AN INVESTIGATION OF COINTEGRATION AND CASUALTY RELATIONSHIPS BETWEEN THE PIIGS' STOCK MARKETS

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ABSTRACT

The aim of this paper is to investigate the relationship of price changes in the southern European E.U. member states through their stock markets and especially among the exchange markets of Portugal, Italy, Ireland, Greece and Spain, known also as the PIIGS countries. More specifically, it is examined whether co integration and causality relationships exists among the PIIGS' Stock Markets while by testing these relationships the existence of the Efficient Market Hypothesis (EMH) among these stock markets is also tested. In case of co integration relationships between these markets it is proved that possible advantages by internationalizing portfolio diversification are limited and further attention must be given for the selection of an internationalized optimal portfolio. It is also wealth mentioning that since 2012 Europe faces a serious economic crisis which is deeper in the member states of the South, so even further attention must be given to the construction of optimal portfolios.

KEY WORDS

Stock Markets, Cointegration, Granger Causality, PIIGS, EMH

JEL CLASSIFICATION

C22, F36, G10, G11

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1. INTRODUCTION

The aim of this paper is to investigate dynamic cointegrations among the PIIGS countries both in the short run and in the long run. The testing period is between January 2005 to December 2011 which covers the period before the financial crisis in the USA in 2007 and the collapse of Lehman Brothers until two years after the European crisis, especially in the southern member states of the E.U. due to their fiscal and banking problems. Our study for the existence of such relationships is applied both in the short run and in the long run, and the empirical findings show that changes in one or more stock market indices "dominates" over the PIIGS by causing to the indices of the other examined countries parallel movements, at a lower or a higher level. We also investigate the existence of the Efficient Market Hypothesis by testing for such relationships between "PIIGS" stock market indices.

We apply cointegration and causality tests to examine the efficiency of the PIIGSs stock markets (Thalassinos and Thalassinos, 2006; Thalassinos and Politis, 2011). In the case that two indices are cointegrated and the changes of the general index of one stock market cause similar changes to the general index of the other stock market, then it can be said that it becomes easier for investors to forecast the prices of an index by studying the price changes of another index. In this way investors can achieve supernormal returns with less risk.

Possible cointegration results between the PIIGS stock markets will imply that literature on the advantages of internationally diversified portfolios is rather overstated and in reality more attention must be given in order to select the optimal internationalized portfolio especially when the international economic and political environment is facing difficulties (Thalassinos and Kiriazidis, 2003). In this paper it is attempted to investigate the relationships between the PIIGS stock indices for the period before and after the financial crisis in the USA and in Europe. We are testing the Efficient Market Hypothesis into the "PIIGSs" area and we investigate how the present crisis was expanded in different member states but more in the PIIGS countries.

The remainder of this paper is organized as follows: In Section 2 we present the literature review, in Section 3 we explain the methodology which is applied in this paper. Then, in section 4 we discuss the outcomes and our findings while in the last section 6 we show in summary the concluding remarks of this research.

2. LITERATURE REVIEW

Chouliaras et al. (2012) examine two periods, February 2005 till June 2008 and July 2008 till June 2011 to investigate whether cointegration and causality relationships exist among the stock markets of the PIIGS countries. They apply Johansen cointegration, Granger causality, Gregory and Hansen residuals cointegration tests and a multivariate GARCH model. Their GARCH results confirm the existence of cointegrating relationships among the PIIGS stock markets and volatility spillovers between Greece and the rest of the countries.

Erdem et al. (2010) examine short- and long-run relationships between stock markets performance and economic growth for six emerging countries (Malaysia, Turkey, Mexico, Korea, India, and Brazil). They find that in the long run there is a close relationship between stock market performance and economic growth while in the short run the stock market performance is an impetus for economic growth. Pan Yue and Dai Yi-yi (2008) investigate the linear and non-linear causality relationship between China stock market and Hong-Kong market for the period January 1994 to December 2007.

Himestra and Jones (1994) apply Monte-Carlo simulation to calculate the confidence level and according to their causality tests there is non-linear causality relationship between the two markets. Egert and Kocenda (2007) use Granger causality test to analyze the movements among three stock markets in Central and Eastern Europe and examine the possible interdependence between Western European and Central and Eastern European stock markets. They find no robust cointegration relationship for any of the stock index pairs or for any of the extended specifications. There are signs of short-term spillover effects both in terms of stock returns and stock price volatility.

Yau and Nieh (2009) investigate the exchange rate effects of the New Taiwan dollar against the Japanese Yen (NTD/JPY) on stock prices in Japan and Taiwan from January 1991 to March 2008. They find an assymetric cointegration relationship in Taiwan’s financial market. They also find asymmetric causal relationships between NTD/USD and the stock prices in Taiwan. Subranamian (2009) examines the co-integration and relations among five major stock exchanges in East Asia. He employs recent techniques for investigating unit roots, co-integration, time-varying volatility, and causality in variance.

Lia et al. (2011) apply a panel cointegration approach to investigate the relationship between crude oil shocks and stock markets for the OECD and non-OECD panel from January 1995 to December 2009. Nonlinear cointegration is confirmed for the oil-stock nexus in the panel. The Granger causality tests demonstrate the existence of bidirectional long-run Granger causality between crude oil shocks and stock markets for these OECD and non-OECD countries. Thalassinos, Liapis and Thalassinos (2013) have investigated the role of the rating companies in the determination of the CDS spreads of PIIGS while Thalassinos (2008) has analyzed the trends and the developments in the

European financial sector during the Eurozone crisis and Thalassinos (2014) has examined the CDS spreads and the sovereign debt in Eurozone.

Luo and Esqueda (2011) investigate the cointegration and the relationships between large-cap energy stocks and oil price changes over the last decade. The results reveal that energy stock prices have a long run relationship with oil price fluctuations. Moreover, some particular energy stocks have Granger causal impacts on oil markets as well. Kim (2010) presents an empirical study in the dynamic relationships between each of national stock markets of the East Asian economies (Hong Kong, Singapore, Korea and Taiwan) and the U.S. stock market, by employing wavelet analysis. The empirical results show that the U.S stock market Granger causes almost all the East Asian stock markets. The short-run causal linkages of the U.S market to the East Asian economies are more dominant than the causal linkages of the other direction.

3. METHODOLOGY

In this research we investigate the interactions among the PIIGS stock markets. The purpose is to examine the relationships that exist between these markets by testing the direction of the causality. Because we examine for both the long term and the short term interactions we use Vector Error Correction Model and the cointegration theory.

Initially we apply a time series analysis to test the existence of unit roots based on the tests of Dickey-Fuller and Phillips-Perron. Positive indication for existence of unit root leads to the conclusion that the time series are not stationary and that leads us to the theory of cointegration. The method of cointegration used is that of Johansen (1988, 1991) and Johansen and Juselious (1990).

3.1 Dickey-Fuller Tests

We consider the regression equation yt = α1yt-1 + εt. The purpose of the test is to examine whether α1 = 1. Dickey – Fuller wrote the above equation this way: Δyt = γyt-1 + εt, where γ = α1 – 1, this way they test the hypothesis γ = 0. Dickey – Fuller developed three regressions to test for unit root:

$$\Delta y_t = \gamma y_{t-1} + \varepsilon_t \qquad (1)$$
$$\Delta y_t = a_0 + \gamma y_{t-1} + \varepsilon_t \qquad (2)$$
$$\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \varepsilon_t \qquad (3)$$

The difference of the three regressions has to do with the existence of α0 and α2t. The first equation is a random walk model, the second adds an intercept or drift factor, and the third incorporates both drift and linear trend over time.

The parameter that interests us in all the regression equations is γ. If γ = 0, then the time series yt has a unit root. But, not all time series can sufficiently be represented by autoregressive models of first order such as (1), (2) and (3), Dickey-Fuller (DF) constructed an augmented criterion.

The augmented criterion of Dickey-Fuller (ADF) is applied to test the existence or not of a unit root when the initial model has more than one time lags and has the following form:

$$\Delta y_t = \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \qquad (4)$$

$$\Delta y_t = a_0 + \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \qquad (5)$$

$$\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \qquad (6)$$

In the case of the ADF test the coefficient that interests us if γ. If γ = 0, then the series has a unit root. Furthermore, the differences between regression equations are as the DF test in the following form.

3.2 Phillips-Perron Tests

Phillips-Perron developed a generalization of Dickey-Fuller which allows for less strict hypotheses with respect to the distribution of errors.

To briefly present the procedure, consider the following equation:

$$y_t = a_0 + a_1 y_{t-1} + \mu_t$$

Phillips-Perron created statistical tests that can be used to check the hypotheses regarding the coefficients α0 and α1 under the null hypothesis that the data are being created from:

$$y_t = y_{t-1} + \mu_t$$

Phillips-Perron statistical tests are variations of t – statistics of Dickey-Fuller that consider less the more restricting nature of the errors procedure.

3.3 Cointegration Theory

Engle and Granger (1987) have shown that among two or more non stationary time series there can be a linear combination of them that is not stationary. In this study, the cointegration methods of Johansen (1988, 1991) and Johansen and Juselious (1990) are used, thus it is considered appropriate that this method is presented in brief. Johansen developed a theory to test the existence of cointegration in a equations system, based on the method of maximum likelihood.

The analysis begins with a multivariate autoregressive model, VAR(p). Moving on a multivariate vector error correction is being created (VECM). Generally, Johansen's method deals with specifying the rank of matrix Π. If Π is found to have rank equal to κ, then the conclusion drawn is that κ cointegration relationships between the yt exist and equivalently v – κ common stochastic trends. This can be achieved using the two statistics:

$$\lambda - trace(\kappa) = -T\sum_{i=\kappa+1}^{\nu}\ln\left(1-\hat{\lambda}_i\right) \qquad \lambda - \max(\kappa,\kappa+1) = -T\ln\left(1-\hat{\lambda}_{\kappa+1}\right)$$

where $\hat{\lambda}_i$ are eigenvalues. These eigenvalues are found by solving the equation:

$$\left|\lambda S_{11} - S_{10}S_{00}^{-1}S_{01}\right| = 0$$

And following by taking the corresponding eigenvectors $\hat{V} = (\hat{\upsilon}_1,\ldots,\hat{\upsilon}_\nu)$ which are being normalized in the following way $\hat{V}'S_{11}\hat{V} = I$. The estimations of the cointegration vectors, $\hat{\beta}$, occur from the κ eigenvectors that correspond to the κ greater eigenvalues. The selection of $\hat{\beta}$ is the selection of κ linear combinations of yt-1 that have the greater squared correlation with the stationary part of the procedure Δyt.

The statistic that is known as trace statistic, checks the null hypothesis that the number of the cointegration vectors is less than or equal to κ over an alternative hypothesis. The statistic that is known as maximum eigenvalue statistic, tests the null hypothesis of κ cointegration vectors over the specific alternative of κ + 1. Granger (1988) has shown that in a team of cointegrated variables the relations of causality among these variables must be examined in the framework of a error correction model. Furthermore he has shown that in the framework of a VECM model there are two channels of causality. One channel via the time lags of differences and one via the error correction variable (ECt-1). ECt-1 represents the deviations from the long term equilibrium relationship between these variables. In order for causality between the variables to exist, it is sufficient that one of two channels is “active”.

4. CREATING AND DESCRIBING OF THE SAMPLE OF THE STUDY

In this analysis the existence of causality and cointegration among the stock markets of the PIIGS are being considered, more specifically Portugal Stock Market Index, Irish Stock Exchange, Italy Stock Market, Athens Stock Exchange and Spain stock market index. These five countries form the group of European nations known as PIIGS.

Daily data have been used, in order for the causality relationship between the indices. The data cover the period of 01/01/2005 – 06/11/2011. The analysis tests the cointegration or not the relationships of causality between the examined stock market indices. The number of observations used was 1342. Furthermore, the use of logarithms in all the time series helps in normalizing the data, in order for the stationarity test and the degree of cointegration to be executed by using tests for unit roots. I our analysis we use the financial software Eviews.

5. EMPIRICAL RESULTS

5.1 Stationarity tests

In the tables below the results from the unit roots tests are presented. It is obvious from the tests that all the series are I(1) which means that they are cointegrated with degree 1. This means that in the levels they are not stationary because they contain unit root, while in the first differences they are stationary.

Testing this hypothesis is based in comparing t-statistic that corresponds to the highest statistics value with the critical confidence levels of the Dickey-Fuller, Augmented Dickey-Fuller and Phillips-Perron distributions. Table 1 presents the results we took from testing stationarity by the methods of DF and PP, where in the first part the results from the test in the levels are being presented. In addition, in the second part of the table the results from the test in the first differences are presented. Moreover, two models are used. The first model has a constant factor in the equation while the second model has a constant and a trend in the equation. As we observe in Table 1 (first differences) the statistical values are greater, in absolute, than the critical values of ADF and PP thus the null hypothesis for the existence of unit root is being rejected. Consequently, the time series for the Portuguese, Irish, Italian, and Spanish time series are stationary.

Table 1: Unit root tests by Dickey-Fuller and Phillips-Perron

Variable	lag Length		DF-ADF		PP	
Log Levels	DF	PP	model 1	model 2	model 1	model 2
LNGRE	1	4	1.049468	-0.299383	0.955214	-1.129106
LNIREL	1	4	-2.095788	-3.09151	-2.13747	-4.53051
LNITALY	1	4	-0.51063	-1.222542	-0.685903	-1.88526
LNPORT	1	4	-1.865464	-2.195947	-1.938360	-2.400166
LNSPAIN	1	4	-1.20689	-1.653438	-1.759957	-2.018706
			DF-ADF		PP	
Log First Differences			model 1	model 2	model 1	model 2
DLGRE	1	4	-20.79488*	-14.4879*	-34.21827*	-34.34959*
DLIREL	1	4	-43.00616*	-42.84434*	-83.71229*	-83.6959*
DLITALY	1	4	-24.74336*	-23.2366*	-32.04611*	-32.04715*
DLPORT	1	4	-21.11386*	-20.839*	-25.72266*	-25.71418*
DLSPAIN	1	4	-25.50869*	-17.51931*	-30.64459*	-30.64034*

The critical values of MacKinnon for rejecting the unit root hypothesis		
DF model 1		
1%	5%	10%
-2.5667	-1.9410	-1.6165
DF model 2		
1%	5%	10%
-3.48	-2.89	-2.57
PP model 1		
1%	5%	10%
-3.4351	-2.8635	-2.5678
PP model 2		
1%	5%	10%
-3.9650	-3.4132	-3.1286

The selection of the Lags for the DF test is based on the Akaike Information Criterion (AIC) while for the PP test is based on Newey – West

model 1: contains a constant and model 2: contains a constant and a drift

* rejection of the null hypothesis (Ho) for the existence of a unit root in all the levels.

5.2. Cointegration Test

5.2.1. Cointegration Test by the Method of Maximum Likelihood of Johansen

In Tables 2 and 3 we present the cointegration tests that are used in order to determine the number of cointegration vectors r. The hypotheses are being tested by comparing the statistical prices with the relevant critical values for a confidence level of 95%. If the statistics is greater, then the null hypothesis is being rejected.

Table 2: Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.158517	166.0161	69.81889	0.0000
At most 1	0.030852	40.37122	47.85613	0.2095
At most 2	0.020218	17.55731	29.79707	0.5988
At most 3	0.003526	2.687651	15.49471	0.9792
At most 4 *	0.115887	0.115887	3.841466	0.7335

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 3: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.158517	125.6449	33.87687	0.0000
At most 1	0.030852	22.81391	27.58434	0.1816
At most 2	0.020218	14.86966	21.13162	0.2981
At most 3	0.003526	2.571763	14.26460	0.9711
At most 4 *	0.000159	0.115887	3.841466	0.7335

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

According to the results both the λ-trace statistics and the λ-max eigenvalue statistics show the existence of a cointegration equation CI(1,1), which means a long term equilibrium relationship between the markets and 4 common stochastic trends.

The cointegration equation is written as follows:

SPAIN = 5878–0.567870POR - 1.967314ITA + 1.197895IREL - 0.04170GRE
(0.14725) (0.17541) (0.09915) (0.05356)
[-3,85641] [-11.2156] [12.0819] [-0.07785]
(standard errors in parentheses, t-statistics in []).

Based on the Johansen Cointegration and the statistics tests used we reach the conclusion that the Greek index influences the least the other indices, and after the Greek the least significant is the Portuguese Index, then the Irish and at last the most influencing index is the Italian. The Greek and the Portuguese index cannot significantly influence the equilibrium equation, and as a consequence they cannot influence the other indices in the long run. Thus the weight of correcting any deviation from equilibrium lies in the indices of Spain and Italy.

5.2.2 Cointegration Test and Granger Causality

The VEC Granger Causality/Block Exogeneity Wald Tests are presented in Table 4 while the causality relationships that occur are being presented in |Table 5.

Table 4.a: Dependent Variable D(LNSPAIN)

Excluded	Chi-sq	df	Prob.
DLNPORT	2.950314	2	0.2287
DLNITA	1.634239	2	0.4417
DLNIREL	0.345031	2	0.8415
DLNGREE	23.24111	2	0.0000
ALL	26,71294	8	0,0008

Table 4.b: Dependent Variable D(LNPORTUGAL)

Excluded	Chi-sq	df	Prob.
DLNSPAIN	7.973420	2	0.0186
DLNITA	0.08066	2	0.9665
DLNIREL	0.412018	2	0.8138
DLNGREE	14.94183	2	0.0006
ALL	26,12709	8	0,0010

Table 4.c: Dependent Variable D(LNITALY)			
Excluded	Chi-sq	df	Prob.
DLNSPAIN	10.02652	2	0.0066
DLNPORT	3.459682	2	0.1773
DLNIREL	21.25340	2	0.0000
DLNGREE	4.100769	2	0.1287
ALL	36,63105	8	0,0000

Table 4.d: Dependent Variable D(LNIRELAND)			
Excluded	Chi-sq	df	Prob.
DLNSPAIN	1.717357	2	0.4237
DLNPORT	0.060977	2	0.9700
DLNITALY	1.336705	2	0.5126
DLNGREE	1.220424	2	0.5432
ALL	14,33485	8	0,0734

Table 4.d: Dependent Variable D(LNGREECE)			
Excluded	Chi-sq	df	Prob.
DLNSPAIN	5.190396	2	0.0746
DLNPORT	4.899071	2	0.0863
DLNITALY	2.214944	2	0.3304
DLNIREL	0.765350	2	0.6820
ALL	15,98050	8	0,0427

TABLE 5: Granger causality relationships

→	LNSPA*	LNGRE*	LNITA*	LNIREL*	LNPOR*
LNSPA	--	NO	YES	YES	YES
LNGRE	YES	--	YES	YES	YES
LNITA	NO	NO	--	YES	NO
LNIREL	NO	NO	YES	--	NO
LNPORT	NO	NO	YES	NO	--
ECT_{t-1} - **	YES	YES	YES	YES	NO

The table is read as follows: The stock indices that are refereed in the first column cause the indices in the following columns. Which means LNSPA → LNITA*, LNSPA → LNPOR* etc. These results are corresponding to tests with a significance level of 5%.

From the above tables it follows that the European markets (PIIGS) are closely related to each other, since at least one channel of causality is open for all markets. There are causality relationships either by short term influences or by long term influences. So PIIGSs stock markets indicating serious interactions between them because of the European economies have come closer, as long as their commercial and economical relationships have been enhanced.

6. CONCLUSIONS

A basic conclusion is that the empirical analysis led to results and findings that were consistent with the theoretical framework. In this paper, the long term and the short term relationships among five European Stock Markets, forming the PIIGS group (Portugal, Ireland, Italy, Greece, Spain) were examined, for the period from 01/01/2005 to 06/11/2011.

The examination of the relationships among these indices was made via the methodology of cointegration. In this paper all the time series were transformed in logarithmic. Tests applied include Dickey-Fuller, Augmented Dickey-Fuller and Phillips Perron of unit roots in levels and differences of the prices of the indices. In order to compare the statistics with the critical values, special tables were used that present the results for existence or not of stationarity. All time series were shown to be I(1).

The cointegration tests that were used for five countries (PIIGS) led us to the discovery of a cointegrated matrix (r=1) which means that, the four time series are CI (1,1) which rejects the hypothesis for efficiency in a weak form in the time series we studied. This leads to high profits for the investors. In addition we examined whether relationships of Granger causality exist in the PIIGS indices for the period we examined, had positive results since at least one causality channel, short term or long term is always open. Furthermore, the existence of cointegration among the stock markets means that there is a long term equilibrium condition and the markets cannot deviate a lot, because there exists an arbitrage activity that brings stock markets back to equilibrium in a long term time horizon.

Moreover, the interactions between the markets are quite strong, something that was expected taking into account the momentum of economies to globalization. One stock market influences the other and a “shock” in one of these is diffused in the others. Thus the results of an international diversification are judged as doubtful and extreme. In addition caution is demanded when studying and selecting stock markets and investment strategies.

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