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Transmission of stock prices amongst European countries before and during the Greek sovereign debt crisis

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Abstract

This article employs the lag-augmented VAR (LA-VAR) approach developed by Toda and Yamamoto (1995) to analyze the transmission of stock indices among the European PIIGS (Portugal, Ireland, Italy, Greece and Spain), Germany and the UK before and during the European sovereign debt crisis. The entire sample period is broken down into two periods: Sample A (from January 2, 2007 to November 4, 2009) and Sample B (from November 5, 2009 to June 30, 2011). Our analysis revealed evidence of interdependence as reflected by the Granger causality primarily from Portugal and Ireland to several countries including Germany prior to the crisis. The study also found that a significant causal relationship mostly disappeared during the Greek sovereign debt crisis.

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I. INTRODUCTION

Co-movement events of asset prices across the Euro zone, not only in the government bond markets but also in the stock markets, have been repeatedly observed since the Greek sovereign debt crisis of late 2009. This strong interdependence of different stock exchanges in the region has caught the attention of various fund managers who have explored diversification opportunities for their portfolio. It has also captured the interest of monetary authorities who seek to minimize the negative impact of transmissions from foreign stock markets on their domestic economy.

Since they are popular tools for investigating the interactions of stock exchanges in different nations, many variations of vector autoregression (VAR) models have been extensively used by researchers. Even some studies with a focus on the linkages of European stock markets by VAR approaches have been accumulated. Using the monthly data of stock prices from four Nordic nations and the US from 1974 to 1985, Mathur and Subahmanyam (1990) found evidence of causality from Sweden to Finland and Norway and from the US to Denmark. Applying VAR models and recursive common stochastic trend analyses to the quarterly stock indices' data from Germany, France and England, Rangvid (2001) identified evidence of increased convergence of the three stock markets from 1960 to 1999. Veraros and Kasimati (2007) found that the European stock exchange (FTSE Euro 100) exerted greater influence on the Athens stock exchange in Greece than the US stock exchange (S&P 500) did. In order to obtain these results they used weekly data from 1999 to 2005. Gklezakou and Mylonakis (2009), using daily stock indices data of six South Eastern European countries and Germany from 2000 to 2009, confirmed the Granger causality from the Greek and the German markets to the Bulgarian and Turkish markets.

This study examines the causal relationships of daily stock indices data amongst European PIIGS countries (Portugal, Ireland, Italy, Greece and Spain) and two of the main European stock markets, Germany and the UK. The whole sample ranging from January 2, 2007 to June 30, 2011 was divided into two sub-samples, one before and one after the inception of the Greek sovereign debt crisis. The lag-augmented VAR (LA-VAR) methodology developed by Toda and Yamamoto (1995) is used for analysis, which is applicable regardless of the integration order or the existence of cointegration of variables. This seems to be among the first analyses to assess Granger-causality of stock returns across the Euro zone with a focus on the potential impact of the Greek sovereign debt crisis. In this study, some particularly interesting insights regarding how the shocks initially triggered in the government bond market of a small open economy, namely Greece, would influence the interdependence of equity markets across Europe become apparent.

The remainder of this paper is organized as follows: the second section briefly introduces the LA-VAR methodology; the third section provides a description of our data; the fourth section displays our empirical results; and the fifth section presents a summary.

II. METHODOLOGY

Conventional VAR or Vector Error Correction Model (VECM) models usually require prior tests to investigate the integration order or confirm the existence of cointegration. These pre-tests sometimes generate different results, depending upon which formulation of models is used. Hence, a bias in the pre-tests may trigger problems in statistical inference when VAR or VECM models are used. Toda and Yamaomoto (1995) developed the LA-VAR approach, which allows us to test coefficients in a level VAR when the integration or cointegration order is unknown. Considering this substantial benefit, we apply the LA-VAR method, as described in Hamori and Imamura (2000), which investigated causal relationships of stock prices among G7 countries.

The LA-VAR methodology is briefly described as follows. The vector time series $\{y_t\}$ follows the following model:

$$y_t = a_0 + a_1 t + A_1 y_{t-1} + ... + A_k y_{t-k} + \varepsilon_t \quad t=1, 2, \ldots, T \tag{1}$$

where t is the time trend, k is the lag length, and ε_t is the sequence of random vectors with zero mean and covariance matrix Σ.

We test the following null hypothesis on restriction of parameter sets ϕ in (1):

$$H_0 : f(\phi) = 0. \tag{2}$$

In order to test this null hypothesis, the VAR model in a level form is estimated by ordinary least squares (OLS) as follows:

$$y_t = \hat{a}_0 + \hat{a}_1 t + \hat{A}_1 y_{t-1} + ... + \hat{A}_k y_{t-p} + \hat{\varepsilon}_t \tag{3}$$

where p is equal to the true lag lengths (k) plus a maximum integration order ($d_{\max}$). Note that $d_{\max}$ must not exceed the true lag length k. It is also noted that because the true values of $A_{k+1},..., A_p$ are zero, those parameters must not be included in the parameter restriction in (2).

According to Toda and Yamamoto (1995), when the null hypothesis is true, the Wald test statistic has an asymptotic chi-square distribution with degrees of freedom equal to the number of restrictions. The required process is to first estimate the level of VAR after the maximum integration order ($d_{\max}$) is added to the true lag length (k) and then to investigate the hypothesis using the Wald test. This does not involve any pre-tests to assess integration order or cointegration.

III. THE DATA

The dataset consists of daily returns of stock market indices from seven European nations[1] during the period from January 2, 2007 to June 30, 2011 (1,066 observations in total). The data is extracted from Datastream. All the indices are denominated in the euro[2]. Our use of daily data provides a sufficient number of samples to assess the impact of the European sovereign debt crisis, which is a relatively recent event.

The sample period is divided into two sub-sample periods: Sample A (from January 2, 2007 to November 4, 2009) and Sample B (from November 5, 2009 to June 30, 2011). In this study, November 5, 2009 was regarded as the date when the Greek sovereign debt crisis initiated. This is because, on that date, Greece disclosed that the real size of its fiscal deficit amounted to approximately twice of what had been announced previously, resulting in the spread of concerns by investors as to the country's solvency.

Table 1 presents a summary of descriptive statistics of our data in logarithm form. The standard deviation sharply increased from Sample A to Sample B in the case of Greece, whereas the other six nations interestingly exhibited the opposite pattern. This makes sense in that Sample A contains the period of the 2007/2008 Global financial crisis, first triggered in the U.S. subprime loan market but then spread into various European countries. Increased market uncertainty created by the Global financial crisis is considered to have indeed enhanced the volatilities of the main European stock indices significantly. Table 1 may indicate that the volatilities of those six nations' stocks were more severely affected by the 2007/2008 Global financial crisis, whilst the impact of the European sovereign debt crisis was higher in case of the volatility of the Greek stock index. Jarque-Bera tests reject normality for all the seven countries concerned, except for Portugal and Spain, in Sample B.

We use the Augmented Dickey-Fuller (ADF) test to check for the existence of unit roots. Table 2 displays the results of the ADF test, showing that the conclusions are identical for all seven stock indices concerned. For both Samples A and B, we identify unit root processes for level data, but do not find unit roots for first-differenced data at the 1% significance level.

IV. EMPIRICAL RESULTS

This section analyzes the causal relationships of stock indices in seven European

[1] The indices used in this study include FTSE/ATHEX 20 (Greece), ISEQ-OVERALL PRICE (Ireland), PSI 20 (Portugal), FTSE MIB (Italy), IBEX 35 (Spain), DAX (Germany), and FTSE 100 (UK).
[2] The time series of the UK's FTSE 100 were denominated in British pounds; hence, we converted them into Euro terms to ensure comparison among the seven stock indices.

countries based on the LA-VAR approach. First, we determine the optimum lag length with the Akaike Information Criterion (AIC)[3]. Table 3 displays the AIC using 8 periods for Samples A and B, respectively. The result indicates that six and one are regarded as optimum lag lengths (*k*) for Samples A and B, respectively. Since the ADF test did not indicate that each index has double unit roots as reported in the previous section, it is assumed that a maximum integration order ($d_{\max}$) is equal to one[4]. Hence, the total lag lengths ($p = k + d_{\max}$) are set as seven for Sample A and two for Sample B, respectively.

As is typically applied to the LA-VAR approach, the Granger causality in the VAR framework is analyzed. Table 4 reports the Wald test statistic. The 1% significance level is considered conservatively as we employ a relatively large dataset (i.e. the number of samples are 676 in Sample A and 390 in Sample B). Table 4 also reports the Ljung-Box statistics for the null hypothesis that no autocorrelation exists up to order 15 for each of VAR residuals. The *p*-values are larger than 0.01 for all countries, which results in our acceptance of the null hypothesis of no autocorrelation, despite the relatively low *p*-value in case of Ireland in Sample A.

In Sample A, significant causal effects are extensively identified. Portugal and Ireland were the main sources of transmission which Granger-caused many other countries, whereas Germany, the largest economy in the Euro zone, affected only Ireland. During this period, causal effects were presumably exerted from those nations that were severely influenced by the 2007/2008 Global financial crisis, to the nations that did not suffer so substantially.

By contrast, in Sample B, the overall causal effects dramatically weakened throughout the period. The significant Granger-causality was identified with only two directions: from Italy to Ireland, from Italy to the UK and lastly from Germany to Ireland. These results imply that regional interdependence of stock indices of the seven European countries (PIIGS nations, Germany and the UK) has decreased since the inception of the Greek sovereign debt crisis. This is contrary to the results of previous researches, which report that interdependence of stock markets usually tends to increase when a financial crisis occurs (i.e. Yang 2005 in case of the Asian currency crisis, Cheung et al. 2008 and Yiu et al. 2010 in case of the Global financial crisis). For the purpose of robustness check, we also try to investigate the Granger-causality by using the standard VAR model for first-differenced data as shown in Appendix. We confirm that such model selection does not have critical impacts on our key finding

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[3] An alternative approach is to use the Schwarz Information criterion (BIC), which is more restrictive than the AIC. The BIC suggests that the selected optimum lag lengths are one both for Sample A and Sample B. However, we confirmed that our choice of the information criterion would not have substantial impacts on the results of our analysis.

[4] This selection ensures that the maximum integration order does not exceed the true lag length, satisfying the condition stipulated by Toda and Yamamoto (1995).

that interdependence of the stock markets in the seven nations weakened after the Greek sovereign debt crisis. A recent study by Kizys and Pierdzioch (2011) reported evidence of the significant causal effects from news to speculative bubbles in the Greek stock market to news to those in Portugal, Ireland, Italy, and Spain especially during the Greek sovereign debt crisis, based on one specific model of speculative bubbles. Combining their findings with results of our study implies that contagious linkages of equity markets from the source of the sovereign debt crisis (Greece) to neighbourhood countries may have occurred at the levels of “speculative bubble” portions rather than among stock indices themselves.

V. CONCLUDING REMARKS

This article analyzes the causal relationships among the stock indices of seven European countries before and during the sovereign debt crisis, which originated in Greece. The use of the LA-VAR method allowed us to test for the Granger-causality without conducting tests of unit roots or cointegration and thus avoided pre-testing bias.

We find that, prior to the Greek debt crisis, Portugal and Ireland significantly Granger-caused multiple other countries, including Germany, whereas Germany itself only had influence on Ireland. On the other hand, our findings also show that these causal relationships mostly disappeared throughout the crisis. Hence, despite some observed events of co-movement among stock exchanges of PIIGS countries, interestingly, we see that a decreasing level of interdependence has occurred during the overall period since the Greek sovereign debt crisis. Clarification of root causes behind such counter-intuitive behaviours of the stock indices would require in-depth investigation of the underlying economic conditions before and after the crisis. We leave this for future research.

APPENDIX

Besides the LA-VAR approach used in this paper, another possible approach would be to take first-differences of nonstationary variables and estimate a standard VAR. In this appendix, we report the results using such an alternative approach for robustness check, so that we can demonstrate that our key findings do not stem solely from using the selected model.

Table A1 presents the statistic of log-differences of the level data, multiplied by 100, while Table A2 reports that the selected lag lengths based on the AIC are 6 for Sample A and 1 for Sample B, respectively. Table A3 indicates the Granger causality Wald test for Sample A and Sample B. We find no substantial differences in terms of the Granger-causality results between in Table 4 and in Table A3, although in Table A3 we identify a larger number of statistically significant causal relationships at the 1% level in Sample A. In particular, the decreasing interdependence after the Greek sovereign debt crisis, one of the key findings derived from using the LA-VAR model, still seem to hold even if we apply the conventional VAR approach to the series.

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Table 1. Summary statistics of the stock indices

Whole Sample: (January 2, 2007 - June 30, 2011)

	Level data						
	GR	IR	PG	IL	SP	GM	UK
Mean	7.34	8.56	9.16	10.31	9.40	8.78	8.75
Median	7.62	8.76	9.16	10.42	9.38	8.78	8.69
Maximum	7.95	9.21	9.53	10.70	9.68	9.00	9.21
Minimum	6.29	7.87	8.75	9.82	9.07	8.42	8.27
Std. Dev.	0.53	0.49	0.20	0.29	0.15	0.11	0.27
Skewness	-0.58	-0.20	0.16	-0.26	0.15	0.04	0.29
Kurtosis	1.68	1.29	1.73	1.37	1.82	2.30	1.82
Jarque-Bera	138.01	136.60	76.45	129.93	65.49	22.26	76.38
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000
Number of observations	1066	1066	1066	1066	1066	1066	1066

Sample A: (January 2, 2007 - November 4, 2009)

	Level data						
	GR	IR	PG	IL	SP	GM	UK
Mean	7.72	8.90	9.28	10.51	9.48	8.79	8.84
Median	7.73	8.96	9.27	10.55	9.51	8.79	8.90
Maximum	7.95	9.21	9.53	10.70	9.68	9.00	9.21
Minimum	6.99	7.91	8.75	9.92	9.10	8.42	8.27
Std. Dev.	0.15	0.26	0.15	0.14	0.12	0.12	0.28
Skewness	-1.18	-1.46	-0.50	-1.38	-0.34	-0.10	-0.28
Kurtosis	5.49	5.16	2.99	4.94	2.07	2.25	1.63
Jarque-Bera	330.81	373.47	28.38	321.54	37.40	16.80	62.37
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000
Number of observations	676	676	676	676	676	676	676

Sample B: (November 5, 2009 - June 30, 2011)

	Level data						
	GR	IR	PG	IL	SP	GM	UK
Mean	6.69	7.98	8.95	9.97	9.26	8.77	9.10
Median	6.63	7.98	8.96	9.97	9.27	8.74	9.10
Maximum	7.28	8.16	9.09	10.08	9.41	8.92	9.21
Minimum	6.29	7.87	8.80	9.82	9.07	8.60	8.99
Std. Dev.	0.22	0.05	0.05	0.06	0.07	0.09	0.05
Skewness	0.62	0.55	-0.03	-0.13	-0.03	0.15	0.05
Kurtosis	2.84	3.83	2.76	2.29	3.12	1.68	1.81
Jarque-Bera	25.78	30.86	1.00	9.21	0.30	29.84	23.13
Probability	0.0000	0.0000	0.6055	0.0100	0.8606	0.0000	0.0000
Number of observations	390	390	390	390	390	390	390

Note1 : Statistics for the logarithm of the daily stock prices are reported for level data.

Note2 : Names of the countries are abbreviated as follows: GR(Greece), IR(Ireland), PG(Portugal), IL(Italy), SP(Spain), GM(Germany), and UK(the United Kingdom).

Table 2. Augmented Dickey-Fuller (ADF) test of unit roots

Sample A: (January 2, 2007 - November 4, 2009)
For first differences:

	GR	IR	PG	IL	SP	GM	UK
Unit root without time trend (1% critical value = -3.44)							
ADF test statistic:	-3.44	-3.80	-3.72	-3.91	-6.65	-7.52	-28.65
p-value:	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unit root with time trend (1% critical value = -3.98)							
ADF test statistic:	-5.98	-9.58	-4.61	-5.22	-7.38	-7.99	-28.63
p-value:	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sample B: (November 5, 2009 - June 30, 2011)
For first differences:

	GR	IR	PG	IL	SP	GM	UK
Unit root without time trend (1% critical value = -3.45)							
ADF test statistic:	-15.87	-11.64	-11.35	-11.07	-11.99	-10.83	-22.41
p-value:	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unit root with time trend (1% critical value = -3.98)							
ADF test statistic:	-15.90	-11.63	-11.34	-11.05	-11.99	-10.81	-22.40
p-value:	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3. Selection of lag length of VAR

Sample A: (January 2, 2007 - November 4, 2009)

	Level data
lag length	AIC
1	-44.18
2	-44.27
3	-44.23
4	-44.28
5	-44.29
6	-44.28
7	-44.29 *
8	-44.27

Sample B: (November 5, 2009 - June 30, 2011)

	Level data
lag length	AIC
1	-52.27 *
2	-52.20
3	-52.12
4	-52.02
5	-51.93
6	-51.81
7	-51.73
8	-51.63

Note : * indicates lag order selected by the criterion.

Table 4. Modified Ward test statistics based on the LA-VAR method

Sample A: (January 2, 2007 - November 4, 2009) (*k* =7, *dmax* =1)

	GR	IR	PG	IL	SP	GM	UK
GR (Greece)		7.549	6.950	11.906	10.917	13.823	12.167
IR (Ireland)	9.953		13.756	31.898 **	20.645 **	25.353 **	8.430
PG (Portugal)	21.792 **	15.600		31.811 **	36.208 **	27.200 **	8.590
IL (Italy)	22.162 **	15.413	15.081		16.772	18.564	9.375
SP (Spain)	17.761	13.484	8.560	18.764		15.587	6.079
GM (Germany)	16.202	21.996 **	11.166	17.330	8.136		7.683
UK (the United Kingdom)	8.376	10.546	5.764	4.508	6.878	4.555	
Ljung-Box statistics for VAR residuals							
Q(15)	16.679	24.635	16.380	12.294	7.318	4.828	13.305
p-value	0.338	0.055	0.357	0.657	0.948	0.993	0.579

Sample B: (November 5, 2009 - June 30, 2011) (*k* =1, *dmax* =1)

	GR	IR	PG	IL	SP	GM	UK
GR (Greece)		1.040	1.077	2.195	1.188	1.741	2.306
IR (Ireland)	1.901		2.209	1.137	2.926	2.131	0.637
PG (Portugal)	0.201	0.040		0.971	0.096	1.440	0.270
IL (Italy)	3.299	14.062 **	0.711		5.788	7.452	9.753 **
SP (Spain)	0.584	8.470	1.555	4.523		1.566	2.193
GM (Germany)	5.054	12.819 **	7.937	5.101	5.009		7.805
UK (the United Kingdom)	0.142	6.312	1.770	1.256	1.867	2.627	
Ljung-Box statistics for VAR residuals							
Q(15)	13.270	16.293	9.802	22.682	11.920	19.222	18.697
p-value	0.581	0.363	0.832	0.091	0.685	0.204	0.228

Note1 : The horizontal axis indicates dependent variables, while the vertical axis shows explanatory variables.

Note2 : ** indicates statistical significance at the 1% level.

Note3 : *Q(15)* is the Ljung-Box statistic for the null hypothesis that there is no autocorrelation up to order 15 for residuals.

Table A1. Summary statistics of the stock indices

Whole Sample: (January 2, 2007 - June 30, 2011)

	First-differenced data						
	GR	IR	PG	IL	SP	GM	UK
Mean	-0.09	-0.08	-0.01	-0.05	0.00	0.02	-0.03
Median	0.02	0.00	0.05	0.08	0.11	0.13	0.05
Maximum	10.28	9.73	14.07	14.47	13.48	13.46	13.26
Minimum	-10.01	-13.96	-10.38	-8.75	-9.59	-8.40	-10.34
Std. Dev.	2.23	2.04	1.44	1.76	1.77	1.67	2.02
Skewness	-0.08	-0.49	0.59	0.19	0.30	0.29	0.12
Kurtosis	6.20	8.01	18.58	12.19	11.94	12.06	9.33
Jarque-Bera	455.98	1153.92	10815.42	3754.51	3560.53	3649.95	1776.43
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000
Number of observations	1065	1065	1065	1065	1065	1065	1065

Sample A: (January 2, 2007 - November 4, 2009)

	First-differenced data						
	GR	IR	PG	IL	SP	GM	UK
Mean	-0.09	-0.14	-0.04	-0.08	-0.02	-0.02	-0.07
Median	0.04	-0.04	0.02	0.02	0.08	0.11	0.00
Maximum	10.11	9.73	14.07	14.47	12.78	13.46	13.26
Minimum	-7.82	-13.96	-10.38	-8.60	-9.59	-7.74	-10.34
Std. Dev.	1.73	1.96	1.32	1.42	1.53	1.43	2.01
Skewness	-0.09	-0.70	0.77	0.85	0.12	0.24	0.33
Kurtosis	8.61	10.28	30.30	24.41	16.10	18.88	10.04
Jarque-Bera	884.92	1545.61	21001.25	12949.68	4818.03	7089.34	1404.57
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000
Number of observations	675	675	675	675	675	675	675

Sample B: (November 5, 2009 - June 30, 2011)

	First-differenced data						
	GR	IR	PG	IL	SP	GM	UK
Mean	0.06	0.04	0.11	0.03	0.08	0.08	0.03
Median	0.10	0.03	0.12	0.11	0.14	0.17	0.06
Maximum	6.82	5.60	3.84	2.24	2.60	2.61	2.64
Minimum	-5.81	-5.02	-2.46	-3.84	-3.06	-3.46	-3.46
Std. Dev.	1.18	1.03	0.64	0.85	0.91	1.01	0.86
Skewness	-0.14	-0.41	0.16	-0.68	-0.53	-0.46	-0.40
Kurtosis	7.11	8.31	7.04	4.49	4.33	3.74	4.68
Jarque-Bera	275.21	468.48	266.77	66.00	46.95	22.76	56.27
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000
Number of observations	390	390	390	390	390	390	390

Note1 : Statistics for first-differences of the level data, multiplied by 100, are reported.
Note2 : Names of the countries are abbreviated as follows: GR(Greece), IR(Ireland), PG(Portugal), IL(Italy), SP(Spain), GM(Germany), and UK(the United Kingdom).

Table A2. Selection of lag length of VAR

Sample A: (January 2, 2007 - November 4, 2009)

	first-differences
lag length	AIC
1	-44.22
2	-44.19
3	-44.22
4	-44.23
5	-44.23
6	-44.24 *
7	-44.22
8	-44.20

Sample B: (November 5, 2009 - June 30, 2011)

	first-differences
lag length	AIC
1	-52.16 *
2	-52.10
3	-52.00
4	-51.93
5	-51.80
6	-51.71
7	-51.59
8	-51.45

Note : * indicates lag order selected by the criterion.

Table A3. Wald statistics based on the standard VAR method using first-differenced data

Sample A: (January 2, 2007 - November 4, 2009) (*lag* =6)

	GR	IR	PG	IL	SP	GM	UK
GR (Greece)		7.207	9.819	9.460	12.170	13.098	5.309
IR (Ireland)	7.256		8.438	23.593 **	15.007	18.022 **	9.607
PG (Portugal)	17.387 **	10.044		25.815 **	28.804 **	22.182 **	5.003
IL (Italy)	22.350 **	7.445	17.231 **		19.164 **	18.705 **	3.584
SP (Spain)	15.706	12.387	10.160	16.512		12.975	6.395
GM (Germany)	20.073 **	14.717	10.992	16.077	9.066		7.771
UK (the United Kingdom)	5.208	3.889	2.489	3.894	5.042	3.477	
Ljung-Box statistics for VAR residuals							
Q(15)	20.899	24.539	33.800	14.944	14.486	7.359	15.147
p-value	0.140	0.056	0.004	0.455	0.489	0.947	0.441

Sample B: (November 5, 2009 - June 30, 2011) (*lag* =1)

	GR	IR	PG	IL	SP	GM	UK
GR (Greece)		0.425	0.686	1.501	0.775	1.247	1.015
IR (Ireland)	1.035		1.165	0.349	2.137	1.524	0.164
PG (Portugal)	0.057	0.084		0.430	0.030	0.736	0.000
IL (Italy)	1.980	4.698	0.331		4.302	6.112	7.193 **
SP (Spain)	0.002	0.039	0.003	0.102		0.116	0.033
GM (Germany)	3.949	9.243 **	2.624	3.070	3.119		6.674
UK (the United Kingdom)	0.160	2.346	1.880	0.617	1.584	1.159	
Ljung-Box statistics for VAR residuals							
Q(15)	13.329	15.526	10.745	22.597	11.306	19.987	19.396
p-value	0.577	0.414	0.770	0.093	0.731	0.172	0.196

Note1 : The horizontal axis indicates dependent variables, while the vertical axis shows explanatory variables.

Note2 : ** indicates statistical significance at the 1% level.

Note3 : *Q(15)* is the Ljung-Box statistic for the null hypothesis that there is no autocorrelation up to order 15 for residuals.