes the stock market in all bandwidths of all kernel functions. Weak form of causality we have also with the stock market of the same country and is shown in the same test as above, but in different bandwidths. Here the test verified the relation in bandwidths one to six. With the stock market of Spain we have exactly the same results as above, meaning the relation between the bond and the stock market of Portugal. In contrast the causalities that were being developed with the UK and US stock markets are in different form, here we have strong form of causality. In both cases the causality is strong in all bandwidths of all kernels in the bilateral tests and in the one way tests that investigate the hypothesis that the bond market is granger causes the stock market.

As for the Spanish bond market we see causality in weak form with the Greek stock market in the bilateral test in bandwidths six to twenty and in the test that checks if the stock market of Greece granger causes the bond market of Spain in the same bandwidths. Also we see a weak form of causality between the above mentioned bond market and the stock market of Netherlands in bilateral test in bandwidths ten to twenty. Also we see the same behavior in the one way test that investigates the hypothesis that the bond market granger causes the stock market in bandwidths twelve to twenty. In bandwidths eleven to twenty of the kernel functions in the one way test that checks the effect of bond market of Spain on the stock market of Portugal we also see a weak form of causality. The last causality that developed was with the American stock market and was in a strong form. More specific the causality was verified in all tests but in different bandwidths. As for the one way test that checks the effect of bond market on the stock market the bandwidths are from two to twenty, in the other one way test the bandwidths are from six to twenty and in the bilateral test the bandwidths are from five to twenty.

The English bond market developed strong causality with the Greek stock market and that is shown in the bilateral test of these two markets and especially in bandwidths one to eight and thirteen to twenty. Also we see the above relation in the test that checks the effect of the above mentioned bond market on the Greek stock market in bandwidths seven to twenty. The strong form of causality is continued also with the stock markets of Italy, Netherlands and Portugal. As for the relation between the bond market and the Italian stock market the one way test that tests the hypothesis that the bond market Granger causes the stock market verified the strong causality in bandwidths eight to twenty, also the bilateral test does the same verification in bandwidths ten to twenty of all kernels except Parzen kernel function. The bond market of England Granger causes the stock market of Netherlands and that is verified in the corresponding test in bandwidths ten to twenty, also the causality that we mentioned above is shown in the bilateral test specifically in bandwidths ten to twenty. The Portuguese stock market is Granger caused by the English bond market and this is verified in bandwidths ten to twenty in the corresponding one way causality test and also in bandwidths ten to twenty in the bilateral test. As for the relation with the Spanish stock market we see a weak form of causality between them and that is verified in the one way causality test that tests the hypothesis that the bond market of England Granger causes the stock market of Spain, specifically in bandwidths eight to twenty.

The last bond market that we examine in our paper is the bond market of US. At first we see causality in weak form with the Greek stock market and that is shown in the one way causality test that checks the effect of stock market on bond market in bandwidths one to seven. Second we observe strong correlation with the Italian stock market and especially in the same test as above but in all bandwidths of all kernel functions and also in bilateral test in bandwidths three to twenty in all kernel functions except the Quadratic function. The same results are represented in the relation between the above mentioned bond market and the stock market of Netherlands except in the one way test we have verification in all bandwidths. The relation between the bond market of US and the stock market of Portugal matches exactly with the relation between the above mentioned bond market and the stock market of Netherlands. Strong form of causality we also see between the bond market and the stock market of England, in this case we have verification in all bandwidths of all kernel function in bilateral test and also in the above mentioned one way causality test.

For the last part of this section we will present some of the results, in form of tables, which we have used to make the heat map that has been described above. In order to make the tables understandable some notes must be reported. The title ‘’**Causality from 1to2**’’ denotes that in this particular table is being tested the effect of the bond market to the stock market, in other words the above one way test tests the hypothesis if one particular bond market Granger causes one particular stock market. The title ‘’**Causality from 2to1**’’ denotes exactly the opposite. The first column shows us the bandwidths that have been used in the kernel functions. Below the title we present the six kernel functions that we use to compute the results. As for the results we know from the section of methodology that the null hypothesis of non causality is being tested by computing the test statistic Q_1 and comparing it to the upper tailed critical value of N(0,1) at an appropriate level. So if the Q_1 statistic exceeds the critical value then the null hypothesis is being rejected, in order to show this on the tables we mark with red color each bandwidth of each kernel function that verified the above relation. In our essay we use a significant level of 5% so the Q_1 statistic must be greater than 1,64 to say that between two variables exists causality. The tables that we are going to show are 6 from the 363 that we have computed as total (For more information see Appendix).

Table 1.3

<u>Bond market of Austria and stock market of Austria</u>

Bandwith		Causality from 1to2				
	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	-0,687533517	NaN	NaN	NaN	-0,6894166	3,823205
2	-0,790274667	-0,6894166	-0,6894166	-0,689416572	-0,9844012	-0,30633
3	-0,523205686	-0,83924	-0,7017956	-0,76278664	1,47926119	-0,9235
4	0,05719161	-0,5113143	-0,76139	-0,769765153	0,92780841	-0,58833
5	0,362942147	-0,1194061	-0,7556002	-0,429072036	0,52055228	-0,06469
6	0,47769811	0,11465363	-0,6019082	-0,050785764	0,42922986	0,236899
7	0,500843592	0,2439639	-0,3560595	0,218539682	0,24809238	0,358301
8	0,472822344	0,31284717	-0,1109509	0,380557797	0,27522099	0,435428
9	0,416340204	0,34790308	0,08863213	0,467026425	0,03470054	0,412488
10	0,337945098	0,36065403	0,23612836	0,505745704	-0,1455732	0,451288
11	0,246812756	0,35421395	0,33846811	0,514615493	-0,3501596	0,460025
12	0,150271978	0,33249835	0,40585929	0,503406415	-0,5182644	0,362981
13	0,049105841	0,29881104	0,44717566	0,477624178	-0,6369313	0,332587
14	-0,05836873	0,25665997	0,4690812	0,440740372	-0,7885635	0,364306
15	-0,158074368	0,20850278	0,47634295	0,395354071	-0,9432868	0,193326
16	-0,260922507	0,15565487	0,47245742	0,343540274	-1,0885226	0,133239
17	-0,370438791	0,09913552	0,45990051	0,286901992	-1,2085215	0,218714
18	-0,472553062	0,03994384	0,44037895	0,226656774	-1,3397407	0,186531
19	-0,559347171	-0,0211379	0,41513006	0,163750418	-1,3680285	-0,01319
20	-0,636823985	-0,0830332	0,38518123	0,098937367	-1,4398951	-0,21568

		Causality form 2to1			
Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
-0,50486606	NaN	NaN	NaN	-0,45691696	0,801105
-0,548740923	-0,45692	-0,456917	-0,456916957	-0,74235054	-0,5804
-0,747201932	-0,58706	-0,4673816	-0,519586525	-1,01174609	-0,67136
-0,920401103	-0,72589	-0,5261264	-0,643902071	-1,10818768	-0,82851
-1,039550844	-0,84612	-0,6148937	-0,768719657	-1,11762219	-0,97946
-1,132567883	-0,9386	-0,7053501	-0,877425399	-1,2013764	-1,08218
-1,214630091	-1,01174	-0,7911595	-0,964632492	-1,33821697	-1,16104
-1,293679612	-1,07672	-0,8674825	-1,034391639	-1,4714762	-1,22439
-1,373371665	-1,13922	-0,9336771	-1,093737088	-1,51391709	-1,27453
-1,449039304	-1,19901	-0,9908319	-1,148095822	-1,63457558	-1,33093
-1,518135337	-1,25623	-1,0410689	-1,199956808	-1,76196776	-1,41707
-1,584882327	-1,31259	-1,086412	-1,250286553	-1,78353363	-1,47362
-1,65034871	-1,36746	-1,1285551	-1,299730685	-1,87620487	-1,51181
-1,713027561	-1,42034	-1,1686092	-1,348506341	-1,8616834	-1,57518
-1,773198494	-1,47071	-1,2073529	-1,396513212	-1,96830296	-1,60293
-1,828584654	-1,51863	-1,24517	-1,443478704	-1,92390369	-1,66385
-1,87887399	-1,56401	-1,282283	-1,489131128	-2,03680243	-1,70903
-1,923566299	-1,60698	-1,3187325	-1,533240614	-2,14533024	-1,76993
-1,963143702	-1,6487	-1,3545287	-1,575666245	-2,16852376	-1,84884
-2,000682738	-1,68939	-1,3896554	-1,616455167	-2,14899846	-1,90134

		Billateral			
Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
0,02517885	0,04726065	0,047260654	0,047260654	-0,634487824	0,04726065
-0,113396144	-0,2255718	-0,02427196	-0,225571804	-1,070866155	-0,27251367
-0,17460336	-0,508611	-0,28738151	-0,529634089	0,323908516	-0,76389011
-0,137883198	-0,5404125	-0,50145354	-0,704447675	-0,104481471	-0,76299696
-0,119738566	-0,4651175	-0,63613941	-0,645875228	-0,388256085	-0,59176568
-0,131906098	-0,4220391	-0,6634545	-0,521108464	-0,511414676	-0,49393335
-0,164099073	-0,411389	-0,61329429	-0,429244662	-0,732430569	-0,48120631
-0,21170585	-0,4242745	-0,54066087	-0,383425105	-0,809092615	-0,48234291
-0,270991274	-0,4526257	-0,477841	-0,374228932	-1,007141054	-0,53708604
-0,33920264	-0,491268	-0,43443841	-0,390329145	-1,218008257	-0,55508948
-0,412570859	-0,5393355	-0,41071109	-0,423180019	-1,450702729	-0,61137829
-0,48983789	-0,5960132	-0,40349933	-0,467719421	-1,585156769	-0,71782734
-0,570912824	-0,6591795	-0,40941959	-0,521099113	-1,734607403	-0,76811668
-0,655707132	-0,7264531	-0,42561478	-0,581355934	-1,832496667	-0,79349339
-0,738538807	-0,796008	-0,44993375	-0,646801896	-2,01668428	-0,93054943
-0,822463948	-0,8670633	-0,48061666	-0,715926635	-2,08919862	-1,01574932
-0,908629475	-0,938898	-0,51635472	-0,787499756	-2,253611618	-0,99210282
-0,990683286	-1,0109542	-0,55615739	-0,86055574	-2,422836224	-1,05821218
-1,064948803	-1,0834666	-0,59928155	-0,934359203	-2,460699029	-1,25021093
-1,134918276	-1,1558633	-0,64507945	-1,008423857	-2,499023636	-1,42664565

Table 1.4

Bond market of France and stock market of Greece

		Causality from 1to2				
Bandwith						
	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	-0,564457137	NaN	NaN	NaN	-0,5145095	22,13659
2	-0,609884787	-0,5145095	-0,5145095	-0,514509494	-0,8632754	-0,60916
3	-0,80488014	-0,6704334	-0,5269807	-0,589349833	-1,1107759	-0,69352
4	-1,019702086	-0,8241276	-0,5969231	-0,735163129	-1,2723417	-0,56847
5	-1,092954093	-0,9577807	-0,7005726	-0,873086941	-1,4296179	-0,73274
6	-0,884919462	-1,0745922	-0,8029515	-0,994941282	1,24857837	-1,03136
7	-0,527398536	-1,0349765	-0,8987542	-1,088506247	0,97438338	-1,12208
8	-0,190480887	-0,8697611	-0,9803453	-1,085776476	1,84680778	-0,809
9	0,097029376	-0,6597308	-1,0335666	-0,977216766	1,50672241	-0,52284
10	0,351204217	-0,4390589	-1,046481	-0,795904971	1,25680094	-0,32195
11	0,564944977	-0,2416129	-1,0148967	-0,577341959	1,01767748	-0,08691
12	0,732579274	-0,0760251	-0,9403895	-0,351769618	0,96171635	0,163769
13	0,862909473	0,05989653	-0,8299217	-0,139230546	2,00906804	0,381012
14	0,963353702	0,18502762	-0,696598	0,05033063	1,77162434	0,583134
15	1,045330492	0,30690813	-0,5523003	0,21642843	1,53385128	0,766854
16	1,120848854	0,4182461	-0,4052298	0,362939019	1,39913244	0,836671
17	1,191008803	0,51656561	-0,2606832	0,493227223	1,27573397	0,879638
18	1,253509249	0,60193766	-0,1224345	0,609369579	1,13679342	0,956503
19	1,309467474	0,674954	0,00729851	0,712595256	1,10739388	1,051781
20	1,361505643	0,73701419	0,12760085	0,803712716	0,95576751	1,117175

		Causality form 2to1			
Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
-0,376340738	NaN	NaN	NaN	-0,34493504	-11,4138
-0,416131723	-0,34494	-0,344935	-0,344935039	-0,56564778	-0,25212
-0,552700328	-0,44497	-0,3529665	-0,393062712	-0,86814296	-0,33294
-0,718382548	-0,56849	-0,3983966	-0,493318359	-1,03331513	-0,42683
-0,533395781	-0,69044	-0,4704311	-0,608022531	1,180534506	-0,78913
-0,220775703	-0,63221	-0,5496871	-0,698634012	1,240547065	-0,76596
0,043828153	-0,43811	-0,6206484	-0,665719774	0,909614273	-0,53621
0,218070289	-0,24231	-0,655288	-0,517133864	0,652672367	-0,24972
0,315517231	-0,08533	-0,6389365	-0,321238637	0,383868615	-0,04141
0,35470896	0,028932	-0,5724303	-0,129514524	0,18872423	0,099017
0,335221672	0,10621	-0,4675495	0,033208081	-0,02904825	0,299229
0,286073119	0,15369	-0,3443546	0,159311839	-0,21709575	0,397337
0,229612957	0,177379	-0,2192637	0,249683864	-0,39003243	0,377659
0,169349044	0,182498	-0,1027628	0,30854048	-0,55500169	0,346203
0,104364156	0,173147	-0,000508	0,340980012	-0,65070303	0,300934
0,031704311	0,153041	0,08531925	0,351907148	-0,79465139	0,344728
-0,041963589	0,124921	0,15449179	0,345698186	-0,79744561	0,316614
-0,112301765	0,091393	0,20791277	0,326087422	-0,67746581	0,278592
-0,17814455	0,055879	0,2469817	0,296253114	-0,6938929	0,234173
-0,237798532	0,020399	0,27334881	0,259026656	-0,83089789	0,206103

		Billateral			
Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
-0,528288846	-0,5110542	-0,51105421	-0,51105421	-0,791265963	-0,51105421
-0,62628873	-0,6843666	-0,56256341	-0,684366609	-1,132281553	-0,7470647
-0,730975013	-0,8577098	-0,71727718	-0,833047999	-1,488656631	-0,87458001
-0,85596624	-1,0329938	-0,82872701	-0,985529646	-1,707443343	-0,86934034
-0,874558946	-1,1992441	-0,94180495	-1,143114482	-0,322118186	-1,18024131
-0,769413248	-1,2586488	-1,05592716	-1,280608263	1,54904886	-1,35612397
-0,606376016	-1,1430611	-1,16276363	-1,327336587	1,154843979	-1,2759424
-0,450897037	-0,9377955	-1,24111075	-1,239815035	1,590425277	-0,89612116
-0,318265038	-0,7161139	-1,27160445	-1,049949767	1,183716099	-0,5729269
-0,205328199	-0,5053324	-1,24508647	-0,810097919	0,885765592	-0,34335618
-0,120279662	-0,3264085	-1,16438155	-0,559760587	0,576932366	-0,04932308
-0,059292748	-0,183113	-1,04196234	-0,324879589	0,413476197	0,19029933
-0,013655621	-0,0721971	-0,89230045	-0,119383728	1,0248292	0,33079744
0,019265796	0,02054564	-0,73060562	0,051776081	0,750182942	0,45347308
0,042620114	0,10206095	-0,56859911	0,190756778	0,52231057	0,55448634
0,059505996	0,16974206	-0,41354453	0,302779149	0,331723928	0,63856698
0,072882283	0,2235156	-0,26955845	0,392612697	0,246731208	0,65567865
0,083543852	0,264955	-0,1389703	0,463896915	0,236133657	0,68841469
0,09246483	0,29658506	-0,02269308	0,51943145	0,206554921	0,72885451
0,101590879	0,32060446	0,079455761	0,561565166	0,007180327	0,75973539

- **<u>Yin-Wong Cheung and Lilian K. Ng test</u>**

As we proceed through the analysis of the computed results of the particular methodology we see an interest fact. In contrast with the previous methodology here the majority of the considered markets have none causality with each other. So we will present only the markets that developed causality, the total number of tables that were formed by the computed results is 242. From the theory we know that in Yin-Wong Cheung and Lilian K. Ng test the causality is verified only if the p-value in a particular lag is below five percent (0, 05) because the null hypothesis supports the non causality behavior between two variables. In this case we present the tables with all the lags that we have computed and have marked with red color the lags that show causality (Tables 2.1 to 2.14). The arrows indicate the direction of the causality test because is one way, for example in table 2.1 we have Pb → Fs meaning that in the particular test we test the hypothesis that the bond market of Portugal (Pb) Granger causes the stock market of France (Fs). According to the colored lags we see that in bandwidths four and nine the hypothesis that the bond market of Portugal Granger causes the stock market of France, given an information set, improves the forecast of the latter based only in its past information is being supported strongly. Below we present the tables 2.1 and 2.2 that analyze the behavior of the Portugal bond market with the stock markets.

Table 2.1

Portugal bond(Pb)-Stock of France(Fs)		
lags	Pb→Fs	Fs→Pb
1	1,71911206	-0,501402075
2	1,09660008	1,356814033
3	0,3580248	0,225098697
4	0,00126259	0,026231498
5	-0,8310952	-0,768702578
6	-0,5786059	0,772318715
7	1,12785713	-0,857883896
8	-0,1339384	1,014971273
9	-0,0209355	-0,489841869
10	-0,9637942	-0,960558058
11	1,21892593	-0,91299556
12	0,45106374	-1,047146327
13	0,45252588	-0,024144853
14	0,38933339	-1,308101985
15	-0,5801445	0,270819972
16	0,19622928	-1,300275577
17	-0,6320049	-0,01988382
18	-1,0374524	0,159415056
19	0,93338437	-0,293205618
20	-1,0750528	-0,116001137

Table 2.2

Portugal bond(Pb)-Stock of Spain(SPs)		
lags	Pb→SPs	SPs→Pb
1	2,66497172	-0,418700865
2	1,17394283	0,450059048
3	0,49087108	1,264207288
4	0,35043123	0,319761871
5	0,20276863	-0,301647518
6	0,39564747	1,638523082
7	1,34382251	-0,571933665
8	1,23322691	0,335795691
9	-0,1967583	0,082855577
10	-0,2635707	-0,486390842
11	0,15513479	-0,190024896
12	0,20583388	-0,344676831
13	-0,7448489	-0,968758797
14	1,64169114	-0,319781839
15	-0,5639571	-0,312602886
16	-0,2957162	-0,77350055
17	0,02806113	0,022853836
18	-0,2365837	-0,139291428
19	0,90503752	0,014931845
20	-0,8911931	-0,661520632

<u>UK bond market</u>

Below we present the tables that referred to the bond market of England (tables 2.3 to 2.12). In table 2.5 for example we see the third column that checks the hypothesis that the German stock market (GERs) has effect on the above mention bond market (GERs → UKb). In lags eight to twenty we see that the above hypothesis is strongly supported, meaning that the null hypothesis is rejected.

Table 2.3

UK bond(UKb)-Stock ofAustria(As)		
lags	UKb→As	As→Ukb
1	-0,4228292	-0,547554591
2	-0,3875293	-0,498361266
3	-0,3597167	-0,065986469
4	-0,049557	-0,032465648
5	0,38070584	0,352180936
6	0,77682203	-0,494815245
7	0,65906613	-0,038516183
8	-0,5237355	-0,447025462
9	-0,466997	-0,45815781
10	1,587208	0,005879565
11	-0,5503931	0,009568958
12	-0,3957281	0,014373692
13	-0,2212084	0,019354521
14	-0,5470802	0,006830716
15	-0,0262664	0,00574217
16	-0,0759169	0,026537823
17	-0,5364112	0,016866415
18	-0,4074211	0,008763614
19	0,58859661	-0,001657144
20	-0,4184505	-0,000920238

Table 2.5

UK bond(UKb)-Stock of German(GERs)		
lags	UKb→GERs	GERs→Ukb
1	-0,5525232	-0,541789166
2	-0,5725366	-0,311188486
3	-0,3999856	0,124607114
4	-0,5425072	0,16954313
5	-0,2819581	-0,341586648
6	0,01267367	-0,271718367
7	-0,4464206	-0,528297783
8	1,5405779	0,025141104
9	2,25988944	0,010588439
10	-0,1209945	0,015957902
11	0,21297943	-0,001466633
12	0,384877	-0,0039726
13	-0,5731703	0,001385489
14	-0,5772628	0,010068552
15	4,86887446	0,007998996
16	0,32644076	0,032503044
17	-0,5629129	0,014989207
18	-0,4996811	0,009934207
19	-0,3148025	-0,002388259
20	0,10211665	0,008693123

Table 2.6

UK bond(UKb)-Stock of Greece(GREs)		
lags	UKb→GREs	GREs→Ukb
1	0,10942759	-0,485806273
2	-0,0829711	-0,249686264
3	0,32210115	-0,490031925
4	-0,4807178	-0,48214493
5	-0,5060925	0,719336651
6	4,59814192	0,94102367
7	-0,4446264	-0,489808913
8	-0,4932	-0,458858013
9	1,64135483	1,788670538
10	2,08527431	0,0225399
11	1,17550272	0,016966887
12	-0,3951154	0,011201052
13	0,04457473	0,02763677
14	-0,5180294	0,015883267
15	-0,491528	0,017319834
16	-0,4551597	0,005850752
17	-0,314126	0,018090885
18	-0,1607162	0,014843323
19	-0,232112	0,001834551
20	0,18011368	0,011083908

Table 2.7

UK bond(UKb)-Stock of Ireland(IRIs)		
lags	UKb→IRIs	IRIs→Ukb
1	-0,0503268	-0,44656409
2	-0,4283973	-0,201432521
3	0,13902694	0,016793981
4	-0,1638575	0,194227688
5	-0,4258448	-0,409874804
6	-0,2291607	-0,418295258
7	-0,3925762	-0,457171117
8	-0,4625827	0,002903351
9	-0,3867734	0,012113933
10	0,59942923	0,031902402
11	-0,4526308	0,021644521
12	-0,3668655	0,000602506
13	-0,2767269	0,001977414
14	0,63105798	0,00453645
15	-0,4350616	0,005323528
16	-0,4732863	0,008070313
17	-0,4563174	0,01361961
18	0,07140809	0,001759912
19	-0,3329163	-0,010272052
20	0,79810048	0,014074176

Table 2.8

UK bond(UKb)-Stock of Italy(ITAs)		
lags	UKb→ITAs	ITAs→Ukb
1	-0,3297565	-0,496795314
2	-0,5933927	-0,366211132
3	-0,5584465	1,229529533
4	-0,5762868	1,149163578
5	-0,5217407	2,817452017
6	-0,5001838	-0,460924003
7	-0,5630944	0,407680683
8	4,07618717	0,022966634
9	3,19178756	0,018794903
10	5,82208236	0,039712103
11	1,44606487	0,020753664
12	0,24756378	0,012084137
13	0,15206851	0,017575245
14	-0,5915282	0,019693003
15	0,01621671	0,020009453
16	-0,5736916	0,053289561
17	-0,5564219	0,027744681
18	-0,5775582	0,013122238
19	-0,2620063	0,003431387
20	0,28105331	0,006100833

Table 2.9

JK bond(UKb)-Stock of Netherland(NETHs		
lags	JKb→NETHE	NETHEs→Ukb
1	-0,580947	-0,541438347
2	-0,5864329	-0,503234091
3	-0,5686012	-0,558331514
4	-0,5463816	0,18031992
5	-0,2830447	0,625085232
6	-0,4024683	-0,341304121
7	-0,5442366	-0,454319129
8	0,60248337	0,011827366
9	-0,4487477	0,009573077
10	17,3928122	0,039642323
11	0,52960115	0,010196584
12	-0,5538721	0,010281189
13	-0,5398309	0,022587731
14	4,96387992	0,015778785
15	-0,5530897	0,031394782
16	-0,2969834	0,026377294
17	-0,5340277	0,015636575
18	-0,1386476	0,020988764
19	-0,0892254	0,010752134
20	-0,2353952	0,029280279

Table 2.10

UK bond(UKb)-Stock of Portugal(PORTs)		
lags	UKb→PORTs	PORTs→Ukb
1	0,51495901	-0,50460544
2	0,04043144	-0,447208491
3	-0,3842368	-0,240246918
4	-0,4932741	-0,514694282
5	-0,3525836	-0,366256602
6	-0,4214792	0,75961672
7	-0,2828202	0,230523967
8	1,15415048	0,024884822
9	2,91683136	-0,001568762
10	11,6804743	0,012136752
11	1,11341851	-0,002448426
12	-0,3482071	0,005777625
13	-0,2730689	-0,001798427
14	-0,5208775	0,039371619
15	-0,1716326	0,009575312
16	-0,0989659	0,037456553
17	-0,4468689	0,009164805
18	0,6100876	0,012995311
19	-0,4967354	0,000620662
20	-0,5137062	0,020099295

Table 2.11

UK bond(UKb)-Stock of UK(UKstock)		
lags	UKb→UKstocks	UKstocks→Ukb
1	0,181607028	-0,567307564
2	0,346095349	-0,131405789
3	-0,59560669	-0,427511482
4	-0,587401445	-0,547996953
5	-0,55836201	-0,276854372
6	-0,591811646	-0,511285504
7	-0,426791789	-0,491497341
8	-0,376716584	0,005037751
9	-0,114204015	-0,008227882
10	5,677934431	0,043003432
11	0,326732532	0,002446199
12	-0,548769436	0,006119362
13	0,624346377	0,002053672
14	0,711877441	-0,004694127
15	-0,595634734	0,01433887
16	-0,618370626	0,03728844
17	-0,578149623	0,010749015
18	-0,162644653	0,013003778
19	-0,40272342	-0,00296994
20	0,014608953	0,040538215

Table 2.12

UK bond(UKb)-Stock of US(USs)		
lags	UKb→USs	USs→Ukb
1	-0,524570184	-0,483431726
2	-0,52995572	-0,266077901
3	-0,178823515	-0,305271958
4	-0,389131338	-0,157622574
5	-0,524163234	-0,523534415
6	-0,440425774	-0,479141944
7	-0,418242777	-0,106886652
8	0,20245287	0,018035877
9	0,425930552	0,008965876
10	2,967932902	0,039437687
11	-0,457873236	-0,01028916
12	-0,205028946	0,025064885
13	0,769028496	0,01265785
14	-0,037119748	0,000901251
15	-0,536609399	0,000513904
16	-0,407374562	0,003146941
17	-0,074430051	0,038539125
18	-0,056234041	0,008716016
19	0,138827254	0,013316592
20	-0,522178715	0,037920641

US bond market

Finally we have the bond market of US that developed only with two stock markets causality, the Greek and the Irish.

Table 2.13

US bond(USb)-Stock of Greece(GREs)		
lags	USb→GREs	GREs→USb
1	-0,505834543	2,154654556
2	0,583248825	0,133984508
3	0,888439151	0,238861483
4	-0,675544208	0,25087918
5	-0,799969693	0,139796921
6	-0,421017743	0,204274875
7	-0,854966877	0,802101102
8	2,293317972	0,185567903
9	-0,414257923	-0,201216211
10	0,497545092	0,352711004
11	1,338925056	0,209672856
12	-0,326072077	0,198958849
13	-0,733753828	-0,010279693
14	4,186822952	-0,00196253
15	-0,469885575	0,004311674
16	-0,480203064	0,107159817
17	1,290907312	0,031857241
18	2,162379878	0,376268338
19	0,862704905	-0,019256192
20	-0,135175589	0,140364817

Table 2.14

US bond(USb)-Stock of Ireland(IRIs)		
lags	USb→IRIs	IRIs→USb
1	-0,310032676	-0,110900624
2	-0,387799771	0,50694973
3	-0,412964881	0,344015431
4	0,103273987	0,114178436
5	-0,148789058	0,010632691
6	-0,31539127	0,26147805
7	-0,595691242	0,411761663
8	-0,605402348	0,009293592
9	0,690005829	0,36643725
10	0,157284801	0,208785626
11	-0,366495701	0,035925977
12	-0,299641583	0,093506743
13	-0,268323249	0,359333891
14	-0,168428184	0,144222562
15	-0,47314507	-0,09326031
16	-0,586843994	-0,01898492
17	-0,597171415	0,039262088
18	0,805879056	0,433223443
19	-0,574426536	0,034629685
20	-0,307266817	0,002931876

- **<u>Sub-sample analysis</u>**

At first we see the changes in the causality among the markets through two major events, the creation of Eurozone and the sub-prime crisis of 2008 (*<u>sub-sample analysis between stock and bond markets</u>*). In order to adjust the data, that we have collected, in this analysis we must take three subtotals. First we have the period before the creation of Eurozone, second we have the period of the Eurozone but before the crisis and third we have the period of the crisis. Because in this section we analyze only the markets that took part in the Eurozone, so as to have a clear view of the effect of the latter in these markets, we didn't take notice the markets of US and UK. An important notice is that we concentrate our analysis only in the Eurozone so we shift the beginning of the crisis from 2008 to 2009 because in the particular year the crisis begun to have major impact on the European continent, so as on the Eurozone. We will introduce three tables (3.1 to 3.3) in the form of heat maps; the particular form of map and his characteristics have been analyzed thoroughly in the above sections. The heat maps were based on the analytical tables that we created from the computed results of our analysis. The total number of the analytical tables is 243. (For the analytical tables that include the results of the particular analysis see Appendix). After each heat map that we introduce we present also the detailed map that comes from the computed results in the same philosophy as the **<u>table 1.2</u>**

Table 3.1

			Before the Eurozone						
	Austria	*France*	*Germany*	*Greece*	*Ireland*	*Italy*	*Netherlanc*	*Portugal*	*Spain*
Austria									
France									
Germany									
Greece									
Ireland									
Italy									
Netherlands									
Portugal									
Spain									

Table 3.1.1

				stocks						
		Greece	Austria	Ireland	France	Germany	Italy	Spain	Portugal	Netherlands
bonds	Greece	–	–	–	→	–	← ↔ →	–	–	–
	Austria	–	–	–	–	–	–	↔	←	←
	Ireland	–	–		–	–	←	–	–	–
	France	–	–	–	–	–	–	↔	–	–
	Germany	↔	↔	↔ →	↔ ←	↔	↔	↔ ←	↔ ←	↔ →
	Italy	–	–	–	–	–	← ↔	↔	←	← ↔
	Spain	–	–	–	–	–	–	–	→	–
	Portugal	←	–	–	↔	–	← ↔	↔	← →	← ↔ →
	Netherlan	↔	↔	↔ →	↔ ←	↔ ←	↔	↔ ←	↔ ←	↔ →

We observe among the three tables that overall there is no strong causality among the markets. From the 18 markets few were developed causality with each other. A significant observation is that even in the period of the crisis (**Table 3.3)** there weren't any major changes in the causality that had already been among the markets. In addition we see that the causality was stronger in the period before the Eurozone (**Table 3.1)** than in any other table. As for the few cases that we observe causality between two markets we can say that is a results of the flight to quality phenomenon, meaning that in periods of high volatility in markets the investors tend to move their investments into safer places, such as the bond markets.

Table 3.2

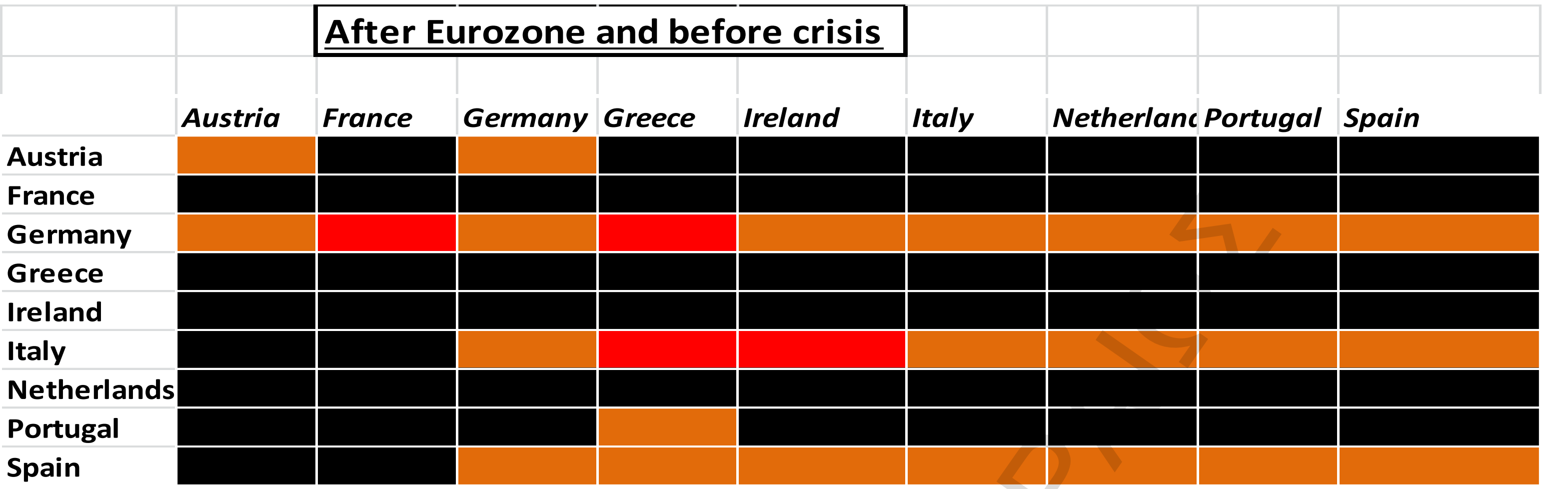

Table 3.2.1

					stocks					
		Greece	Austria	Ireland	France	Germany	Italy	Spain	Portugal	Netherlands
bonds	Greece	–	–	–	–	–	–	–	–	–
	Austria	–	→	–	–	→	–	–	–	→
	Ireland	–	–	–	–	–	–	–	–	–
	France	–	–	–	–	–	–	–	–	–
	Germany	↔ →	↔	↔	↔ ←	↔	↔	↔	↔	↔
	Italy	↔ →	–	↔	–	↔	↔	↔	↔	↔
	Spain	↔	–	↔	–	↔	↔	↔	↔	↔
	Portugal	→	–	–	–	–	–	–	–	–
	Netherlan	–	–	–	–	–	–	–	–	–

Table 3.3

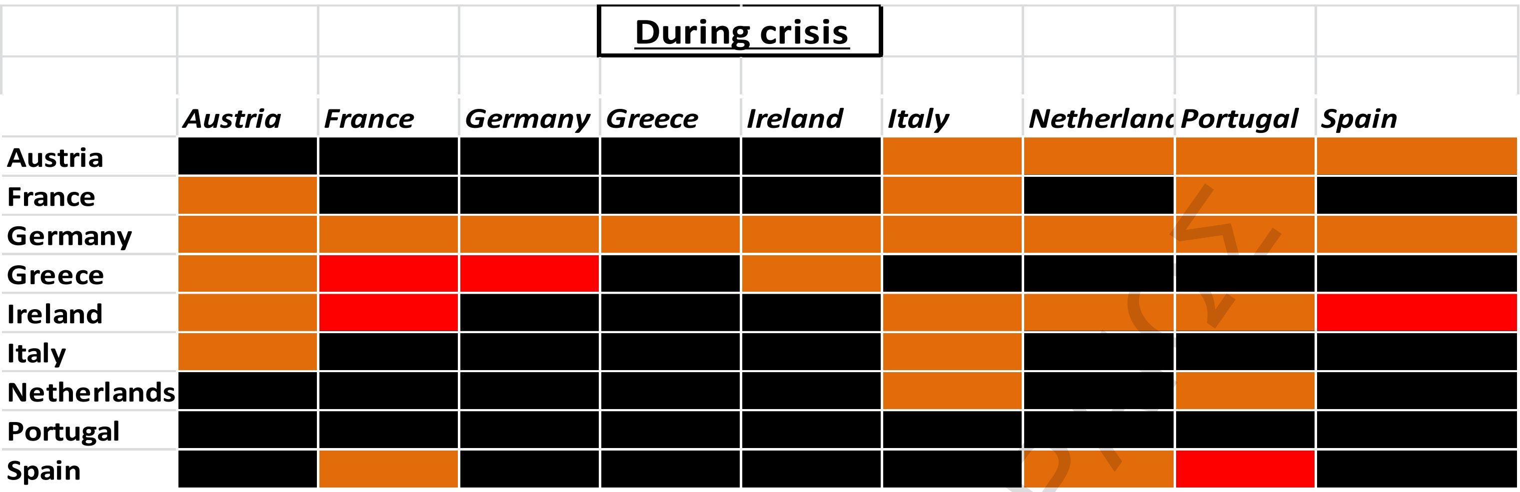

Table 3.3.1

				stocks						
		Greece	Austria	Ireland	France	Germany	Italy	Spain	Portugal	Netherlands
	Greece	–	←	←	←	↔ ←	–	–	–	–
	Austria	–	→	–	–	–	→	←	←	–
	Ireland	–	↔	–	↔ ←	↔	–	–	↔	↔ ←
	France	–	←	–	–	–	→	–	←	←
b o n d s	Germany	↔	↔	↔	←	↔	↔	↔	↔	↔
	Italy	–	←	–	–	–	→	–	←	←
	Spain	–	–	–	↔	–	–	–	→ ↔	↔
	Portugal	–	–	–	–	–	–	–	–	–
	Netherlan	–	–	–	–	–	→	–	←	–

Now we will see the changes in the causality that developed the bond markets of the countries through the same two major events (*sub-sample analysis among bond markets*). The reason to do that is to see if the causality in the markets of the same asset differs from the causality among markets with different assets. Another reason is to see which of the two analyses is best for an investor to choose if he want to have a portfolio that is diversified. The tables 3.4-3.6 are in the same form as above. The total number of tables that were used to form the heat maps is 108. Also here we introduce the detailed maps as we did with the previous analysis.

Table 3.4

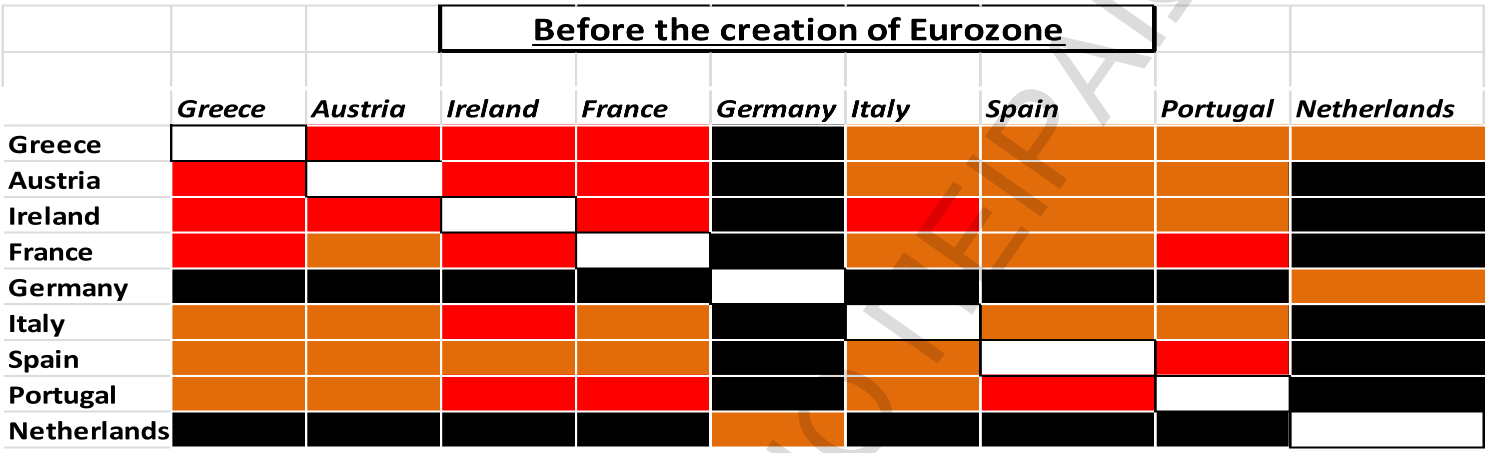

Table 3.4.1

	Greece	Austria	Ireland	France	Germany	Italy	Spain	Portugal	Netherlands
Greece		← ↔	→ ↔	→ ↔	–	↔	→	←	→
Austria	← ↔		→ ↔	↔	–	↔	↔	↔	–
Ireland	→ ↔	→ ↔		← ↔	–	← ↔	↔	← ↔	–
France	→ ↔	↔	← ↔		–	↔	↔	← ↔	–
Germany	–	–	–	–		–	–	–	↔
Italy	↔	↔	← ↔	↔	–		↔	↔	–
Spain	→	↔	↔	↔	–	↔		← →	–
Portugal	←	↔	← ↔	← ↔	–	↔	← →		–
Netherlands	→	–	–	–	↔	–	–	–	

At this particular table we have the results for 9 bond markets of the Eurozone, but before the creation of the latter. We see that the causality is strong among the markets and we have few cases of non causality, as for example the bond market of Greece and the bond market of Netherlands. In this table and the **table 3.6** we can say that the strong causality that is being displayed among markets may be a result of the flight to quality phenomenon. In these cases where the risk is high and even higher in periods of crisis, the investors seek markets to secure their investments. As we know the bonds are known as safe investments in contrast to stocks.

Table 3.5

	After the creation of Eurozone and before the crisis								
	Greece	*Austria*	*Ireland*	*France*	*Germany*	*Italy*	*Spain*	*Portugal*	*Netherlands*
Greece									
Austria									
Ireland									
France									
Germany									
Italy									
Spain									
Portugal									
Netherlands									

Table 3.5.1

	Greece	Austria	Ireland	France	Germany	Italy	Spain	Portugal	Netherlands
Greece		–	–	–	–	–	–	–	–
Austria	–		–	–	–	→ ↔	–	↔	↔
Ireland	–	–		–	–	–	–	–	–
France	–	–	–		–	–	–	–	–
Germany	–	–	–	–		↔	↔	–	–
Italy	–	← ↔	–	–	↔		↔	–	–
Spain	–	–	–	–	↔	↔		–	–
Portugal	–	↔	–	–	–	–	–		↔
Netherlands	–	↔	–	–	–	–	–	–	

In contrast with the above table here we see that the majority of the markets didn't developed causality with each other. In this case we can say that real economic integration with the EMU and the reduction in currency in risk with the Euro have generally stimulated inter financial market integration. In the previous table the markets have the currencies of their countries so they have different risk, in the other hand as they introduced themselves in the Eurozone they behaved as integrated owing to Euro. So there were few possibilities that they would develop causality among them.

Table 3.6

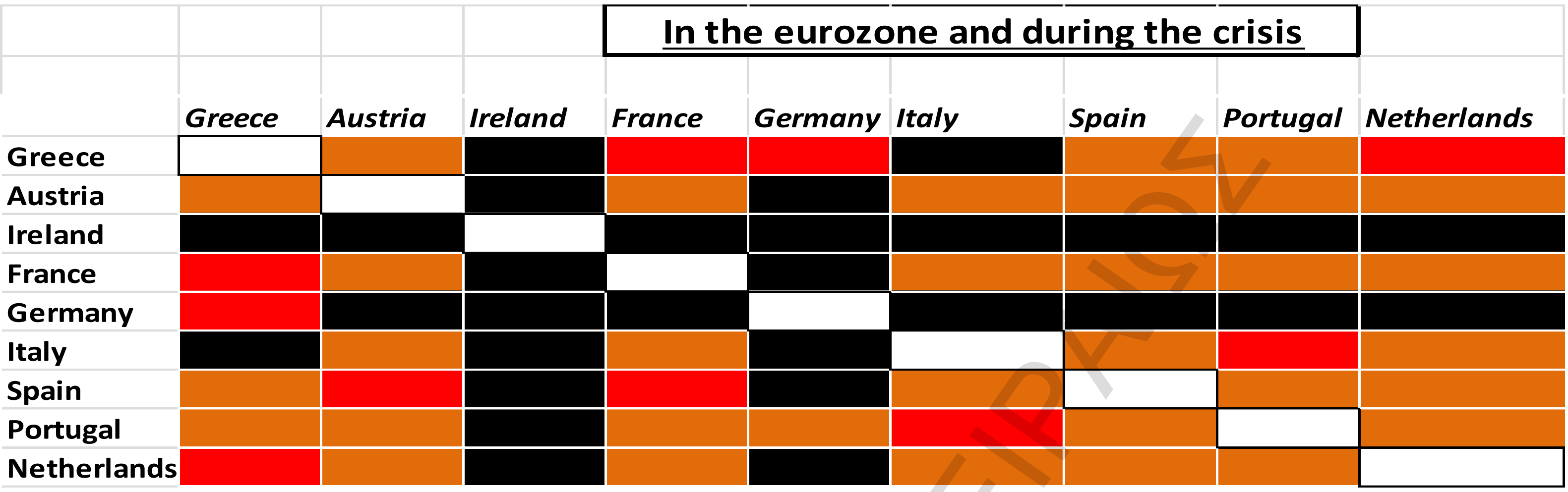

Table 3.6.1

	Greece	Austria	Ireland	France	Germany	Italy	Spain	Portugal	Netherlands
Greece		→	–	→ ↔	→ ↔	–	↔	↔	↔
Austria	→		–	↔	–	↔	↔	↔	↔
Ireland	–	–		–	–	–	–	–	–
France	→ ↔	↔	–		–	↔	↔	↔	↔
Germany	→ ↔	–	–	–		–	–	–	–
Italy	–	↔	–	↔	–		↔	← →	↔
Spain	↔	↔	–	↔	–	↔		↔	↔
Portugal	↔	↔	–	↔	–	← →	↔		↔
Netherlands	↔	↔	–	↔	–	↔	↔	↔	

In the last table we see the effect of the crisis in the bond markets. As we observe the causality is strong in the majority of the markets. Two reasons that we see this phenomenon are, among others, first we have the domino theory meaning that if one country bankrupts then almost immediately the investors think that a country with similar characteristics goes next, a proper example is the countries that consist the PIIGS. Second it may exist a country with strong economy that constitutes benchmark for the whole union, so her bond market affects the bond markets of the other countries. A perfect example of strong economy is the economy of Germany and as a sequence the bond market of the country is the benchmark for spreads of the whole union's bond markets.

Conclusion

In this particular essay we try to investigate the existence of the volatility spillover between equity and bond markets. To do so we use two methodologies which were actually causality tests, Hong's test and Yin-Wong Cheung's and Lilian K. Ng's test. The data which have collected was from twenty two markets, eleven bond and eleven stock markets which were formed eleven countries. Then we split the sample period into three subtotals to analyze the changes on causality among the above mentioned markets through two major events; the creation of Eurozone and the subprime crisis of 2008. The changes were analyzed also exclusive for the bond markets to observe any difference from the above when the markets referred to the same asset, such as the bond markets. From the two above analyses also we try to examine in which case a portfolio can be diversified. We came to some conclusions which we introduce below:

- According to which methodology we used we got different results.
- The Yin-Wong Cheung and Lilian K. Ng's test rejected the alternative hypothesis of causality in almost any given test between a bond and a stock market in contrast to Hong's test where there were some cases of causality between the above markets. One reason is that the Cheung and Ng's test has a major disadvantage; it can't distinguish the recent past volatility of the distant past volatility of an asset. As we know recent past volatility has greater impact on current volatility than distant past volatility, in terms of causality that means that current volatility of an asset is affected more by the recent past volatility of another asset than by the distant past volatility of the same asset. This is a significant problem especially when in the sample exist periods of crisis.
- As for the analysis that we make exclusively for the bond markets we observed strong causality among the markets in all periods except the period that we marked as the Eurozone period.
- From the above we can conclude that in a period of crisis the investors don't shift their funds to markets with different assets but in different markets of the same asset that they have been invest on. Also from the same analysis we conclude that in a period high volatility in a particular market the markets with the same type of asset tend to experienced causality in variance with the above market but also among them, in contrast to markets with different type of asset (stock markets).
- We see that in the beginning of the Euro in both analyses investors have better differentiated between individual markets than before, but in a period of crisis the above advantage apply only among markets with different assets.

- As for the diversified portfolio from the three above conclusions we can say that in under some circumstances a portfolio can be diversified by shifting funds from a bond market to a stock market or the opposite, regarding of course the causality relations that have been developed between some of the variables.

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Appendix

Hong's test

Below we present some of the tables that contain our results. As total we have 363 tables, we present some of them the others follow the same pattern. We remind that the title **causality 1to2** is referred to the one way test that checks if a particular bond market Granger causes a particular stock market, the title **causality 2to1** denotes the exactly opposite.

Austria bond market and stock market of US

		Causality from 1to2				
Bandwith	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	-0,754701918	NaN	NaN	NaN	-0,7031799	-1,71052
2	-0,808277335	-0,7031799	-0,7031799	-0,703179925	-0,9870611	-0,81106
3	-0,983619634	-0,8501666	-0,715379	-0,775361284	-1,0571612	-0,95539
4	-1,119969569	-0,9630931	-0,7820878	-0,901675699	-1,2641653	-1,05331
5	-1,237335772	-1,0588269	-0,8723537	-0,998993296	-1,421169	-1,16038
6	-1,332529787	-1,1510239	-0,9511286	-1,083313129	-1,3314392	-1,25778
7	-1,406372364	-1,2274328	-1,0196259	-1,162836456	-1,4766095	-1,34185
8	-1,465103958	-1,2904344	-1,0818384	-1,233289794	-1,4653011	-1,44
9	-1,518157402	-1,3451703	-1,139955	-1,29352134	-1,5170564	-1,48991
10	-1,569028328	-1,3924794	-1,193623	-1,345205156	-1,5353882	-1,53513
11	-1,619973428	-1,4341711	-1,242653	-1,389915816	-1,6672124	-1,5778
12	-1,669948154	-1,4729289	-1,2867777	-1,429075071	-1,7605974	-1,62884
13	-1,721000444	-1,5111386	-1,3262578	-1,464241503	-1,8577044	-1,66052
14	-1,773903712	-1,549526	-1,3617892	-1,49701864	-1,914476	-1,69542
15	-1,829108742	-1,5880436	-1,3941925	-1,528690933	-2,0156756	-1,69888
16	-1,885330684	-1,62671	-1,4240656	-1,560090208	-2,0351221	-1,71536
17	-1,940403184	-1,6652123	-1,4519585	-1,591686301	-2,1420607	-1,75153
18	-1,993643132	-1,7034443	-1,4783675	-1,623669061	-2,2328472	-1,81551
19	-2,046238606	-1,7417995	-1,5037361	-1,656069479	-2,3263646	-1,88679
20	-2,099119123	-1,7804321	-1,528402	-1,688889781	-2,4185531	-1,93434

		Causality form 2to1			
Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
-0,61650594	NaN	NaN	NaN	-0,58375636	-5,48403
-0,65256092	-0,58376	-0,5837564	-0,583756357	-0,81863057	-0,65057
-0,728044805	-0,70551	-0,5938637	-0,643554855	-0,75008359	-0,81359
-0,875747343	-0,77688	-0,6487158	-0,742060899	-1,00111106	-0,35462
-0,82597396	-0,83835	-0,7186329	-0,801864704	-1,16931193	-0,68888
-0,397629864	-0,90997	-0,7729719	-0,854875746	3,128291154	-1,03223
0,121779801	-0,75742	-0,8162185	-0,892319726	2,732700907	-0,83484
0,579147456	-0,42258	-0,8476837	-0,800766811	2,313365727	-0,52142
0,912182546	-0,08436	-0,8481771	-0,562125966	1,964178077	-0,02333
1,13755413	0,206125	-0,7987354	-0,245617863	1,745998287	0,401981
1,29407543	0,442038	-0,6938295	0,083544208	1,469274369	0,658496
1,393036276	0,628095	-0,5382205	0,387142869	1,203286292	0,870113
1,434731982	0,770464	-0,3441287	0,648398122	1,135134269	1,052345
1,425138569	0,878081	-0,1320526	0,862912131	0,938090128	1,295805
1,382380473	0,958414	0,08057118	1,032905694	0,724225324	1,451555
1,323499084	1,015714	0,28238538	1,163504912	0,610013364	1,525996
1,259736834	1,054219	0,46687812	1,260435084	0,473076491	1,587257
1,202320143	1,077761	0,63106638	1,329141434	0,293609917	1,568431
1,157201879	1,088809	0,77416442	1,374498536	0,141446429	1,464461
1,123014566	1,089256	0,89676347	1,400659691	0,03654934	1,363897

		Billateral			
Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
-0,26741501	-0,2421234	-0,24212344	-0,242123435	-0,882762802	-0,24212344
-0,413174276	-0,5315463	-0,32128409	-0,531546348	-1,250245142	-0,72635899
-0,531700114	-0,8012315	-0,59222279	-0,815908153	-1,274586268	-1,05559706
-0,654011785	-0,9922874	-0,79459198	-1,019985248	-1,590829462	-0,93526414
-0,727945828	-1,1433377	-0,95297804	-1,160493422	-1,819432567	-1,22656464
-0,688058247	-1,2831377	-1,07587797	-1,276313079	1,153425323	-1,52328988
-0,593666129	-1,2776963	-1,17557732	-1,372722347	0,795437313	-1,47629699
-0,492022944	-1,1436372	-1,25789295	-1,378936973	0,522939028	-1,35492915
-0,412808179	-0,9886065	-1,31464488	-1,280346234	0,252093601	-1,07558836
-0,359604958	-0,8484885	-1,33449576	-1,120329781	0,092417032	-0,83247905
-0,325297191	-0,7325336	-1,31355597	-0,942162799	-0,1874393	-0,6935087
-0,308757195	-0,6421944	-1,25424306	-0,772805531	-0,434593704	-0,5874652
-0,313065492	-0,5768931	-1,16425738	-0,625588391	-0,548027864	-0,48674293
-0,338271178	-0,5325923	-1,0571844	-0,50559417	-0,723401317	-0,34629153
-0,378884483	-0,5052166	-0,94510903	-0,413073416	-0,941857508	-0,2425239
-0,42825241	-0,4925043	-0,83625162	-0,345804058	-1,034490511	-0,20166038
-0,481025637	-0,4918059	-0,73570386	-0,300722789	-1,204110132	-0,1828933
-0,532018071	-0,5007435	-0,64619059	-0,2746159	-1,392400659	-0,23722233
-0,578804908	-0,5180794	-0,56889951	-0,264436947	-1,563801669	-0,35467934
-0,621999886	-0,542749	-0,50397387	-0,267527893	-1,70146668	-0,45428836

Bond market of France and stock market of UK

		Causality from 1to2				
Bandwith	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	0,093837603	NaN	NaN	NaN	0,10302926	11,42643
2	0,072309777	0,10302926	0,10302926	0,103029259	-0,0302648	0,142745
3	0,044988187	0,06458641	0,10042096	0,086295755	0,08052761	0,031281
4	0,000769779	0,05315698	0,08511102	0,055175701	-0,2781871	0,044436
5	-0,06630836	0,01963488	0,06474656	0,039985288	-0,1278666	0,016112
6	-0,074552162	-0,0201162	0,04839425	0,010262862	-0,1739941	-0,1083
7	-0,046432257	-0,0490628	0,03189213	-0,025902503	0,47089568	-0,17527
8	-0,022500187	-0,0472625	0,0114456	-0,055843778	0,21246586	-0,17103
9	-0,017761702	-0,0243213	-0,0117514	-0,067247268	-0,0004313	-0,1347
10	-0,03399837	-0,0058517	-0,032172	-0,059404329	-0,1712321	-0,10292
11	-0,065421013	0,00180024	-0,0458404	-0,041909569	-0,3384318	-0,0974
12	-0,109732405	-0,0018242	-0,0520241	-0,02407142	-0,5195675	-0,09788
13	-0,163976523	-0,0159724	-0,051793	-0,011722008	-0,4996747	-0,09979
14	-0,224758407	-0,0371652	-0,0468346	-0,007650413	-0,6354354	-0,10484
15	-0,287761444	-0,0628214	-0,0391603	-0,012284141	-0,7434552	-0,14001
16	-0,351093796	-0,0924612	-0,0312842	-0,024750456	-0,8842083	-0,19977
17	-0,417149311	-0,1256523	-0,0252233	-0,043850854	-1,0275667	-0,21333
18	-0,484518408	-0,1622231	-0,0221484	-0,068462245	-0,9884777	-0,26925
19	-0,553307087	-0,2007638	-0,0226608	-0,09765812	-1,1052903	-0,29911
20	-0,62295859	-0,2402303	-0,0269186	-0,130577285	-1,2315603	-0,33302

		Causality form 2to1			
Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
0,166270323	NaN	NaN	NaN	0,218945689	-11,7607
0,110894633	0,218946	0,21894569	0,218945689	-0,29718721	0,092337
-0,157656068	0,057386	0,20754976	0,147021717	-0,62019065	-0,04866
-0,417621218	-0,12525	0,13936447	-0,01855879	-0,89027864	-0,21525
-0,630618017	-0,29608	0,02530785	-0,192391241	-1,09013378	-0,4272
-0,775023029	-0,45123	-0,0989472	-0,355309879	-0,94994587	-0,63464
-0,888577154	-0,57508	-0,2218695	-0,502359878	-1,03182734	-0,75705
-0,993909882	-0,66971	-0,3379113	-0,625766733	-1,20999867	-0,83038
-1,086695439	-0,75073	-0,4445752	-0,724646915	-1,37642905	-0,91503
-1,165877819	-0,82678	-0,5398941	-0,80547519	-1,49150644	-1,02575
-1,237393134	-0,90023	-0,6238296	-0,875554136	-1,52763465	-1,10749
-1,305856962	-0,97016	-0,6971871	-0,939881448	-1,42652546	-1,12276
-1,368997628	-1,03354	-0,7616353	-1,000795432	-1,47296875	-1,21913
-1,429077807	-1,08973	-0,8192647	-1,058551433	-1,53312478	-1,21397
-1,481718346	-1,14058	-0,8719272	-1,112648507	-1,65302164	-1,32388
-1,531727698	-1,18804	-0,9209055	-1,162826399	-1,77228955	-1,38764
-1,582695587	-1,2338	-0,9670629	-1,209299619	-1,84817776	-1,35593
-1,629224364	-1,27858	-1,0108577	-1,252650544	-1,94945834	-1,4169
-1,672171297	-1,3227	-1,0525801	-1,293580973	-1,88074162	-1,51659
-1,717043489	-1,36558	-1,0923752	-1,332740596	-1,82239748	-1,55983

		Billateral			
Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
0,504824583	0,50018254	0,500182541	0,500182541	0,474706836	0,50018254
0,514879375	0,54746292	0,51828119	0,547462923	0,016675703	0,5162971
0,465343525	0,46670167	0,545532145	0,493619249	-0,164130471	0,34504354
0,388822734	0,34291132	0,496955126	0,357312482	-0,612096769	0,21088452
0,300768619	0,20012147	0,405289298	0,216726239	-0,670199482	0,03085978
0,2349526	0,05723987	0,303142787	0,072782343	-0,624670876	-0,20474013
0,184685091	-0,0629628	0,199273082	-0,065309037	-0,253890445	-0,35267391
0,134916926	-0,1465825	0,096507501	-0,184061445	-0,562808678	-0,42154012
0,082408525	-0,2064326	-0,00219905	-0,274248421	-0,832663906	-0,47323079
0,026634805	-0,2630633	-0,09184957	-0,338793108	-1,03802242	-0,54190701
-0,032700787	-0,3225504	-0,1695415	-0,388285707	-1,185965461	-0,60687575
-0,09665635	-0,3852592	-0,23498548	-0,432126129	-1,248002087	-0,6303487
-0,163486052	-0,4492476	-0,28971184	-0,47593685	-1,272273039	-0,70705733
-0,232782124	-0,5121638	-0,33604905	-0,522016837	-1,413575089	-0,71723462
-0,30104021	-0,5736902	-0,37648704	-0,570565915	-1,576880223	-0,82361532
-0,369211084	-0,6348971	-0,41354185	-0,621018882	-1,762365514	-0,91517776
-0,439672306	-0,6967173	-0,44918014	-0,672856518	-1,919324864	-0,91074176
-0,509528336	-0,7596047	-0,48456984	-0,725819043	-1,966603617	-0,99689458
-0,579063365	-0,8229444	-0,52039407	-0,779834639	-2,00376138	-1,09137878
-0,650376885	-0,8857042	-0,55693893	-0,834824107	-2,054509792	-1,15003333

Bond market of Germany and stock market of Spain

Bandwith		Causality from 1to2				
	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	1,97959938	NaN	NaN	NaN	2,0201158	1,241016
2	1,903486435	2,0201158	2,0201158	2,020115803	0,96743811	2,010019
3	1,533907587	1,80166311	2,00820524	1,935750726	0,84969908	1,883458
4	1,346464699	1,58357835	1,92736441	1,701355967	1,02370956	1,486947
5	1,251388044	1,45861721	1,77672592	1,493767365	1,09663416	1,431657
6	1,176253422	1,39697238	1,62155574	1,362800268	0,72737804	1,343208
7	1,153178776	1,34619545	1,49716623	1,289805814	0,59234142	1,248167
8	1,168963003	1,28774948	1,40683959	1,240536762	1,64269234	1,160545
9	1,204078294	1,26115055	1,3429197	1,196317061	1,41514077	1,137891
10	1,245286922	1,26843854	1,29554808	1,164532285	1,43107186	1,13241
11	1,284912051	1,28661434	1,25891926	1,152638928	1,21587533	1,120777
12	1,311169444	1,30568668	1,23041121	1,158253741	1,45608859	1,185905
13	1,325888333	1,32469042	1,20913535	1,175150995	1,20440371	1,248286
14	1,335496859	1,34252032	1,19515496	1,197992193	1,38916181	1,264791
15	1,341167821	1,35834985	1,18843667	1,223089747	1,17405982	1,259257
16	1,340464582	1,37207393	1,18868508	1,24809578	0,96315772	1,26112
17	1,331003414	1,38066354	1,19510296	1,271588329	0,79925126	1,290914
18	1,313184189	1,38305543	1,20592238	1,292361174	1,00443205	1,324966
19	1,289161163	1,38158489	1,21940267	1,309405326	0,99869875	1,363651
20	1,262123952	1,37865739	1,23421097	1,322261257	0,90372703	1,382637

		Causality form 2to1			
Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
-0,729504015	NaN	NaN	NaN	-0,70538824	-1,03796
-0,744259214	-0,70539	-0,7053882	-0,70538824	-0,70391036	-0,74937
-0,803733783	-0,75466	-0,7104309	-0,733097172	-0,94450028	-0,77592
-0,94221171	-0,82316	-0,7363112	-0,778856378	-1,16577475	-0,6595
-0,926940437	-0,91168	-0,7725952	-0,842023766	-0,57820364	-0,91087
-0,765239292	-0,95181	-0,8146563	-0,913929787	0,557625081	-1,03186
-0,589970569	-0,88764	-0,8624171	-0,949765168	0,314584367	-0,94215
-0,453798925	-0,77065	-0,902766	-0,915132082	0,049335956	-0,77887
-0,365130266	-0,66292	-0,9224497	-0,824009292	-0,18201388	-0,65189
-0,323113025	-0,58053	-0,9140743	-0,710906556	-0,29369163	-0,49061
-0,316894039	-0,52246	-0,8785833	-0,601675462	-0,31980575	-0,33839
-0,323604274	-0,48224	-0,8229065	-0,509052448	-0,50005509	-0,27889
-0,329961301	-0,45646	-0,755272	-0,436525484	-0,63607041	-0,25626
-0,329261332	-0,44361	-0,6843451	-0,383325471	-0,47982835	-0,30372
-0,325190975	-0,43853	-0,616513	-0,347288142	-0,51378395	-0,34067
-0,324267857	-0,43727	-0,5554367	-0,325415409	-0,35048128	-0,34379
-0,329879306	-0,43737	-0,5028769	-0,314418371	-0,43958846	-0,30924
-0,340842312	-0,43786	-0,4592275	-0,311200463	-0,05545551	-0,24444
-0,352393139	-0,43666	-0,4241218	-0,31315231	0,001240034	-0,22689
-0,361560531	-0,43186	-0,3967155	-0,31805162	-0,15565856	-0,22661

		Billateral			
Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
153,9228943	153,95249	153,95249	153,95249	89,65889541	153,95249
151,8775558	145,4618	153,436753	145,4618004	69,03776543	133,781359
149,3727675	129,618271	141,466576	120,7374511	58,15243008	109,42985
146,9583991	116,230515	124,5058886	104,5876736	51,25242414	94,7577985
144,688408	105,718361	111,6799264	93,48779632	46,8008203	84,6532633
142,5590058	97,4250297	102,0018331	85,27591656	43,60751622	77,1913124
140,545961	90,7688467	94,4214249	78,91545954	40,40843915	71,4845751
138,6255752	85,297009	88,29628235	73,83080172	38,54071327	66,9352716
136,7819118	80,7095354	83,22875498	69,65596278	36,21125518	63,1950264
135,0033624	76,7973605	78,95711516	66,15143605	34,42575457	60,0761538
133,2840291	73,4034826	75,30025395	63,15501796	32,76886678	57,3986975
131,6218989	70,4205482	72,12774001	60,55106211	31,50277811	55,0657616
130,0176659	67,7715839	69,34283034	58,25627193	30,07444711	52,9917091
128,4723973	65,3970742	66,8722515	56,21020342	29,27387794	51,0732501
126,9817482	63,2534737	64,65980635	54,36801941	28,16563452	49,3399721
125,5388823	61,3068165	62,66250847	52,69606621	27,2837432	47,7966731
124,1382292	59,5275979	60,84653558	51,16864236	26,33256261	46,4358512
122,7774335	57,8921764	59,18473571	49,7653996	26,03236507	45,2173483
121,4567622	56,3841195	57,65517254	48,46984924	25,41253432	44,0731319
120,1765616	54,9903256	56,24027479	47,26873911	24,6298854	42,9937722

Greek bond market and stock market of Portugal

		Causality from 1to2				
Bandwith						
	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	-0,696371484	NaN	NaN	NaN	-0,7023758	-20,1265
2	-0,66295549	-0,7023758	-0,7023758	-0,702375767	-0,3161504	-0,80917
3	-0,588701456	-0,6194875	-0,6977264	-0,669885522	-0,5969136	-0,70965
4	-0,633555949	-0,5946681	-0,6677264	-0,597595857	-0,7783549	-0,67345
5	-0,736807825	-0,6276847	-0,623604	-0,579958735	-0,9927654	-0,69691
6	-0,854332643	-0,6874151	-0,597818	-0,608747429	-1,1947418	-0,76494
7	-0,985739673	-0,7621494	-0,599738	-0,664131758	-1,3149916	-0,81023
8	-1,100081688	-0,8423285	-0,6222494	-0,734487163	-1,3889314	-0,91756
9	-1,184757881	-0,9209134	-0,6588835	-0,811874873	-1,4771933	-1,04684
10	-1,247985789	-0,9954318	-0,7045416	-0,890532908	-1,5628869	-1,16031
11	-1,298112935	-1,0658203	-0,7558618	-0,967045572	-1,023121	-1,24995
12	-1,341619811	-1,1221193	-0,8101062	-1,039537149	-1,1801271	-1,30912
13	-1,381976613	-1,1629389	-0,8653938	-1,104824631	-1,3240819	-1,35143
14	-1,420010794	-1,1968226	-0,92002	-1,160303071	-1,4591013	-1,38231
15	-1,454534692	-1,2281712	-0,9726458	-1,20600639	-1,5810106	-1,44467
16	-1,488230254	-1,2591908	-1,0222285	-1,243657269	-1,6918969	-1,4918
17	-1,523431046	-1,2908879	-1,0681696	-1,275513336	-1,5845674	-1,50522
18	-1,55963529	-1,322142	-1,1102031	-1,303667683	-1,6507503	-1,54587
19	-1,597821983	-1,3520797	-1,1483624	-1,329600158	-1,6784263	-1,56742
20	-1,638060171	-1,3809886	-1,1828292	-1,354178671	-1,7614526	-1,57838

Causality form 2to1

Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
-0,329909167	NaN	NaN	NaN	-0,51982995	15,45447
-0,029545771	-0,51983	-0,51983	-0,519829953	1,6804569	-0,63724
0,730196059	0,198088	-0,4682707	-0,196836389	0,964149905	0,439509
1,345512132	0,626226	-0,1695575	0,428447007	3,221756793	0,669077
1,856707965	1,046699	0,25231338	0,831723758	2,733949951	1,106653
2,136656849	1,461904	0,60869953	1,214138453	2,209880778	1,560141
2,236726088	1,746719	0,90392262	1,583075296	1,782082386	1,916234
2,23505107	1,915889	1,17610135	1,875934438	1,614739061	2,067458
2,157370082	2,007169	1,43448733	2,074850696	1,297474262	2,236688
2,05280353	2,046626	1,66213777	2,191890939	1,118122038	2,195896
1,933557973	2,050042	1,84718344	2,246396188	0,854006952	2,148928
1,801073814	2,028289	1,98787378	2,255528572	0,649891701	2,097191
1,659112446	1,98806	2,08783213	2,232443222	0,437732611	2,048315
1,51386158	1,934514	2,15307724	2,186576264	0,234364208	1,986002
1,371097453	1,871116	2,18980064	2,124628286	0,165405025	1,903178
1,234897126	1,801569	2,20371986	2,051360226	0,047740825	1,798765
1,107157426	1,728851	2,19958209	1,970352336	-0,11946179	1,713022
0,991010272	1,654087	2,18118725	1,884405361	-0,20545181	1,603574
0,888350392	1,578231	2,15154265	1,795614069	-0,36185611	1,499289
0,800880649	1,501943	2,11311636	1,705503216	-0,44486103	1,391766

		Billateral			
Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
-0,453937758	-0,4350952	-0,43509522	-0,435095222	-0,956825523	-0,43509522
-0,511575509	-0,6982336	-0,50947797	-0,698233634	0,668154662	-0,88811005
-0,397244421	-0,5271741	-0,72856775	-0,722628657	0,075870862	-0,44275172
-0,264176498	-0,3127946	-0,70131966	-0,382336957	1,483701269	-0,26893686
-0,137026402	-0,0820852	-0,49582659	-0,121409082	1,042543876	0,00400539
-0,058665718	0,15009861	-0,28128026	0,116638283	0,568827677	0,26928821
-0,033614482	0,30739658	-0,09557508	0,336005601	0,206611371	0,49166686
-0,039688695	0,39275362	0,072625562	0,500746603	0,049249692	0,54436446
-0,067802188	0,42811181	0,227443891	0,600914941	-0,223623408	0,59025832
-0,104999286	0,42954084	0,359405346	0,645606011	-0,401970967	0,50645322
-0,149093713	0,40680694	0,461586728	0,648471181	-0,207804429	0,42992345
-0,201171824	0,37334761	0,533356546	0,621610422	-0,454493373	0,36728325
-0,260679142	0,33492338	0,577393682	0,57580261	-0,698867253	0,31552742
-0,325145278	0,28994288	0,598168698	0,519231259	-0,93184768	0,26079733
-0,391301781	0,23818582	0,600315336	0,456615964	-1,062943767	0,1698442
-0,457983556	0,18090479	0,588154692	0,390264556	-1,220669418	0,07328026
-0,524830862	0,11962304	0,565205192	0,321303301	-1,261224899	0,01093018
-0,589824426	0,05601493	0,534211676	0,25040496	-1,366289392	-0,08666178
-0,652077961	-0,008536	0,497232874	0,178144436	-1,493833873	-0,16860684
-0,710418065	-0,0736238	0,455884812	0,105097508	-1,608985174	-0,24618844

Irish bond market and stock market of Netherlands

Bandwith		Causality from 1to2				
	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	-0,376627809	NaN	NaN	NaN	-0,3654681	15,35268
2	-0,388253458	-0,3654681	-0,3654681	-0,365468102	-0,4072368	-0,3771
3	-0,417046378	-0,4055862	-0,3691498	-0,38646626	-0,3267445	0,003612
4	-0,46499884	-0,41627	-0,3880721	-0,413535437	-0,6016455	0,465701
5	-0,306675889	-0,4431813	-0,4080907	-0,422836696	-0,8361107	-0,50021
6	-0,488146774	-0,4994771	-0,4206262	-0,446459966	-1,0129787	0,728181
7	-0,791020458	-0,5716815	-0,4338666	-0,493199221	-1,2041797	1,264005
8	-0,530255566	-0,6518173	-0,4552932	-0,557021345	-1,3533139	0,439749
9	0,346248139	-0,7355163	-0,4875901	-0,631120631	-0,2702902	-0,49774
10	1,595448747	-0,7901458	-0,5290713	-0,709190346	16,1935593	-0,86915
11	2,976217758	-0,4802695	-0,5770798	-0,764178612	15,2806271	-0,62654
12	4,32651491	0,23388237	-0,6247553	-0,685528545	14,4302715	0,084835
13	5,559629719	1,09802687	-0,6556348	-0,38098744	13,8107397	1,078874
14	6,64158727	1,98817681	-0,646711	0,149874505	13,7206952	2,162974
15	7,563094147	2,85046458	-0,5769882	0,854613183	13,07591	3,267998
16	8,329445919	3,6587793	-0,4321938	1,668432053	12,487356	4,362685
17	8,956681569	4,39830914	-0,2058346	2,533676713	12,2590582	5,39589
18	9,465997059	5,06722539	0,10211788	3,40556536	11,7674025	6,270418
19	9,875095668	5,66819053	0,48679829	4,252648617	11,3204174	7,03099
20	10,19782254	6,20430962	0,93981516	5,054724664	10,8799968	7,697794

		Causality form 2to1			
Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
-0,269596714	NaN	NaN	NaN	-0,22784037	-14,4495
-0,321728723	-0,22784	-0,2278404	-0,227840365	-0,57810715	-0,20858
-0,484388365	-0,36405	-0,2382849	-0,291560432	-0,56170284	-0,38404
-0,597089908	-0,46108	-0,2973005	-0,411050817	-0,77152973	-0,48462
-0,700580414	-0,53912	-0,3800649	-0,496908388	-0,91693054	-0,62853
-0,79172041	-0,61731	-0,4515881	-0,568113558	-0,95430265	-0,65829
-0,869182381	-0,68921	-0,5109952	-0,636777381	-0,99348978	-0,57801
-0,92422977	-0,75162	-0,5641992	-0,702092688	-1,06309832	-0,80257
-0,983411269	-0,80668	-0,6149392	-0,761652168	-1,12872869	-0,74701
-1,061820382	-0,85685	-0,6634802	-0,815095893	-1,19673436	-0,56317
-1,086390421	-0,90357	-0,7095631	-0,863336189	-1,30652915	-0,77586
-1,067558077	-0,94853	-0,7527419	-0,907568198	-1,40468589	-1,05753
-1,064441134	-0,99299	-0,7929796	-0,949026382	-1,1280126	-1,08118
-1,108185325	-1,03292	-0,830487	-0,988712698	-1,27492783	-0,85867
-1,188638141	-1,06737	-0,8656651	-1,026510207	-1,29361	-0,59155
-1,27632969	-1,09874	-0,8988694	-1,061830571	-1,4205169	-0,43058
-1,342684304	-1,12839	-0,9303869	-1,094447913	-1,54362148	-0,35711
-1,365486619	-1,15788	-0,9603794	-1,124546583	-1,55646061	-0,42903
-1,333390778	-1,18738	-0,9889719	-1,152630659	-1,61759354	-0,60749
-1,244955921	-1,21665	-1,0162498	-1,179266545	-1,69082551	-0,80119

		Billateral			
Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
0,254679813	0,2667297	0,266729701	0,266729701	-0,188493967	0,2667297
0,178070504	0,1116706	0,228766143	0,111670598	-0,503815246	0,02398068
0,102174132	-0,0719802	0,072651077	-0,091280546	-0,480722833	-0,0015552
0,02933753	-0,2076901	-0,07235149	-0,249172737	-0,826422711	0,15279391
0,006203364	-0,323454	-0,19282653	-0,356561106	-1,101337244	-0,52156982
-0,096460192	-0,4441028	-0,28748711	-0,450832508	-1,262371209	0,17620247
-0,238695847	-0,5644376	-0,36592506	-0,55032978	-1,432253697	0,55344703
-0,210616929	-0,680191	-0,43902791	-0,654339042	-1,59276816	-0,11568113
0,028188164	-0,790992	-0,51290947	-0,758754802	-0,901537445	-0,69446284
0,416119992	-0,8788629	-0,58827478	-0,860114448	10,40637118	-0,83031093
0,904276061	-0,7354207	-0,66426266	-0,941925665	9,719027603	-0,82291419
1,431692263	-0,3291322	-0,73685315	-0,932843009	9,077211835	-0,54895092
1,939057462	0,18327612	-0,7958537	-0,771639609	8,851228402	0,08913477
2,392987714	0,72497896	-0,82661802	-0,456549643	8,696463977	0,95876853
2,78520378	1,26024593	-0,81550851	-0,020699881	8,243317621	1,87967169
3,122653519	1,76874548	-0,75296665	0,493876127	7,751971586	2,72838051
3,418650444	2,23826674	-0,6343838	1,04885639	7,512618892	3,48113541
3,688168773	2,6651531	-0,45934758	1,613748258	7,165466128	4,03136174
3,941705557	3,0498911	-0,2307477	2,166523842	6,814767117	4,43375277
4,184751719	3,39379186	0,046094712	2,692577087	6,459334236	4,76290666

Italian bond and stock market

Bandwith		Causality from 1to2				
	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	1,988733589	NaN	NaN	NaN	2,04554429	13,79759
2	1,914925729	2,04554429	2,04554429	2,045544291	0,95624451	1,937481
3	1,450170026	1,81632637	2,03289637	1,956467691	0,37272324	1,782681
4	1,059189216	1,50818974	1,94613331	1,689465286	0,36605049	1,41323
5	0,809020852	1,26228037	1,77050533	1,388496596	0,19259505	1,066111
6	0,611376194	1,07808369	1,56290046	1,140569666	0,10343614	0,872066
7	0,441777402	0,93086004	1,36428962	0,949532156	-0,1710024	0,748547
8	0,312832669	0,8023869	1,19132789	0,799128025	-0,3855613	0,574216
9	0,218233213	0,68115427	1,04561445	0,673451418	-0,1977298	0,398304
10	0,130661367	0,57372473	0,92210796	0,561417558	-0,1174347	0,30721
11	0,037637883	0,48582297	0,81493006	0,460058203	-0,3249137	0,302098
12	-0,052091633	0,41093882	0,71985012	0,370449168	-0,44989	0,263665
13	-0,126684932	0,34239355	0,6341197	0,292407192	-0,5725691	0,202531
14	-0,178979308	0,27761821	0,55602583	0,223946948	-0,6826898	0,106646
15	-0,207634855	0,21525431	0,48440675	0,162618367	-0,6285276	-0,02478
16	-0,217097421	0,15607167	0,41859308	0,106277446	-0,7807692	-0,11037
17	-0,211978034	0,0999175	0,35802836	0,053511081	-0,0740437	-0,19463
18	-0,197589765	0,05129815	0,30228729	0,003540932	-0,1562598	-0,29397
19	-0,180338452	0,01276433	0,25090606	-0,043432676	0,79174251	-0,29971
20	-0,162699666	-0,0130424	0,20333037	-0,08649237	0,68156423	-0,33425

		Causality form 2to1			
Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
-0,175251511	NaN	NaN	NaN	-0,12453773	-17,6787
-0,229543235	-0,12454	-0,1245377	-0,124537725	-0,58695052	-0,23289
-0,477232657	-0,29192	-0,137057	-0,201678103	-0,80063794	-0,31725
-0,624284426	-0,45449	-0,2094077	-0,362117585	-0,63167564	-0,49961
-0,694939483	-0,55512	-0,3206763	-0,504066044	-0,76334906	-0,64417
-0,710271329	-0,61873	-0,4272709	-0,597990088	-0,5149013	-0,72501
-0,703374934	-0,65501	-0,5152001	-0,65702429	-0,44592202	-0,78409
-0,696069503	-0,66635	-0,5815858	-0,690475057	-0,50811187	-0,78994
-0,69507294	-0,66738	-0,6287115	-0,703244711	-0,68777471	-0,78467
-0,702824392	-0,66985	-0,6606649	-0,702824479	-0,60227815	-0,77008
-0,716252257	-0,67447	-0,6811667	-0,697168316	-0,71819528	-0,78971
-0,738927738	-0,68043	-0,6928592	-0,691120026	-0,7822629	-0,77873
-0,770129367	-0,68923	-0,6980766	-0,686831257	-0,94485546	-0,76866
-0,805930327	-0,7019	-0,6991798	-0,685375632	-0,93954207	-0,77234
-0,843767645	-0,7179	-0,6981264	-0,687387564	-1,05768263	-0,80565
-0,884378619	-0,73637	-0,6964227	-0,693079534	-1,07286258	-0,82474
-0,927585428	-0,75686	-0,69514	-0,702311339	-1,20769626	-0,84156
-0,973022069	-0,77917	-0,6949445	-0,714757278	-1,33892587	-0,87721
-1,02131599	-0,8038	-0,6962192	-0,730050747	-1,46186438	-0,88451
-1,071234952	-0,83091	-0,6990797	-0,747923397	-1,41601237	-0,90876

		Billateral			
Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
0,546324541	0,51294134	0,512941339	0,512941339	1,405195604	0,51294134
0,706925696	0,93630051	0,630516103	0,93630051	0,463009813	1,04679075
0,666067795	1,01651754	1,006347275	1,175747258	-0,0861549	1,09536837
0,581537604	0,87663283	1,1409261	1,038307099	-0,005991188	0,82483916
0,509486722	0,7156589	1,079533994	0,808273429	-0,230007399	0,53061914
0,448089599	0,57570762	0,941860484	0,603107405	-0,137131817	0,34659352
0,39179359	0,45933731	0,788700115	0,440002964	-0,288840575	0,21526104
0,342460871	0,3633849	0,646978504	0,312790571	-0,48846855	0,08472317
0,298918053	0,27601731	0,524778606	0,212494538	-0,491582101	-0,03986779
0,252788614	0,19544964	0,421167816	0,129060766	-0,384529278	-0,10295471
0,200919548	0,12550147	0,332684083	0,056157045	-0,614211887	-0,13086256
0,145018988	0,06311339	0,256345511	-0,008401803	-0,750847448	-0,15918214
0,089887323	0,00332153	0,189662612	-0,06603133	-0,95396331	-0,20211529
0,040292361	-0,0561563	0,13044113	-0,118704906	-1,031633417	-0,27671617
-0,001502971	-0,1158818	0,076896676	-0,168472419	-1,080549849	-0,39467921
-0,036928449	-0,1748528	0,027738252	-0,216938308	-1,201133102	-0,4722131
-0,06737529	-0,2328926	-0,01803511	-0,265001952	-0,806325031	-0,54705753
-0,094662091	-0,2869221	-0,06111184	-0,313015941	-0,95827049	-0,6446021
-0,121709606	-0,3355816	-0,10204107	-0,360642617	-0,385356791	-0,65928665
-0,149090027	-0,3771911	-0,14126745	-0,407115953	-0,432604371	-0,70463904

Yin-Wong Cheung and Lilian K. Ng test

In the same way we present the tables of this test. We remind that **r(12)** denotes the one way causality test that test if the bond market Granger causes the stock market, the **r(21)** denotes the exactly opposite. We have 242 tables, we preset six tables the others follow the same pattern. The red colored cells denotes when the null hypothesis is rejected, meaning that there is causality between the variables.

US bond market and stock market of Austria

lags	r(12)	r(21)
1	-0,2165471	0,250740231
2	-0,3746764	0,17361767
3	0,64060032	0,207223777
4	0,00742732	-0,181850175
5	-0,4098124	0,008356996
6	-0,7233071	0,187694161
7	-0,6254243	0,349462623
8	-0,6307244	0,111043836
9	-0,4857473	0,082282965
10	-0,4902656	0,34627675
11	-0,526257	0,328960224
12	0,04145761	0,147462668
13	0,27485655	-0,035101803
14	0,73348924	0,204261296
15	0,75233303	-0,047881957
16	-0,5531258	0,104534045
17	-0,4855031	0,213330121
18	1,95884525	0,075359004
19	-0,3533332	0,058074958
20	-0,5831354	0,124920817

UK bond market and stock market of France

lags	r(12)	r(21)
1	-0,4779433	-0,530099044
2	-0,4975582	-0,475159656
3	-0,5788643	-0,393157225
4	-0,5831472	0,456249872
5	-0,5363355	-0,049212313
6	-0,2552783	-0,53292295
7	-0,3909594	-0,132821221
8	-0,4681473	0,01696898
9	0,16062499	-8,53E-05
10	3,54298013	0,033060295
11	1,33275872	0,012816894
12	-0,0346255	0,005336503
13	3,67082253	-0,000863243
14	-0,5920914	0,002861365
15	0,50215018	0,016665365
16	-0,5732853	0,063842905
17	-0,5669968	0,027439808
18	-0,4635846	0,011682088
19	-0,5670847	-0,001769905
20	1,78193093	0,009646289

Bond market of Spain and stock market of Germany

lags	r(12)	r(21)
1	0,55425315	-0,905716784
2	0,57955325	-0,361890727
3	-0,4982718	-0,517969269
4	0,3045208	-0,555530848
5	1,05727405	-0,586006256
6	-0,3261744	1,102228767
7	-0,0215196	-0,600450305
8	0,59608916	0,786917826
9	0,41040283	-0,43023146
10	-0,2654945	-0,6822269
11	0,00017218	0,076140938
12	1,0879958	0,11898668
13	-0,5709388	0,296224973
14	-1,0527829	-0,558815332
15	1,39732099	-0,046334728
16	0,28458818	-0,293241527
17	-0,1947461	0,528864562
18	-0,9923653	-0,63708181
19	-0,1225922	0,449291435
20	-0,1202108	-0,408172475

Bond market of Portugal and stock market of Greece

lags	r(12)	r(21)
1	-0,85624	-0,124267544
2	1,47971749	0,433399689
3	1,20343913	2,126840253
4	0,64964222	-0,118714594
5	-0,9148254	2,858973872
6	-0,32883	0,476729863
7	0,63536438	0,725488455
8	1,50617083	0,406596492
9	-0,9727967	-0,090782757
10	-0,541278	-0,370500597
11	-0,5261351	-0,146892274
12	-0,0210549	0,244515047
13	-1,3469974	-0,237771823
14	-0,4660511	-0,279547922
15	-0,4355352	-0,376239201
16	0,07212403	-1,083764131
17	-0,6747206	-1,52267982
18	-0,558075	0,358135672
19	-0,1285306	-0,701090334
20	-1,0534692	-0,163461205

Holland bond market and stock market of Ireland

lags	r(12)	r(21)
1	-0,8421896	-0,486459971
2	-0,2925959	-0,063633001
3	-0,0952121	-0,522001283
4	-0,4157435	-0,65490939
5	-0,6156587	-0,328739222
6	-0,2992182	-0,468677436
7	-0,5092841	-0,804059863
8	-0,6461354	-0,813367319
9	0,13643358	-0,443266738
10	0,36522252	0,435828154
11	0,73271394	-0,095994395
12	-0,3621829	-0,303668177
13	-0,3428442	-0,718579144
14	-0,6115551	-0,417433625
15	-0,4796916	0,801677435
16	-0,6915486	-0,171572925
17	-0,6411651	-0,83405634
18	-0,7308897	-0,606740877
19	0,43980435	0,14808104
20	0,33003521	-0,690247848

From the first application of Hong's test.

In our essay we check if the causality changes through two major events among markets. From 243 tables we present 9 tables, the others follow the same pattern.

- Before Eurozone

Greek bond market and stock market of France

Bandwith	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	-0,734372272	-0,7069	-0,707	-0,706902454	-1,207584	-0,7069
2	-0,8882584	-0,9927	-0,79	-0,992744595	-1,567056	-1,21307
3	-1,036761699	-1,2413	-1,047	-1,228781799	-1,858327	-1,48349
4	-1,181362733	-1,4501	-1,218	-1,419095404	-2,109842	-1,71331
5	-1,32195185	-1,6321	-1,363	-1,588018809	-2,334475	-1,91734
6	-1,45867987	-1,7954	-1,494	-1,741193516	-2,539499	-2,10205
7	-1,591740505	-1,9447	-1,616	-1,88222011	-2,72904	-2,27109
8	-1,72134273	-2,0831	-1,728	-2,013544296	-2,906186	-2,42798
9	-1,847678348	-2,2127	-1,834	-2,136901246	-3,073191	-2,57504
10	-1,970931507	-2,335	-1,934	-2,253567351	-3,231514	-2,71339
11	-2,091274771	-2,4511	-2,03	-2,364513109	-3,382547	-2,84922
12	-2,208867524	-2,5618	-2,121	-2,470496683	-3,527053	-2,97233
13	-2,323853973	-2,6679	-2,208	-2,572123752	-3,665736	-3,09267
14	-2,436368096	-2,7699	-2,292	-2,66988705	-3,799461	-3,20872
15	-2,546533916	-2,8683	-2,373	-2,764193125	-3,928488	-3,32099
16	-2,654466597	-2,9633	-2,452	-2,855381878	-4,053615	-3,43075
17	-2,760273504	-3,0554	-2,528	-2,943740896	-4,175079	-3,53754
18	-2,864054803	-3,1447	-2,602	-3,029516225	-4,292877	-3,63811
19	-2,96590307	-3,2315	-2,673	-3,112920596	-4,40755	-3,74212
20	-3,065908288	-3,3161	-2,743	-3,194139332	-4,518916	-3,83337

Greek bond market and stock market of Austria

Bandwith	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	-0,734176834	-0,7065	-0,706	-0,706491536	-1,214068	-0,70649
2	-0,889233773	-0,9951	-0,791	-0,995100511	-1,572214	-1,2168
3	-1,038189075	-1,2453	-1,049	-1,233587674	-1,862612	-1,48874
4	-1,182962068	-1,4548	-1,222	-1,424600122	-2,113748	-1,71909
5	-1,323642881	-1,637	-1,369	-1,593596153	-2,338331	-1,92319
6	-1,460421864	-1,8003	-1,5	-1,746643599	-2,542985	-2,10683
7	-1,593505505	-1,9496	-1,621	-1,887498066	-2,732104	-2,27525
8	-1,723107121	-2,0879	-1,734	-2,018649669	-2,909034	-2,43307
9	-1,849430643	-2,2174	-1,839	-2,141838851	-3,075779	-2,58112
10	-1,972665932	-2,3396	-1,94	-2,258341277	-3,233959	-2,72109
11	-2,092986042	-2,4556	-2,035	-2,369127573	-3,384802	-2,85245
12	-2,210549483	-2,5663	-2,126	-2,474956725	-3,529214	-2,9786
13	-2,325503521	-2,6723	-2,213	-2,576435301	-3,667843	-3,10063
14	-2,437984956	-2,7742	-2,297	-2,674056726	-3,801404	-3,21604
15	-2,548119871	-2,8724	-2,378	-2,768228133	-3,930455	-3,32906
16	-2,656024966	-2,9673	-2,456	-2,859289674	-4,055358	-3,43559
17	-2,761807946	-3,0593	-2,532	-2,947528941	-4,176644	-3,54217
18	-2,865569636	-3,1485	-2,606	-3,033191702	-4,294421	-3,64642
19	-2,967404163	-3,2352	-2,678	-3,116490063	-4,409078	-3,74332
20	-3,067397805	-3,3197	-2,748	-3,197608635	-4,520972	-3,83634

Greek bond market and stock market of Germany

Bandwith	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	-0,730340461	-0,7068	-0,707	-0,706818424	-1,084059	-0,70682
2	-0,862946462	-0,9423	-0,777	-0,942269462	-1,471855	-1,11959
3	-1,003613701	-1,1616	-0,986	-1,134862254	-1,778264	-1,35483
4	-1,145471266	-1,3598	-1,129	-1,313898835	-2,039573	-1,58213
5	-1,285092327	-1,5388	-1,263	-1,482525447	-2,271314	-1,7499
6	-1,421527414	-1,7022	-1,39	-1,638896079	-2,481132	-1,98131
7	-1,554619701	-1,853	-1,511	-1,784099015	-2,674615	-2,15705
8	-1,684399423	-1,9934	-1,626	-1,919685501	-2,855327	-2,32046
9	-1,811154748	-2,1253	-1,734	-2,047071757	-3,0252	-2,32339
10	-1,934673728	-2,2499	-1,837	-2,16744255	-3,185915	-2,50259
11	-2,055224109	-2,3683	-1,935	-2,281763522	-3,339171	-2,70413
12	-2,172953752	-2,4812	-2,029	-2,39081672	-3,485557	-2,88515
13	-2,288270707	-2,5894	-2,119	-2,49523963	-3,626158	-2,96149
14	-2,400813797	-2,6934	-2,206	-2,595557049	-3,761241	-3,12979
15	-2,511296332	-2,7935	-2,289	-2,692205231	-3,891884	-3,19877
16	-2,620778508	-2,8903	-2,37	-2,785550148	-4,018298	-2,97069
17	-2,725298194	-2,9841	-2,448	-2,875901829	-4,140744	-3,3529
18	-2,830146977	-3,075	-2,524	-2,963525648	-4,259686	-3,2911
19	-2,931160568	-3,1633	-2,598	-3,048650635	-4,375299	-3,48056
20	-3,033148709	-3,2492	-2,669	-3,13147586	-4,487988	-3,31924

- <u>After Eurozone</u>

<u>Bond market of Germany and stock market of Portugal</u>

Bandwith						
	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	497,2903601	497,482	497,48	497,4820227	286,76781	497,482
2	490,1857692	468,825	495,49	468,8247004	221,60454	430,6894
3	481,9959261	417,098	455,68	387,9879898	186,83498	351,4532
4	474,1959168	373,776	400,28	335,7487791	164,37214	304,0849
5	466,7626299	339,843	358,7	300,050787	148,31511	271,7029
6	459,66873	312,987	327,48	273,6682777	136,09661	247,7298
7	452,8820154	291,257	303,08	253,1413326	126,38993	229,7974
8	446,3474198	273,288	283,36	236,5778698	118,43023	215,4085
9	440,2679647	258,144	267	222,8444429	111,74708	201,5489
10	434,4300206	245,174	253,15	211,2151222	106,0318	191,0213
11	428,645466	233,912	241,21	201,2005628	101,06635	183,491
12	422,9584381	224,019	230,79	192,4572934	96,702583	177,1062
13	417,5173256	215,241	221,6	184,7361838	92,821306	170,7089
14	412,4470711	207,385	213,4	177,8515459	89,340378	164,102
15	407,8056005	200,301	206,02	171,6617612	86,196743	157,5452
16	403,5912152	193,872	199,35	166,0566748	83,334675	151,3642
17	399,7649875	188,001	193,27	160,9491412	81,712344	145,7879
18	396,2709349	182,621	187,7	156,2692982	79,334492	140,9572
19	393,0500659	177,671	182,57	151,961246	117,42385	136,8521
20	390,0474	173,317	177,83	147,9826536	114,3542	133,4395

Bond market of Germany and stock market of Spain

Bandwith	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	500,0557118	500,254	500,25	500,2538517	288,19507	500,2539
2	492,8827532	471,367	498,23	471,3672693	222,72348	432,9821
3	484,6385588	419,315	458,14	390,0218472	187,78037	353,2682
4	476,7928479	375,74	402,39	337,480258	165,20533	305,6363
5	469,3179482	341,617	360,57	301,5863778	149,07162	273,0796
6	462,184833	314,613	329,17	275,0635172	136,79252	248,9857
7	455,3613819	292,766	304,64	254,4295103	127,03661	230,9468
8	448,7913798	274,701	284,81	237,7808375	119,03756	216,4817
9	442,6764554	259,477	268,36	223,9774178	112,32218	202,5712
10	436,8052993	246,438	254,43	212,2891979	106,57839	191,984
11	430,9907959	235,117	242,44	202,2241408	101,58919	184,3894
12	425,275698	225,172	231,97	193,4369313	97,203632	177,9519
13	419,8064765	216,349	222,72	185,6771227	93,304434	171,5171
14	414,7067107	208,453	214,48	178,7580566	89,807799	164,8862
15	410,0337835	201,333	207,07	172,5373817	86,648692	158,3132
16	405,7860917	194,87	200,37	166,9043794	83,77329	152,1182
17	401,9251361	188,97	194,26	161,7714605	82,020947	146,5266
18	398,3954606	183,561	188,66	157,0683941	79,578694	141,6783
19	395,1385862	178,583	183,5	152,7388658	117,36752	137,5526
20	392,0999681	174,201	178,74	148,7400501	114,29719	134,1175

Bond market of Germany and stock market of Netherlands

Bandwith	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	525,4185491	525,617	525,62	525,6169426	303,10124	525,6169
2	517,938143	495,386	523,52	495,3859943	234,38321	455,0227
3	509,3140242	440,793	481,51	410,0353142	197,64073	371,3381
4	501,0919792	395,069	423,02	354,8956908	173,90472	321,346
5	493,2492758	359,248	379,13	317,2159814	156,94441	287,1646
6	485,7607641	330,894	346,17	289,3645229	144,03776	261,8586
7	478,5956496	307,95	320,42	267,6913076	133,78386	242,6554
8	471,7131338	288,976	299,6	250,2008956	125,38242	227,1811
9	465,2351676	272,984	282,33	235,6977332	118,33051	213,1145
10	459,0141794	259,288	267,7	223,4159934	112,30457	202,0026
11	452,9227154	247,396	255,1	212,8393861	107,06229	193,4143
12	446,9849456	236,949	244,1	203,6054817	102,45666	186,0455
13	441,2925363	227,681	234,38	195,4513229	98,360632	179,0315
14	435,9217698	219,386	225,72	188,180836	94,690783	172,1904
15	430,9053064	211,906	217,94	181,6444342	91,372601	165,641
16	426,2371545	205,118	210,89	175,7257462	88,353343	159,5499
17	421,8877358	198,92	204,47	170,3327004	86,479195	154,0352
18	417,8165083	193,238	198,59	165,3914622	84,176124	149,1861
19	413,9817318	188,011	193,17	160,8428157	107,75712	144,9247
20	410,344312	183,322	188,16	156,6407502	104,92144	141,253

- <u>During crisis</u>

<u>Irish bond market and stock market of Germany</u>

Bandwith						
	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	-0,733858955	-0,706	-0,706	-0,705955488	-1,221012	-0,70596
2	-0,890073908	-0,9975	-0,791	-0,997485635	-1,576518	-1,21327
3	-1,039197663	-1,2492	-1,052	-1,238483841	-1,864728	-1,48383
4	-1,183730533	-1,4588	-1,227	-1,429842976	-2,114615	-1,71319
5	-1,323964335	-1,6408	-1,374	-1,598398974	-2,33768	-1,9181
6	-1,460181314	-1,8036	-1,505	-1,750763305	-2,540029	-2,09873
7	-1,592579374	-1,9522	-1,626	-1,890863626	-2,728737	-2,27289
8	-1,721500057	-2,0898	-1,738	-2,02122149	-2,904636	-2,39658
9	-1,847150283	-2,2185	-1,843	-2,143604027	-3,069745	-2,5559
10	-1,969732145	-2,34	-1,943	-2,25931418	-3,228074	-2,64876
11	-2,089290737	-2,4552	-2,037	-2,369331296	-3,378293	-2,788
12	-2,206000857	-2,5652	-2,128	-2,474419348	-3,5213	-2,88174
13	-2,319842991	-2,6705	-2,214	-2,575190445	-3,659146	-3,06113
14	-2,431269776	-2,7718	-2,298	-2,672137807	-3,783342	-3,11882
15	-2,540467865	-2,8692	-2,378	-2,765662187	-3,912096	-3,2085
16	-2,646941404	-2,9633	-2,456	-2,856081901	-4,036397	-3,35016
17	-2,751977237	-3,0544	-2,531	-2,943657611	-4,156775	-3,37618
18	-2,854149744	-3,1427	-2,605	-3,028619394	-4,273337	-3,51624
19	-2,954857456	-3,2285	-2,676	-3,111175261	-4,38728	-3,67372
20	-3,054036063	-3,312	-2,745	-3,191512994	-4,499704	-3,70096

Irish bond market and stock market of Greece

Bandwith	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	-0,676722154	-0,6916	-0,692	-0,691557228	0,0754613	-0,69156
2	-0,588516589	-0,4583	-0,638	-0,458254638	0,0103302	-0,39022
3	-0,578841842	-0,2838	-0,402	-0,184149446	-0,50359	-0,16561
4	-0,637397767	-0,2564	-0,221	-0,100430233	-0,885415	-0,20618
5	-0,728318719	-0,3244	-0,142	-0,144376498	-1,125908	-0,2739
6	-0,827986117	-0,4316	-0,137	-0,255313392	-1,379608	-0,44811
7	-0,917548787	-0,5529	-0,183	-0,391941014	-1,577742	-0,65388
8	-1,011149244	-0,6782	-0,259	-0,534520685	-1,448846	-0,74046
9	-1,105941235	-0,7939	-0,351	-0,674400667	-1,617214	-0,81854
10	-1,186571909	-0,897	-0,449	-0,804851613	-1,79009	-0,97777
11	-1,245485015	-0,9929	-0,549	-0,922512349	-1,968513	-1,1048
12	-1,280419555	-1,0847	-0,647	-1,028159188	-2,07933	-1,26376
13	-1,292564436	-1,1735	-0,741	-1,124282064	-0,724694	-1,47113
14	-1,294413895	-1,2428	-0,829	-1,212892411	-0,474845	-1,51392
15	-1,290879099	-1,2828	-0,913	-1,29202394	-0,628009	-1,49962
16	-1,280692044	-1,3027	-0,99	-1,357406433	-0,312329	-1,55859
17	-1,267789446	-1,3079	-1,062	-1,406493921	-0,503893	-1,60936
18	-1,258470612	-1,3027	-1,128	-1,438895819	-0,68167	-1,6099
19	-1,25699867	-1,2927	-1,187	-1,455795388	-0,811798	-1,49683
20	-1,261692025	-1,2814	-1,24	-1,459535428	-0,974528	-1,40964

Irish bond market and stock market of France

Bandwith	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	-0,731648607	-0,7037	-0,704	-0,703694701	-1,221558	-0,70369
2	-0,888117559	-0,9961	-0,789	-0,99610961	-1,57556	-1,20768
3	-1,037076666	-1,2482	-1,051	-1,237975931	-1,861665	-1,47381
4	-1,18050209	-1,4576	-1,226	-1,429285301	-2,105398	-1,70582
5	-1,320015754	-1,6387	-1,373	-1,597280324	-2,326583	-1,89145
6	-1,454674789	-1,8002	-1,504	-1,748578415	-2,530498	-2,07992
7	-1,582798239	-1,9477	-1,624	-1,887339871	-2,716832	-2,2537
8	-1,707867828	-2,0842	-1,736	-2,016388023	-2,799898	-2,36506
9	-1,829178068	-2,2096	-1,84	-2,13745158	-2,970937	-2,50683
10	-1,944602983	-2,3251	-1,939	-2,250821077	-3,132524	-2,60347
11	-2,053554511	-2,4339	-2,032	-2,356830662	-3,283789	-2,74579
12	-2,156623901	-2,5374	-2,121	-2,456510416	-3,428214	-2,85123
13	-2,255939439	-2,6367	-2,206	-2,551053718	-3,249217	-3,00207
14	-2,351914686	-2,7289	-2,287	-2,64139412	-3,396673	-3,05524
15	-2,445081703	-2,8132	-2,364	-2,727523382	-3,532687	-3,14205
16	-2,536194184	-2,8921	-2,438	-2,809006225	-3,668742	-3,26272
17	-2,627193607	-2,9674	-2,509	-2,885785173	-3,799763	-3,26836
18	-2,716790018	-3,0401	-2,577	-2,958216324	-3,924867	-3,37138
19	-2,805570447	-3,1109	-2,643	-3,026892231	-4,045208	-3,49935
20	-2,892933258	-3,1802	-2,706	-3,092475207	-4,164383	-3,51995

Second application on Hong's test

In this application we checked for changes in causality among markets with similar asset, meaning the bond markets. From the 108 tables we preset three of them, each from one of the three periods; the others follow the same pattern.

Italian and Greek bond markets.

Bandwith						
	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	-0,579752755	-0,7076	-0,708	-0,707552272	3,63002	-0,70755
2	0,109364889	0,9804	-0,27	0,980399219	2,1920858	1,730397
3	0,267797314	1,8845	1,3218	2,450500794	1,3260064	2,818557
4	0,370321196	2,10095	2,2683	2,711803229	3,3130372	2,522258
5	0,497268606	2,26125	2,5904	2,608059091	2,5750696	2,358058
6	0,580087797	2,43513	2,6374	2,565872067	1,9841391	2,435345
7	0,609933881	2,53009	2,611	2,603935584	1,489507	2,533195
8	0,596552589	2,55153	2,5962	2,643592404	1,0617392	2,513878
9	0,546433525	2,51833	2,6094	2,647432453	0,7365152	2,512831
10	0,484779873	2,44818	2,6315	2,60912842	0,3984996	2,251479
11	0,400874946	2,35358	2,6446	2,534903395	0,0918848	2,222654
12	0,305351128	2,24243	2,6404	2,43375872	-0,18813	2,173692
13	0,218578421	2,12038	2,6167	2,313714774	-0,448682	1,906185
14	0,142746573	1,99147	2,5749	2,181043769	-0,297403	1,581452
15	0,066896673	1,8623	2,5174	2,040496238	-0,537887	1,341604
16	-0,01947695	1,73644	2,447	1,896224955	-0,761641	1,233229
17	-0,119975002	1,61291	2,3665	1,751699288	-0,972909	1,206604
18	-0,231697555	1,49125	2,2784	1,609213759	-1,173359	1,202061
19	-0,348181146	1,37125	2,1848	1,47003165	-1,365603	1,18585
20	-0,462060723	1,25282	2,0875	1,334701664	-1,549394	1,104463

<u>Austrian bond market and bond market of France</u>

Bandwith	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	262,6888073	262,766	262,77	262,7661906	152,30238	262,7662
2	259,0628161	247,961	261,8	247,9613131	117,46455	227,8316
3	254,7473	220,792	241,09	205,5394169	98,841634	186,052
4	250,5928755	197,912	212	177,9532474	86,76629	160,9635
5	246,6161255	179,934	190,07	159,0201052	78,115968	143,772
6	242,8198769	165,673	173,55	144,984775	71,613014	130,9661
7	239,1901404	154,117	160,6	134,0396578	66,375849	121,0449
8	235,7090267	144,552	150,12	125,1941714	62,073779	113,0965
9	232,3779865	136,482	141,4	117,8524534	58,577345	106,4338
10	229,2000738	129,566	134,01	111,6306265	55,46668	100,6915
11	226,1588252	123,559	127,64	106,2697549	52,757985	95,84206
12	223,2447971	118,279	122,08	101,587831	51,085891	91,60708
13	220,453359	113,6	117,16	97,45237155	49,423423	87,84535
14	217,7760974	109,428	112,78	93,76640392	47,66876	84,43965
15	215,1988271	105,681	108,83	90,45791107	45,898554	81,46938
16	212,7110185	102,289	105,26	87,470705	44,274347	78,78567
17	210,3038807	99,1981	102,01	84,75882395	42,794674	76,40312
18	207,9725068	96,3636	99,029	82,28376256	41,614561	74,26365
19	205,7156694	93,7517	96,289	80,01312104	40,354945	72,26577
20	203,5321591	91,3346	93,76	77,91980932	39,184235	70,39164

Irish and Spanish bond market

Bandwith	Quadratic-spectral	Bartlett	Parzen	Tukey-Hanning	Truncated	Daniell
1	262,6888073	262,766	262,77	262,7661906	152,30238	262,7662
2	259,0628161	247,961	261,8	247,9613131	117,46455	227,8316
3	254,7473	220,792	241,09	205,5394169	98,841634	186,052
4	250,5928755	197,912	212	177,9532474	86,76629	160,9635
5	246,6161255	179,934	190,07	159,0201052	78,115968	143,772
6	242,8198769	165,673	173,55	144,984775	71,613014	130,9661
7	239,1901404	154,117	160,6	134,0396578	66,375849	121,0449
8	235,7090267	144,552	150,12	125,1941714	62,073779	113,0965
9	232,3779865	136,482	141,4	117,8524534	58,577345	106,4338
10	229,2000738	129,566	134,01	111,6306265	55,46668	100,6915
11	226,1588252	123,559	127,64	106,2697549	52,757985	95,84206
12	223,2447971	118,279	122,08	101,587831	51,085891	91,60708
13	220,453359	113,6	117,16	97,45237155	49,423423	87,84535
14	217,7760974	109,428	112,78	93,76640392	47,66876	84,43965
15	215,1988271	105,681	108,83	90,45791107	45,898554	81,46938
16	212,7110185	102,289	105,26	87,470705	44,274347	78,78567
17	210,3038807	99,1981	102,01	84,75882395	42,794674	76,40312
18	207,9725068	96,3636	99,029	82,28376256	41,614561	74,26365
19	205,7156694	93,7517	96,289	80,01312104	40,354945	72,26577
20	203,5321591	91,3346	93,76	77,91980932	39,184235	70,39164