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THE INTERDEPENDENCE OF MAJOR EUROPEAN STOCK MARKETS: EVIDENCE FOR GREECE*

By

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Abstract

This paper provides new evidence on the relationship between the Greek "blue chip" stock market and the six relative European markets by applying cointegration tests. The time period examined is 1998 to 2000, which marks the entry of Greece to the European Exchange Rates Mechanism II. The empirical results indicate that the Athens Stock Exchange has no considerable links, except for one case, with any other European developed markets examined. These findings have some significant implications for European-oriented portfolio diversification and the national stock market integration hypothesis. JEL Classification: C12, C32, G14.

1. Introduction

The significance of the stock markets increases along with the globalization of the world economy. In European Union, the liberalization of securities markets and the political decision for the monetary union increased the interest of both investors and academic scholars in examining the interrelationships among the European stock markets.

This paper focuses on the examination of interdependencies among European "blue chips" stock markets. More specifically, it investigates the existence

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of cointegration relationships between the emerging Greek stock market and developed markets in six European countries (United Kingdom, Germany, France, Portugal, Italy, Belgium). The Greek stock market and the other European markets are analyzed both individually and collectively to test for the weak-form market efficiency. According to the cointegration literature (Granger, 1986; Chan, Gup and Pan, 1992, Arshanapalli and Doukas, 1993), if two markets are collectively efficient in the long run, then their stock prices cannot be cointegrated. If two markets are cointegrated, then possible arbitrage profits can be explored. The cointegration hypothesis is applied and tested in this paper by using the Engle-Granger's two-step methodology and the Johansen's Maximum Likelihood procedure.

The results of cointegration tests have important implications for portfolio diversification through investing strategy. According to Defusco, Geppert and Tsetsekos (1993), Arshanapalli and Doukas (1993), and Chan, Gup and Pan (1992 and 1997), diversifying into international stock markets cannot be effective if those markets are cointegrated (there are price co-movements). This is because the systematic/country risk cannot be diversified away. Therefore, it is not in the best interest of investors aiming for diversified portfolios to invest in cointegrated markets.

A hypothesis that explains national stock market integration is also investigated in this paper. This hypothesis states that the stronger the economic ties are among countries of the same continent or within the same economic zone the higher the degree of their integration with each other. The existence of a common feature among stock markets leads them to cointegration (Engle and Susmel, 1993).

The last thirty years, a great number of studies have examined the interrelationships among world stock markets, using different data sets and a number of nations (e.g. Gruber and Fadner, 1971; Agmon, 1972; Panton, Lessig and Joy, 1976; Finnerty and Scheeweis, 1979; Schollhammer and Sand, 1985; Eun and Shim, 1989). The last two decades, the cointegration theory has intensively been used in order to analyze world and European stock markets[1].

Some of the studies provide evidence of the interdependence of stock markets, finding insignificant correlations to the returns of developed and emerging stock markets (Dwyer and Hafer, 1988; Hauser et. al., 1994; and Errunza, 1994). These results support the portfolio diversification to those markets.

Other empirical evidence shows the existence of linkages between international stock markets (Jaffe and Westerfield, 1985; Eun and Shim, 1989; Speidell and Sappenfield, 1992; Arshanapalli and Doukas, 1993; Blackman et. al. 1994 Chan, Gup and Pan, 1997, although observed contradictory results are due to different using methodologies (Kohlhagen, 1983; Khoury et. al., 1987).

This research is significant for the following related but different reasons. First, this paper empirically examines the linkages that existed between the emerging Greek stock market and six developed European stock markets (United Kingdom, Belgium, Italy, Portugal, Germany and France) for the period after the Greek entry to the European Exchange Rates Mechanism II (March 1998). Second, it examines the weak-form efficient market hypothesis both individually (for each of the seven stock markets by unit roots tests), and collectively by cointegration tests. The cointegration tests examine the existence of a long-run common stochastic trend among stock prices. The reason for choosing those "blue chip" stock indices is because they are benchmarks for investors when formulating their portfolio strategy (especially for the emerging Greek stock market). The findings of this paper should provide useful information for investors in formulating their European diversification strategy. Third, the hypothesis of explaining market integration in the European Union is investigated.

The rest of the paper is organized as follows: Section 2 outlines the methodological issues (unit root and cointegration tests and their connection with the concept of Market Efficiency) relevant to the theme of the study. Section 3 describes the data and presents the empirical results, while conclusions are coming forth in section 4.

2. Methodological issues: Unit Roots, Cointegration Tests and Market Efficiency

In order to test for cointegration, two econometric procedures are implemented: the Engle-Granger two-step methodology (Engle and Granger, 1987) and the Johansen's Maximum Likelihood approach (Johansen, 1988 and 1991).

According to Engle and Granger, two basic steps are followed

1. Testing the existence of unit roots (integration order) in each index, following the analysis of Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1981) through the relationship:

$$ADF: \Delta S_t = a + \beta T + \varrho S_{t-1} + \sum_{t=1}^{\kappa} \gamma_t \Delta S_{t-1} + u_t \tag{1}$$

where $\Delta S_t = S_t - S_{t-1}$, St is the index of the examined market, T the total number of observations and k is chosen so that the innovations u_t to be white noise. For the DF test, the γ_t's are considered equal to zero. The null hypothesis is H_o: $\rho=0$. If the null hypothesis of only a unit root cannot be rejected, then the stock prices follow a random walk. Thus, the stock market is weak-form efficient.

2. Cointegration testing among the stock market indices. Consider stock prices (in log) in countries i and j (5,' and 5/), and P_t is the vector that consists of S^i_t and S^j_t. According to Engle and Granger (1987), 5,' is said to be integrated of order d, denoted 5,' ~ I (d), if the dth difference of 5,' is stationary. The vector P_t is said to be cointegrated of order d, b, denoted as $P_t \sim CI$ (d, b), if each component of P_t is integrated of order d, and there exists a non-zero vector δ such that δ' P_t is integrated of order d-b, for b>0. If both 5,' and S^j_t are I (1) and $P_t \sim CI$ (1,1) [i.e. δ' Pt~ I (0)], then there are error-correction equations in the following form

$$\Delta S^i_t = \alpha_1 \, [S^i_{t-1} - \delta_1 \, S^j_{t-1}] \; + \; \text{lagged } (\Delta S^i_t \text{ and } \Delta S^j_t) \; + \; e^i_t$$

$$\tag{2}$$

$$\Delta S^j_t = \alpha_2 \, [S^j_{t-1} - \delta_2 \, S^i_{t-1}] \; + \; \text{lagged } (\Delta S^i_t \text{ and } \Delta S^j_t) \; + \; e^j_t$$

where α_1 and α_2 are non-zero coefficients and e^i_t are e^j_t stationary, possibly autocorrelated error terms. As Granger (1986) and MacDonald and Taylor (1988 and 1989) have demonstrated, asset prices from two efficient markets cannot be cointegrated. The implication from the error-correction equations is that stock price changes in country i (country j) are predictable by $[S^i_t \; -\delta_1 S^j_t]$ $[S^j_t \; -\delta_2 S^i_t]$ if stock prices in countries i and j are cointegrated. On the other hand, if stock prices in country i and j are not cointegrated, then stock prices in country i have already incorporated all available information into the pricing process. Therefore, historical stock prices of country j contain no useful information in forecasting the stock price changes of country i. According to MacDonald and Taylor (1988 and 1989):

$$E(S_t^i/I_{t-1}^i) = E(S_t^j/I_{t-1}^{ij}), \tag{3}$$

$$I_{t-1}^i = \{S_t^i,\ S_{t-1}^i,\ S_{t-2}^i, \ldots\ldots\}$$

(4)

$$I_{t-1}^{ij} = \{S_t^i,\ S_{t-1}^i,\ S_{t-2}^i, \ldots,\ S_t^j,\ S_{t-1}^j,\ S_{t-2}^j, \ldots\}$$

Condition (3) is clearly contradicted with error-correction representation in condition (2), unless α_1 and α_2 and the coefficients associated with lagged ΔS^i_t, and ΔS^j_t are all zero. Thus, cointegration implies collective inefficiency.

Engle and Granger proposed several cointegration tests, however, the most preferable is the ADF statistic test.

Johansen extends Engle and Granger's cointegration to a multivariate framework considering a fairly general unrestricted error-correction model in the following form

$$\Delta S_t = \Gamma_1 \Delta S_{t-1} + \ldots + \Gamma_{\varkappa-1} \Delta S_{t-k+1} + r S_{t-k} + \mu + e_t, \tag{5}$$

where S_t = (px1) vector of stock prices at time t;

r = (pxp) parameter matrix;

μ = (px1) intercept term.

The parameter matrix, r, indicates whether the (px1) vector of stock prices has long - run dynamic relationship or not. The rank of r equals the number of cointegrating vectors. If r has full rank, then all the stock price series are stationary in levels. If the rank of r is zero, eq. (5) reduces to a standard vector autoregression model. Cointegration is suggested if the rank of r is between zero and the number of stock series. The null hypothesis is that there is no cointegration among the stock prices.

Hall (1991) has demonstrated that in using the Johansen test for cointegration it is necessary to carry out tests to establish the appropriate order of the VAR. These tests are the multivariate generalizations of the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC):

$$AIC = T \log |\Sigma| + 2N \tag{6}$$

$$SBC = T \log |\Sigma| + N \log (T)$$

where T: number of observations;

N: total number of the forecasting parameters;

$|\Sigma|$: variance-covariance matrix of the residuals.

3. Data and Empirical Results

Daily price "blue-chip" indices of stock markets in Greece (FTSE/ASE 20), United Kingdom (FTSE 100), Belgium (BEL 20), Italy (MIB 30), Portugal (PSI 20), Germany (XETRA DAX 100) and France (CAC 40) are used in this study. The data were collected from the OECD Economic Indicators and Reuters. Because dividends are not included, the indices simply represent prices. The data were converted to natural logs for the purpose of this study. The data cover the period from March 1998 to December 2000.

To test the stationarity on each stock index price series, the DF and ADF unit roots tests are computed (on the levels). Table 1 reports the results of the unit roots tests on the levels of each price series. The results indicate that the null hypothesis of unit roots in stock index prices for all seven countries should not be rejected.

TABLE 1

Unit roots tests on the levels of the seven "blue-chip" stock indices

Index	DF levels	ADF levels
FTSE/ASE 20	-1.7558	-2.2100
FTSE 100	-2.8896	-3.0080
BEL 20	-3.2471	-3.5297
MIB 30	-2.2270	-2.2241
PSI 20	-1.6937	-1.9611
XETRA DAX 100	-1.7822	-1.7964
CAC 40	-2.1740	-2.2972

Note: The critical value of the ADF statistic test is -3,4208 at 5% confidence interval.

To determine the order of integration of each price series, the DF and the ADF tests on the first differences are computed. Table 2 reports the results of the Unit roots tests.

TABLE 2

Unit roots tests on the first differences of the seven "blue-chip" stock indices

Index	DF first differences	ADF first differences
FTSE/ASE 20	-18,5704 *	-15,1739 * (2)
FTSE 100	-21,4688 *	-17,2541 * (2)
BEL 20	-20,0961 *	-16,2776 * (2)
MIB 30	-22,4355 *	-15,8794 * (2)
PSI 20	-18,6886 *	-15,2209 * (2)
XETRA DAX 100	-22,0912 *	-16,4573 * (2)
CAC 40	-20,8775 *	-16,5122 * (2)

Notes: The critical value of the ADF statistic test is -3,4208 at 5% confidence interval. * Indicates statistical significance at 5% confidence interval. The number in parentheses shows the least required lag order to have white noise innovations.

The results indicate that unit roots on the first differences of the stock index prices are rejected at the 5% significance level, suggesting that the stock price changes are stationary[2]. That is, all the daily stock index prices are I(1) processes, indicating that stock prices follow a random walk. This result implies that all the stock markets examined are individually weak form efficient.

Since the stock index price series are I (1), both the Engle-Granger's tests and the Johansen's procedure tests for cointegration are used. Engle-Granger's cointegration tests are implemented to the residuals of the regressions, and Table 3 reports the results of the DF and ADF tests[3].

The results indicate that the null hypothesis of no cointegration between the Greek stock index and the other examined indices (Belgium, Italy, Portugal, Germany, and France) is accepted at 5% significance level. On the other hand, the cointegration test result between the Greek "blue-chip" stock index and the corresponding British one indicates that the alternative hypothesis of one cointegrating vector is accepted at 5% significance level. In order to use the Johansen's procedure tests for cointegration, it is necessary to carry out tests to establish the appropriate order of the VAR for each variable system. The results of the AIC and the SBC established that a lag length of 2 is appropriate for each system[4] The Johansen's multivariate cointegration test results are presented in Table 4.

TABLE 3

Engle-Granger's cointegration tests

System	DF	ADF
FTSE/ASE 20-FTSE 100	-3.7040*	-3,6799* (2)
FTSE/ASE 20-BEL 20	-2.4130	-2,5793* (2)
FTSE/ASE 20-MIB 30	-2.3472	-2,3501* (2)
FTSE/ASE 20-PSI 20	-1.7318	-1,8324* (2)
FTSE/ASE20-XETRA DAX 100	-2.0495	-2,0535* (2)
FTSE/ASE 20-CAC 40	-2.0808	-2,1405* (2)

Notes: The 5% critical value is -3,3497 for ADF statistic test.
* Indicates a 5% level of significance. The number in parentheses shows the least required lag order to have white noise innovations.

TABLE 4

Johansen tests for cointegration

System	Null Hypothesis	Alternative Hypothesis	Tests for cointegration vectors based on	
			Maximal eigenvalue	Trace
FTSE/ASE 20-FTSE 100	r = 0	r ≤ 1	15.9102	18.3680
	r ≤ 1	r = 2	2.4579	2.4579
FTSE/ASE 20-BEL 20	r = 0	r ≤ 1	11.2407	13.2735
	r ≤ 1	r = 2	2.0328	2.0328
FTSE/ASE 20-MIB 30	r = 0	r ≤ 1	4.1406	5.5083
	r ≤ 1	r = 2	1.3677	1.3677
FTSE/ASE 20-PSI 20	r = 0	r ≤ 1	4.0389	7.5347
	r ≤ 1	r = 2	3.4957	3.4957
FTSE/ASE 20-XETRA DAX 100	r = 0	r ≤ 1	4.1830	5.5301
	r ≤ 1	r = 2	1.3470	1.3470
FTSE/ASE 20-CAC 40	r = 0	r ≤ 1	4.9287	4.5999
	r ≤ 1	r = 2	0.32878	0.32878

Note: The. critical values of the test based on Maximal eigenvalue are 14.8800 (r = 0, r =< 1) and 8.0700 (r= < 1, r = 2), while the critical values of the test based on Trace are 17.8600 and 8.0700 respectively.

The above results lead to similar findings with those of the Engle-Granger's methodology. More specifically, the hypothesis of cointegration between the Greek index and the relative ones in Belgium, Spain, Portugal, Germany, and France is rejected, while it is accepted between the Greek and the British stock index[5].

The existence of cointegration between the Greek and the British "blue-chip" stock market implies that it is possible to use the price movements in one market in order to predict the future price movements in the other market, and thus long run possible arbitrage profits can be explored. Moreover, the appearance of cointegration between the above two markets rejects the collective efficiency hypothesis.

The empirical results provide some implications for portfolio diversification and the hypothesis that explains the national stock market integration. The rejection of cointegration between the Greek "blue-chip" stock index and the corresponding ones in Belgium, Italy, Portugal, Germany, and France implies that there are no linkages between them, and that the Greek stock market is offered for a European-oriented portfolio diversification. On the other hand, the long-run co-movements between the Greek and the British "blue- chip" market imply that they are improper for diversification. Finally, countries with common economic ties (e.g. European Union countries) may not cointegrate to each other. That is, the common economic and geographic ties do not necessarily lead national stock markets to follow the same stochastic trend. The lack of significant cointegration in the sample seems not to support this hypothesis.

4. Conclusions

This paper has examined the linkages between the Greek "blue-chip" index market and indices of six European markets using both the Engle-Granger's cointegration tests and the Johansen Maximum Likelihood procedure on a daily data set for the period of 1998-2000.

The stock indices of seven national equity markets examined in the study all have a unit root, suggesting that they are individually efficient in a weak form. The cointegration analysis provides evidence that there are no links (the hypothesis of cointegration is rejected) between the Greek stock market and the stock markets in Belgium, Italy, Portugal, Germany, and France, while there exists a long-run price co-movement between the Greek and the British stock market (the hypothesis of one cointegrating vector is accepted). This evidence supports the hypothesis that the Greek and all other European markets, except the British, are collectively efficient for the examined period.

The existence of a common stochastic trend among the stock prices in the Greek and British "blue chip" stock markets shows that possible arbitrage profits can be explored over time. On the other hand, the lack of significant cointegration between the Greek and the other European markets implies that the Athens Stock Exhange can be used for a European-oriented effective portfolio diversification. Finally, the empirical results seems not to support the hypothesis that common geographic and economic ties do necessarily lead national stock markets to a long run correlation, following the same stochastic trend.

Footnotes

1. Most studies have examined interdependencies among the world stock markets either using 1960s to 1970s data (Gruber and Fadner, 1971; Agmon, 1972; Panton, Lessig and Joy, 1976; and Finnerty and Scheeweis, 1979) or using solely 1980s data (Schollhammer and Sand, 1985; Eun and Shim, 1989; Arshanapalli and Doukas, 1993; and Chan, Gup and Pan, 1992). Chan, Gup and Pan (1997) used a period from 1961 to 1992.

2. Similarly, the computation of Phillips- Perron unit root test (Phillips, 1987 and Perron, 1988) supports the DF and ADF test results.

3. Analysis of the data indicated that there was a problem of normality. This appears to be due to the presence of unanticipated events in each stock market. The problem of non-normality in the data is overcome by including a dummy variable relating to a specific observation in each index. The results in Table 3 and 4 relate to tests including stationary dummy variables. Exclusion of the dummies does not alter the pattern of results.

4. In the interests of brevity, tests results are not presented here. Results are available from the authors on request.

5. The robustness of the results using the Johansen procedure in relation to violations of non-normality and heteroskedasticity was examined using the error- based tests for cointegration proposed by Phillips and Perron (1988). The results presented here were confirmed.

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