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Contagion and causality: an empirical analysis on sovereign bond spreads

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Abstract

The current decade was marked by the worst economic and financial crisis since the Great Depression, many economies experiencing a severe contraction of output in late 2008 and early 2009. But, was this evolution of the activity only the result of the domestic factors or a certain form of international contagion influenced it, at least partially? The aim of this paper is to empirically explore the contagion phenomenon during the subprime crisis for seven EU and non-EU countries. To test for contagion, we apply a Granger causality/VECM methodology on sovereign bond spreads as a measure of perceived country risk. Following partially the methodology of Kleimeier and Sander (2003), we investigate two sub-periods: a pre-crisis tranquil period (January, 1st 2003-July 29, 2007) and a crisis period (July 2, 2007 -September 1, 2009). Results highlight the fact that the causality patterns have changed during the crisis period compared to the pre-crisis tranquil period.

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1. Introduction

The recent financial crisis triggered by the collapse of the US mortgage market in July 2007 has reinforced the concerns about the contagion effect in both emerging and developed economies. The transmission of crises across borders has resulted in the collapse of large financial institutions, the "bail out" of banks by national governments, downturns in stock markets around the world, the major decline in economic activity with significant welfare implications. Surprised by its magnitude and its speed of propagation, many economists consider it as the worst financial crisis since the Great Depression of the 1930s. Hence, the understanding of its mechanisms from the theorethical and empirical fronts is essential.

Contagion is seen as a feature of financial crises and has multiple facets. A large body of the literature defines it as the cross-country transmission of shocks or the general cross-country spillover effects. However, the literature is not unanimous on a distinct definition of this phenomenon. The World Bank gives a more restrictive definition and considers contagion as the transmission of shocks to other countries or the cross-country correlation, beyond any fundamental link among the countries and beyond common shocks. Many economists identify it as a shift in the transmission channel (Forbes and Rigobon, 2002) or as the spread of a currency crisis from the ground zero country (van Rijckeghem and Weder, 2001). Edwards (2000) highlights that "contagion reflects the situation where the effect of an external shock is larger than what was expected by experts and analysis" which implies that contagion has to be differentiated from the "normal" transmission of shocks across countries. Other economists highlight as contagion only certain mechanisms that can be considered a contagion phenomenon such as the mimetic behavior.

In the empirical literature, contagion has been often measured on stock market returns, interest rates, exchange rates, or linear combinations of them. Four major strategies can be identified to explore it: correlation of assets prices, conditional probability of currency crises, volatility changes, co-movements of capital flows and rates of return. Among these strategies, our paper is connected to the study of assets prices correlation.

The focus of our research is to study the contagion effect by directly investigating changes in the existence and the directions of causality on sovereign market debt. For this purpose, we apply a Granger causality methodology on sovereign bond spreads as a measure of perceived country risk. This analysis is made for seven European and non-European countries over three periods: the whole period (2003:01-2009:09), the pre-crisis tranquil period which starts on January 2003 and ends on July 29, 2007 and the crisis period that capture the period from July 2, 2007 to September 1, 2009. The definition of contagion that we retain in our paper is that given by Forbes and Rigobon (2002): a significant increase in the correlation between assets during a period of crisis, compared with a tranquil period. Our empirical results reveal the fact that causality patterns change in the crisis period compared to the tranquil period; this result suggesting evidence for pure contagion (Masson, 1999).

The rest of the paper is organized as follows. Section 2 illustrates our data and explains the methodology. Section 3 presents the empirical results and section 4 concludes.

2. Methodology and data

2.1 Data

Following partially Sander and Kleimeier (2003) and Baig and Goldfajn (1999), we define the contagion as a market change in cross-market interdependencies. We thus retain the US dollar denominated sovereign bond traded in the international financial market as a relevant criterion for contagion. Here, sovereign bond spreads are computed as the difference between the selected country sovereign bond yield and the corresponding US Treasury bill yield and can be interpreted as a pure measure of country risk (Sander and Kleimeier, 2003). All data come from Datastream and are in daily frequency in order to have robust results. Data are ranging from January 2003 to September 2009 and are selected for seven countries: Germany, France, Finland, Portugal, United Kingdom, USA and Japan. We have chosen bonds that are similar across countries according to their maturity. For the sake of results comparability, we selected bonds on 10 years maturity for all countries over the whole sample period. We investigate two periods: a pre-crisis tranquil period that starts on January 1st, 2003 and ends on June 29, 2007 and a crisis period ranging from July 2, 2007 to September 1st 2009. Table I summarizes some descriptive statistics of the daily bond spreads over the three periods: the whole period (2003-2009), the pre-crisis period (January 1st, 2003 - June 29, 2007) and the crisis period (July 2, 2007-September 1st, 2009). The spreads show that the country credit risks rise during the crisis period compared to the pre-crisis period. The volatility of spreads reflected by the standard deviation remains consistently higher in the crisis-period than those of the tranquil period especially in the case of Japan and Portugal.

2.2 Methodology

This section deals with econometric concerns about the estimation of changes in the existence and the directions of causality between different sovereign bond spreads for six countries. To provide evidence on the changes in crisis causation, we use Granger's (1969) causality approach. This traditional method relative to the question whether x causes y implies to establish how much of the current value of y can be explained by its past values and then to see whether adding lagged values of x can get better the explanation.

As point of departure, the Granger approach identifies a bivariate vector autoregressive (VAR) model with a lag length set as k:

$$X_t = \alpha_x + \sum \beta_{x,i} X_{t-i} + \sum \delta_{x,i} Y_{t-i} + \varepsilon_{x,t} \qquad (1)$$

$$Y_t = \alpha_y + \sum \beta_{y,i} Y_{t-i} + \sum \delta_{y,i} X_{t-i} + \varepsilon_{y,t} \qquad (2)$$

The Granger Causality is investigated by testing with a standard F-test whether all δ_i (where i = 1, k) are equal to zero. In this sense, three possibilities can be identified: (i) if we cannot reject the null hypothesis H_0 ($\delta_x = 0$) in equation (1), we tell "Y Granger causes X" (i.e, we reject the hypothesis that Y does not cause X); (ii) if we cannot reject the null hypothesis H_0 ($\delta y = 0$) in equation (2), we tell "X Granger causes Y" (i.e. we reject the hypothesis that X does not cause Y); (iii) if causation cannot be rejected in both equations, the variables are said to be interdependent.

Yet, the equations written previously are pertinent only if our time series are stationary in level (i.e., I(0)) or if time series in relations (1) and (2) don't have unit root. Hence, to determine the econometric method to use and avoid the well know spurious regression issue (Österholm, 2003), we first focus on the order of integration of the series. For this purpose, we apply Augmented Dickey-Fuller test (ADF - Dickey and Fuller, 1979) which is the most commonly procedure used to test stationarity. If series are integrated of order zero, i. e. if they are I(0) they follow a stochastic process whose joint probability distribution does not change when shifted in time or space and, consequently, parameters such as the mean and the variance are stable over time. The ADF test refers to the following regression:

$$\Delta X_t = \alpha + \gamma X_{t-1} + \sum_{i=1}^{k} \rho_i \Delta X_{t-i} + \varepsilon_t \qquad (3)$$

where X_t is a vector of selected time series. The null hypothesis is $\gamma = 0$ which implies that series are not stationary in level against the alternative assumption $\gamma<0$ which refers to the situation when the sovereign bond spreads series are stationary in level (i.e., I(0)). If the series are non-stationary under the null hypothesis, the test statistic will have a non-standard distribution. We use the "from general to the specific" approach to specify the model and test for the presence of an intercept, with a trend or for the case of "no intercept or trend". The lag length *k* is chosen in order to generate a white noise error term ε_t. Investigating the presence of a unit root in the model requires to study basic information criteria given by Akaike information criterion (AIC), Schwarz criterion (SC) and Hannan-Quinn criterion (HQ).

If both sovereign bond spreads series X_t and Y_t are stationary in level, we can estimate the models (1) and (2) with the ordinary least squares and consequently, we can apply directly the Granger Causality test. If series X_t and Y_t are not found to be stationary in level (i.e., they are integrated of order one - I(1)), we have to study the cointegration relationships between the series X_t and Y_t. The purpose of the cointegration test is then to determine whether a group of non-stationary series is cointegrated or not. In order to reproduce the dynamic adjustment through the long run equilibrium path using a vector autoregressive representation, we apply the Johansen test (1991, 1995) illustrated briefly below.

Consider Z_t a sovereign bond spread vector having the dimension (N×1). We note that Z_t follows an unrestricted vector autoregressive model in level:

$$\underset{(N,1)}{Z_t} = \underset{(N,N)}{A_1}\underset{(N,1)}{Z_{t-1}} + \underset{(N,N)}{A_2}\underset{(N,1)}{Z_{t-2}} + \ldots\ldots + \underset{(N,N)}{A_k}\underset{(N,1)}{Z_{t-k}} + \underset{(N,1)}{\mu} + \underset{(N,1)}{\varepsilon_t} \qquad (4)$$

where each A_i (with i = 1,k) is an N×N matrix Z of parameters, μ is a constant term and ε_t is the error term which is identically and independently distributed with zero mean and the contemporaneous covariance matrix Z $\boldsymbol{\Omega}$. The equation (6) can be written as the following VEC specification:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + \ldots + \Gamma_{k-1} \Delta Z_{t-(k-1)} + \Pi Z_{t-k} + \mu + \acute{\varepsilon}_t \qquad (5)$$

This equation gives information about the short and long term dynamic adjustment of the variables in the modelling, represented by the Γ_i (with i = 1, k-1) and respectively, Π. It is worth noting that Π refers to the « long run solution » of the equation (4) while Γ_i is its « short run solution ». In the equation (5), $\Gamma_i = -I + \sum A_j$, where j = 1, k-1 and $\Pi = -I + \Pi_1 + \Pi_2 + \ldots + \Pi_k$. Because Z_t is an I(1), the left-hand side and the (k-1) variables on the right-hand side of equation (5) are stationary in difference (i.e., I(0)). Given the assumptions on the residual term of the equation (5), the last *k*th element of the same equation has to be stationary (i.e.,

$\Pi Z_{t-k} \sim I(0)$). The rank of Π (i.e, r), shows how many linear combinations of Z_t are stationary. We can distinguish three cases: (a) if r = n, the variables in level are stationary; (b) if r = 0 (i.e., $\Pi = 0$), there are no stationary relations; (c) if 0< r < n, there are r co-integration vectors or r stationary linear combinations of Z_t. In the last case, we can factor the matrix Π to have the relation $\Pi = \alpha\beta'$ where α is the speed adjustment and β' contains the cointegration vector (i.e., a matrix containing the long term coefficients such as $\beta' Z_{t-1}$ which give (n-1) maximum cointegration relationship to assure the long term convergence of Z_t). Consequently, the problem is to test if the matrix Π has the rank $\boldsymbol{r}$ with $0 < r \leq N-1$; in other words, if there is an **r** cointegration relationship.

The Johansen procedure proposes two tests to estimate the number of cointegration relationships (Johansen, 1991): the maximal eigenvalue test and the trace test. Both tests assume that the null hypothesis implies that there are, at most, **r** co-integration vectors. While the max-eigenvalue test assumes, as the alternative hypothesis that there are exactly $r + 1$ cointegration vectors, the alternative assumption in the case of trace test is that there are more than r cointegration vectors. If the results of the tests are contradictory, we retain the values of the trace test, which is considered as a more powerful test. As concerns the cointegration rank which is the most important steps in the cointegration analysis, we choose the approach suggested by Juselius (2006) in which the choice of rank should take into account all relevant information given by different criteria (trace test statistics, root of the companion matrix) and especially the economic relevance of the results. Tests of exclusion and week exogeneity are also applied to test the long-run non-causality. The test of exclusion shows whether all variables belong to the system while the week exogeneity test means that bond spreads are determined by the exogenous factors and are not adjusting for the long run parameters β.

Finally, we note that if the rank of Π is equal to zero, there are not the linear combinations of Z_t (which includes both variables X_t and Y_t) in order to have I(0). In this case, we estimate the VAR model in the first difference to eliminate the long-term relationship. By differentiating the series and thus by converting into an I(0) series, we can apply the Granger Causality test. The previous equations (1) and (2) can be described as follows:

$$\Delta X_t = \alpha_x + \sum \beta_{x,i}\, \Delta X_{t-i} + \sum \delta_{x,i}\, \Delta Y_{t-i} + \varepsilon_{x,t} \qquad (6)$$

$$\Delta Y_t = \alpha_y + \sum \beta_{y,i}\, Y_{t-i} + \sum \delta_{y,i}\, \Delta X_{t-i} + \varepsilon_{y,t} \qquad (7)$$

In the equation (6), we consider as null assumption "X does not Granger cause Y" while in the equation (7) we suppose that "Y does not Granger cause X".

3. Results

This section presents and discusses the main results of our estimations. Before proceeding to estimations, we had to check out carefully time series properties. Tables II and III report the ADF test results of the level and first differential to study the stationarity in the national bond spreads. Under 1% significant level, the level terms of national bond spreads are unable to reject the null hypothesis of non-stationarity for both periods considered, with Finland and Germany as the only exemptions during the crisis period. In the case of France, bond spreads are slightly stationary in level (at 10% significant level). An arbitrary choice is done and we consider this series stationary in first difference. The differential terms significantly reject the null hypothesis for all countries. Since the unit root test concluded to the non-stationary in level and stationarity in first difference for almost all national bond spreads, implementation of cointegration tests is consistent and makes sense from the statistical point of view. Therefore, we proceed as follows: Johansen trace and eigenvalue tests at 5% confidence level are applied for all cross-country series. Number of cointegrating vectors is in table IV:

Table IV: Johansen Trace test: number of cointegrating vectors at 5% level

	Number of Cointegrated Vectors at 5% level				Cointegration	
	Pre-crisis period		Crisis period		pre-crisis period	crisis period
	Trace Test	*Max-eigen Test*	*Trace Test*	*Max-eigen Test*		
ger → fin	1	1	1	1	yes	yes
ger → fra	1	1	1	1	yes	yes
ger → por	1	1	1	1	yes	yes
ger → uk	0	0	0	0	no	no
ger → jap	1	1	0	0	yes	no
fin → ger	1	1	2	2	yes	yes
fin → fra	1	1	1	1	yes	yes
fin → por	1	1	1	1	yes	yes
fin → uk	0	0	1	1	no	yes
fin → jap	1	1	1	1	yes	yes
fra → ger	1	1	1	1	yes	yes
fra → fin	1	1	1	1	yes	yes
fra → por	1	1	0	0	yes	no
fra → uk	0	0	0	0	no	no
fra → jap	1	1	0	0	yes	no
por → ger	1	1	0	0	yes	no
por → fin	1	1	1	1	yes	yes
por → fra	1	1	0	0	yes	no
por → uk	0	0	0	0	no	no
por → jap	1	1	0	0	yes	no
uk → ger	0	0	0	0	no	no
uk → fin	0	0	1	1	no	yes
uk → fra	0	0	0	0	no	no
uk → por	0	0	0	0	no	no
uk → jap	1	1	0	0	yes	no
jap → ger	1	1	0	0	yes	no
jap → fin	1	1	1	1	yes	yes
jap → fra	1	1	0	0	yes	no
jap → por	1	1	0	0	yes	no
jap → uk	1	1	0	0	yes	no

The rank of cointegrating vectors is applied to both periods considered. We consider the evidence for cointegration as significant only if either one of the two tests (Max-Eigenvalue test and Trace test) allows the rejection of the null hypothesis of no cointegration at 1% level or if both statistics allow rejection at, at least, a 5% level. As concerns the pre-crisis period, results of cointegration tests show the presence of one cointegrating vector in all cases with United Kingdom pairs as the only exemption. The late result implies that individual country risks play the most important role in establishing the risks spreads. The null hypothesis of no cointegrating vector is rejected for both tests (Max-Eigenvalue test and Trace test) while the existence of at most one cointegrating vector is accepted generally at 5% level for all cross-country pairs of the bond spreads. Here, evidence for cointegration suggests a more uniform perception of regional country risks. However, results are quite sensitive to the choice of the period length because during the crisis period, evidence for cointegration is mitigated almost completely. In this case, it is at most short-term causality that might be identified.

The cointegration results will serve as a base for determining the correct causality procedure to measure changes in cross-market interdependencies. Table V[1] presents an overview on the causality patterns of the national bond spreads. As in the case of cointegration, we distinguish the results of our estimations according to the two periods considered: the pre-crisis and the crisis period. In the pre-crisis period, we identify six cross-countries causation: Finland-France, Finland-United Kingdom, Finland-Japan, Germany-Finland, Germany-Japan, and Portugal-Japan. The crisis period reveals a huge rise of cross-market interdependencies compared to the pre-crisis period. The increase of cross-market interdependencies during the crisis period shows that pure contagion could happen if investors will change their expectations that can produce different unbalances in the second country non-affected by the crisis (Masson, 1999). The unbalances are generally generated by a change in beliefs of investors and not by the real economic linkages between countries. We thus identify 6 long-term causality cases and 15 short-term causality cases. It is interesting to note that in the crisis period interdependencies raises between Germany, France and United Kingdom and the other European countries compared to the *pre-crisis* period (figure 1 in appendix). Weak exogeneity tests for VECM confirm these causal relationships.

4. Concluding remarks

The recent financial crisis started with the collapse of the US mortgage market in 2007 has reinforced the concerns about the contagion effect in both emerging and advanced economies. This paper contributes to a better understanding of this phenomenon by exploring changes in cross-market interdependencies on sovereign debt market. In the general background of the Granger causality approach, three periods are considered to understand how shocks are propagated internationally: the pre-crisis period (from January 2003 to July 29, 2007), the crisis period (from July 2 2007 to September 1, 2009) and the sum of the two periods (2003:01-2009:09). We find evidence for new and distorted causality patterns in the crisis period for all countries considered. This result suggests support for pure contagion when investors change the assessment of their rules made in international financial environment.

5. References

Allen, F And D. Gale (2000) “Financial Contagion.” *Journal of Political Econom*y **108**, 1-33.

Árvai, Z, Driessen K and İ. Ötker-Robe (2009) “Regional Financial Interlinkages and Financial Contagion Within Europe”, IMF working paper, WP/09/6.

Calvo, G. A. (2007) “Crises in emerging market economies: a global perspective”, NBER working paper number 11305.

Calvo, G.A. (1998) “Capital Flows and Capital Market Crises: The Simple Economics of Sudden Stops”, *Journal of Applied Economics*, CEMA, **1(1),** 35-54.

[1] The results are presented in table V of the appendix.

Calomiris, C. (2007) "Bank Failures in Theory and history: the great depression and other "Contagious Events", NBER working paper number 13597.

Edwards, S. (2000) "Contagion", *World Economy* **23**, 873-900.

Eichengreen, B, Rose, A and C. Wyplosz (1996) "Contagious Currency Crisis", *Scandinavian Economic Review* **4**, 463-484.

Egert, B and E. Kocenda (2005) „Contagion Across and Integration of Central and Eastern European Stock Markets: Evidence from Intraday Data", William Davidson Institute working paper number 798.

Forbes, K and R. Rigobon (2000) "Contagion in Latin America: Definition, Measurement and Policy Implication", NBER working paper number 7885.

Galesi, A and S. Sgherri (2009) "Regional Financial Spillovers Across Europe: A Global VAR Analysis", IMF working paper, WP/09/23.

Gerlach, S and F. Smets (1995) "Contagious Speculative Attacks", *European Journal of Political Economy*, **11**.

Goldfajn, I and R. O. Valdes (1997) "Capital Flows and the Twin Crises: The Role of Liquidity". IMF – working paper, number WP/97/87.

Ito, T and Y. Hashimoto (2002) "High-Frequency Contagion of Currency Crises In Asia », NBER working paper number 9376.

Johansen, S. (1995) *Likelihood-Based Inference in Cointegrated Vector Auto-regressive Models*, Eds. Oxford University Press.

Johansen, S. (1991) Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models, *Econometrica* (59):1551-1580.

Juselius, K. (2006) *The Cointegrated VAR Model*, Oxford, Oxford University Press.

Jokipii T and B.Lucey (2006) „Contagion and interdependence: measuring CEE banking sector co-movements", Bank of Finland Research, Discussion Papers 15/2006.

Kaminsky, G and C. Reinhart (1999) "The Twin Crises : The Causes of Banking and Balance-of-Payments Problems", *American Economic Review*, **89**(**3**), 473-500.

Kaminsky, G and C. Reinhart (2000) "On Crises, Contagion and Confusion", *Journal of International Economics*, 51(1).

Kaminsky, G, Reinhart C and C. A. Vegh. (2003) "The unholy trinity of financial contagion", NBER working paper number 10061.

Marais, E. (2004) "La contagion financière: une étude empirique sur les causalités lors de la crise asiatique », *International Finance*, number 0404003.

Masson, P. (1999) "Contagion: Macroeconomics Models with Multiple Equilibria", *Journal of International Money and Finance*, **18**, 587-602.

Masson, P. (1999b) ”Multiple Equilibria, Contagion, and the Emerging Market Crises”, IMF working paper number 164.

Mishkin, F. (1999), ”Lessons from the Asian Crisis”, NBER working paper number 7102

Neal, L. and M. Weidenmier (2002) “Crises in The Global Economy from Tulips to Today: Contagion and Consequences”, NBER working paper number 9147.

Österholm, P. (2003) “The Taylor Rule: A Spurious Regression”, Uppsala University, Departement of economics, Sweden working paper series, **20**, 28.

Rigobon, R. (2000) “Contagion: how to measure it?“, NBER working paper number 8118.

Rose, A. K and L. E. O. Svensson (1993) “European Exchange Rate Credibility before the fall”, NBER working paper number 4495.

Sander, H and S. Kleimeier (2003), “Contagion and Causality: An Empirical Investigation of Four Asian Crisis Episodes”, *Journal of International Financial Markets, Institutions and Money*, Volume 13, Issue 2, 171-186.

Van Rijckeghem, C. and B. Weder (2001) “Source of contagion: is it finance or trade?”, *Journal of International Economics* **54**, 293-308.

Weller, C.E and B. Morzouch (2000) „International financial contagion. Why are Eastern Europe’s banks not failing when everybady else’s are?”, *Economics of Transition,* **8(3)**, 639-663.

6. Appendix

Table I. Descriptive statistics

Descriptive statistics	FIN_M10	FR_M10	GER_M10	JP_M10	PT_M10	UK_M10	ZE_M10
average spread							
whole period	-0,36	-0,33	-0,36	-2,89	-0,22	0,31	-0,34
pre-crisis period	-0,53	-0,52	-0,53	-3,01	-0,44	0,20	-0,53
crisis period	0,24	0,27	0,10	-2,42	0,62	0,56	0,34
median spread							
whole period	-0,30	-0,31	-0,33	-2,96	-0,24	0,37	-0,32
pre-crisis period	-0,58	-0,61	-0,63	-3,01	-0,53	0,26	-0,62
crisis period	0,28	0,35	0,15	-2,46	0,65	0,56	0,42
standard deviation of bond spread							
whole period	0,57	0,57	0,52	0,33	0,61	0,40	0,58
pre-crisis period	0,52	0,51	0,50	0,21	0,47	0,39	0,50
crisis period	0,41	0,37	0,32	0,48	0,54	0,28	0,43
maximum spread							
whole period	1,81	1,08	0,98	-1,20	1,65	1,20	1,27
pre-crisis period	0,42	0,51	0,51	-2,41	0,52	0,97	0,46
crisis period	1,81	1,08	0,98	-1,20	1,88	1,20	1,29
minimum spread							
whole period	-1,65	-1,31	-1,28	-3,70	-1,18	-0,62	-1,31
pre-crisis period	-1,65	-1,31	-1,29	-3,70	-1,18	-0,62	-1,31
crisis period	-0,89	-0,53	-0,58	-3,32	-0,44	-0,23	-0,55
number of observations							
whole period	1573	1573	1573	1573	1573	1573	1573
pre-crisis period	1173	1173	1173	1173	1173	1173	1173
crisis period	503	503	503	503	503	503	503

Note : *** and ** means that we reject the null hypothesis of non-stationarity of the series at 1% level and 5% level respectively; ZE - means euro zone.

Table II: Unit root tests: tranquil period

bond spread series_10 years maturity	pre-crisis period				
	level	DW_stat	first difference	DW_stat	I(d)
European countries					
Germany	-0,665	2,020	-32,46***	2,020	I(1)
Finland	-0,662	2,007	-27,041***	2,007	I(1)
France	-0,741	2,011	-30,029***	2,011	I(1)
Portugal	-0,910	2,021	-33,016***	2,021	I(1)
United Kingdom	-1,225	1,995	-22,885***	1,995	I(1)
Euro Zone	-0,611	2,000	-24,208***	2,000	I(1)
Non-european countries					
Japon	-0,259	1,980	-16,579**	1,980	I(1)

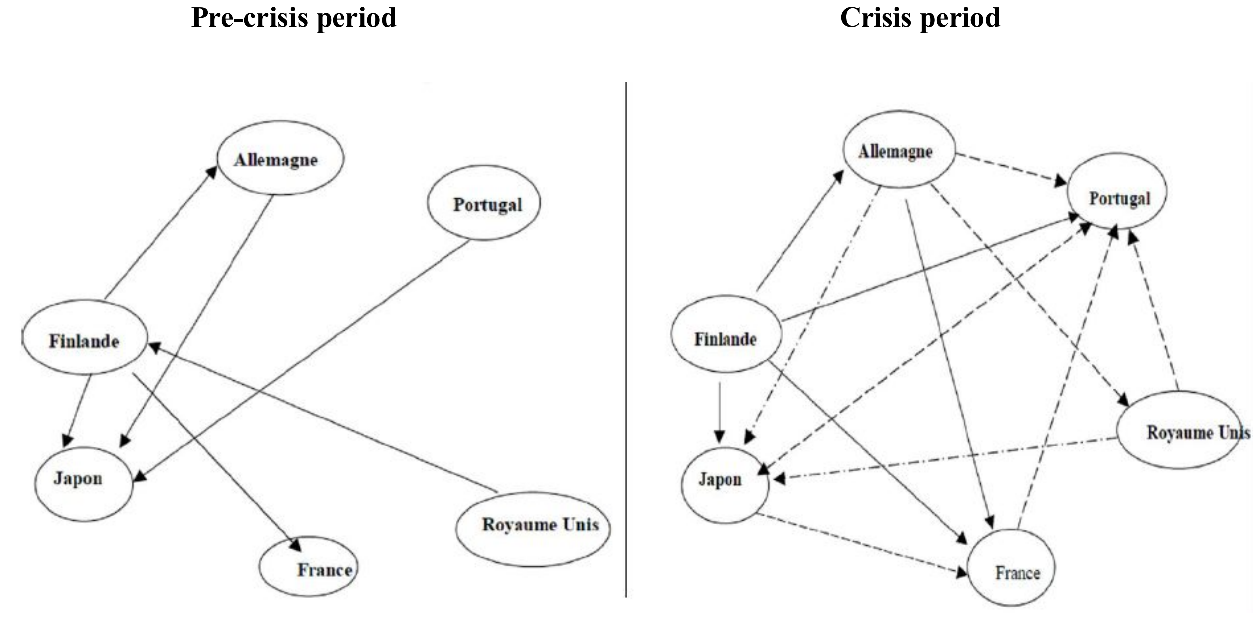
Note: *** and ** means that we reject the null hypothesis of non-stationarity of the series at 1% level and 5% level respectively

Table III: Unit root tests: crisis period

bond spread series_10 years maturity	crisis period				
	level	DW_stat	first difference	DW_stat	I(d)
European countries					
Germany	-2,289***	1,992	-20,290***	1,994	I(0)
Finland	-3,418***	2,021	-13,621***	1,996	I(0)
France	-1,640*	2,000	-19,611***	2,001	I(0)
Portugal	-0,829	2,005	-20,443***	2,006	I(1)
United Kingdom	-1,107	2,009	-8,250***	2,009	I(1)
Euro Zone	-1,300	1,991	-19,881***	1,992	I(1)
Non-european countries					
Japon	-2,057	1,983	-19,412***	1,983	I(1)

Note: *** and ** means that we reject the null hypothesis of non-stationarity of the series at 1% level and 5% level respectively

Figure 1: Causality between european and non-european countries



Note: Solid arrows indicate a long-term causality while the dotted arrows indicate short-term causality at a significance level of at least 5%.

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Table V: Cointegration and causality between selected countries

	Cointegration		Causality			
	Pre-crisis period	*Crisis period*	*Pre-crisis period*		*Crisis period*	
			Short Term	VECM	Short Term	VECM
ger → fin	yes	yes	no	**no**	no	**no**
ger → fra	yes	yes	no	**no**	no	**yes**
ger → por	yes	yes	no	**no**	**yes**	no
ger → uk	no	no	**no**	no	**yes**	no
ger → jap	yes	no	no	**yes**	**yes**	no
fin → ger	yes	yes	no	**yes**	no	**yes**
fin → fra	yes	yes	no	**yes**	no	**yes**
fin → por	yes	yes	no	**no**	no	**yes**
fin → uk	no	yes	no	**yes**	no	**no**
fin → jap	yes	yes	no	**yes**	no	**yes**
fra → ger	yes	yes	no	**no**	no	**no**
fra → fin	yes	yes	no	**no**	no	**no**
fra → por	yes	no	no	**no**	**yes**	no
fra → uk	no	no	**no**	no	**no**	no
fra → jap	yes	no	no	**no**	**yes**	no
por → ger	yes	no	no	**no**	**yes**	no
por → fin	yes	yes	no	**no**	no	**no**
por → fra	yes	no	no	**no**	**no**	no
por → uk	no	no	**no**	no	**no**	no
por → jap	yes	no	no	**yes**	**yes**	no
uk → ger	no	no	**no**	no	**no**	no
uk → fin	no	yes	no	**no**	no	**no**
uk → fra	no	no	**no**	no	**no**	no
uk → por	no	no	**no**	no	**yes**	no
uk → jap	yes	no	no	**no**	**yes**	no
jap → ger	yes	no	no	**no**	**no**	no
jap → fin	yes	yes	no	**no**	no	**no**
jap → fra	yes	no	no	**no**	**yes**	no
jap → por	yes	no	no	**no**	**yes**	no
jap → uk	yes	no	no	**no**	**no**	no