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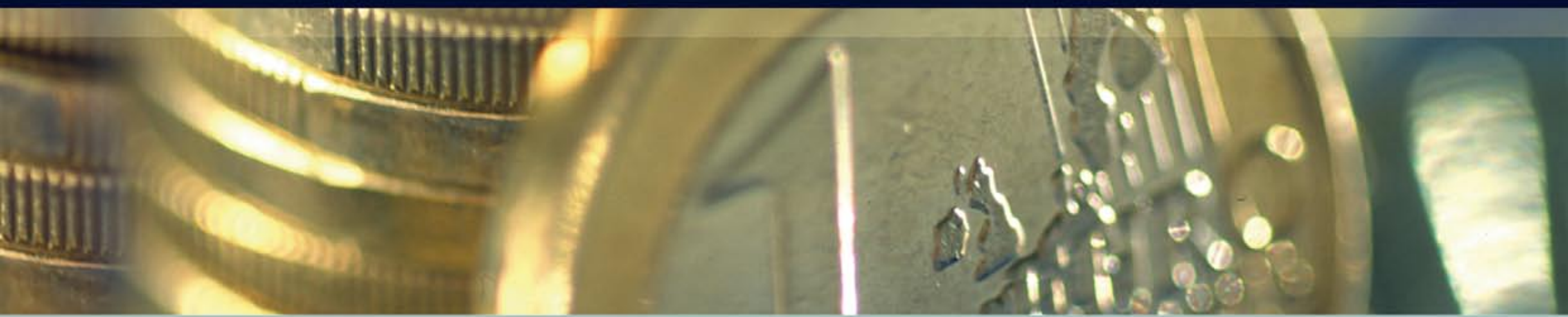

Assessing financial integration: a comparison between Europe and East Asia

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Assessing financial integration:
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Rossella Calvi[1]

Abstract

Two parallel analyses are carried out in order to assess the degree of integration of financial markets within Europe, within East Asia, between these two regions, and with the *external* financial community. The investigation is based on cointegration and Granger causality techniques, to detect the presence of short-run and long-run cross-country relationships in equity and bond markets. The empirical analysis performed for seven European and eleven East Asian financial markets confirms that in Europe financial integration is significantly more advanced than in East Asia. It provides evidence in favour of the fact that the level of integration between bond markets is higher than between equity markets within Europe, whilst the opposite holds true in the East Asian region. An increase in the number of short and long-run relationships in European bond and equity markets is found after the introduction of the Euro in 1999, especially if only EMU countries are considered. In addition, the parallel analysis on East Asia points out that financial integration in Asia is still in its infancy although an increase in the level of integration of equity markets in the last ten years can be recorded. Finally, East Asian bond markets display little evidence of co-movement, despite the recent initiatives launched in order to increase financial integration in the region.

JEL classification: G15, C32, E44

Keywords: financial integration, cointegration, Granger causality

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1. Introduction

In the aftermath of the 1997-1998 Asian financial crisis, which devastated Asian financial markets and economies, several regional initiatives had been launched with the aim of strengthening financial cooperation and integration in the region. This process – whose milestones are the Chiang Mai Initiative (2000) and the Asian Bond Market Initiative (2003) - was mainly driven by the willingness to prevent the occurrence of a new crisis.

In contrast, the process of financial integration in Europe is part of the broader process of integration started long before 1945 as an << integration for peace>>[1] and that took the shape of formal agreements after the Second World War. Different historical, geographical and political conditions and different motivations drive the economic and financial integration processes in Europe and East Asia. Nevertheless, a growing number of studies can be found in the literature, not only comparing the two processes of economic and financial integration, but also trying to extract lessons for the East Asian financial integration process from the European one[2]. With no doubts, the preliminary empirical assessment of the differences between the time frames of the two processes and between the degrees of integration in the two regions is crucial.

In particular, this work focuses on the process of integration of equity and bond markets. On the one hand, a deeper integration of equity markets can lead to lower cost of capital due to better possibilities for international investors to eliminate country-specific risks by diversification, to a consequent increase in the number of productive investment and, therefore, to a boost in economic growth. Moreover, households can benefit from the larger possibilities of risk-sharing, whilst corporations may have access to a larger and international pool of funds[3]. A deeper level of regional equity market integration, however, means also that there may be no gains from portfolio diversification between the countries of the region[4]. On the other hand, the potential benefits of a deeper regional integration in the government bond market need attention. First of all, in a more integrated scenario, governments can reduce the cost of servicing their debt. Investors can indeed diversify geographically their portfolios and eliminate their exposure to local economic shocks, so that lower yields for government bonds

[1] Park, Y. C and C. Wyplosz (2008).
[2] See, for example, Pasadilla, G. O. (2008) and Bertoldi, M. and C. Gaye (2008).
[3] Ibidem.
[4] Worthington A. C., M. Katsura and H. Higgs (2003).

are required. Moreover, further integration increases transparency and homogeneity in pricing, so that government bonds of similar maturity become closer substitutes[5].

Co-movements in the financial markets can be used - and have frequently been used in the empirical literature - to estimate their level of integration[6]. This study provides an assessment of the level of regional financial integration within East Asia and Europe through the use of cointegration and Granger-causality analyses. Historical series of equity indices and government bond returns are used.

Two parallel analyses are indeed developed to assess the presence of co-movements within the two regions – East Asia and Europe – and between the two regions and the external world. As in I. Yu, L. Fung, C. Tam (2008), the Dow Jones Industrial Average (DJIA) and the yield on the US 10-year Treasury bond are used respectively as proxies for external equity and bond markets. In particular, an analysis of the differences in the intensity of integration between the two regions and between bond and equity markets within the two regions is provided. Moreover, the eventual increase in the level of regional integration in both areas over time is analyzed.

The differences in the degree of development and in the institutional framework of the European and the East Asian financial markets must be taken into account and comparisons between the two regions should be interpreted with caution.

A priori, this study expects to provide empirical evidence in favour of the following figures. Firstly, more developed European financial markets are expected to show a higher degree of integration compared to the East Asian ones. Moreover, an increase in the degree of integration is likely to be found within Europe - after the introduction of the Euro – and within East Asia - after the 1997-1998 financial crisis and the following initiatives launched with the aim to avoid future crises in the region.

The remainder of this study is organized as follows. A brief review of the literature on financial integration and on the use of cointegration and Granger-causality analysis is provided in Section 1. Section 2 provides a description of data, while in Section 3 the results of the cointegration analysis are described in order to assess the presence of a long-term equilibrium between the series. In Section 4, the presence of a leading country in the two regions is investigated through a Granger causality analysis. Finally, Section 5 contains some concluding remarks.

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[5] Baele, L., A. Ferrando, P. Hördal, E. Krylova and C. Monnet (2004).

[6] For a brief review of the literature, see section 1.2.

1.1 Features of financial markets integration: literature review

The issue of financial market integration in East Asia has been extensively examined in the literature, but there are few empirical works assessing simultaneously the equity market and the bond market integration. Moreover, the development of two parallel analyses on Europe and on East Asia has been seldom provided.

Financial integration is the process by which a country's or a region's financial markets become more closely integrated with those in other countries or regions[7]. It deserves particular attention since economic theory and empirical findings suggest that integration and development of financial markets are likely to remove frictions and barriers to exchange, to allocate capital more efficiently and, therefore, contribute to economic growth[8]. On the contrary, the achievement of deeper financial linkages between countries or between regions may increase the risk of cross-border financial contagion, so that financial instability in one country can be transmitted to neighbouring countries more rapidly[9].

The process of financial integration within the European Union has been analyzed widely in the literature in order to identify the effects of the introduction of the Euro and of the ongoing EU Enlargement process. For example, B. M. Lucey, S. J. Kim and E. Wu (2004) examine the time-varying level of integration of European government bond, using daily returns over the 1998-2003 period, and provide evidence for strong contemporaneous and dynamic linkages between existing EU member bond markets with that of Germany. However, for the UK and the three countries which accessed the EU in 2004 – namely of Czech Republic, Poland and Hungary – they find such linkages relatively weak but stable over the sample. Moreover, M. Fratzscher (2002) finds that European equity markets have become highly integrated only since 1996 and that the Euro area market not only has increased its importance in world financial markets but also has taken over from the USA as the dominant market in Europe. Moreover, he claims that the integration of European equity markets can be mainly attributed to the drive towards the monetary union, and in particular to the elimination of exchange rate volatility and uncertainty. Analogously, G. A. Hardouvelis, D. Malliaropuls and R. Priestley (2006) find that in the second half of the 1990s the degree of equity markets integration within EMU gradually increased to the point where individual Eurozone country stock

[7] Worthington, A.C. and H. Higgs (2007).
[8] Ibidem.
[9] See, fore example, Yu, I., L. Fung and C. Tam (2008).

markets appear to be fully integrated into the EU market due, on the one hand, to the evolution of the probability of joining the single currency – measured by each country's forward interest rate differential with Germany – and, on the other hand, to the evolution of inflation differentials.

Furthermore, examples of correlation analysis and cointegration analysis used to assess the level of financial integration within Europe can be frequently found in the literature. For example, M. Croci (2004) investigates whether the euro equity markets have become more integrated over the period 1994-2004 analyzing unconditional correlations, ex-post rolling estimates of correlations and dynamic conditional correlations. In particular, she finds that the increase of the level of integration between equity markets is mainly explained by the relaxation of restrictions to capital mobility and of institutional barriers and by economical convergence in Europe, rather than by the actual introduction of the single currency. J. Soares da Fonseca (2008) uses the Engle-Granger cointegration methodology in order to evaluate the international integration of sixteen stock markets within Europe over the period 2001-2005. The results of his analysis indicate that the introduction of a single currency not only did not affect the nature of the long-term relationships between the variables, but also that no evidence of any difference of patterns between EMU and non EMU members can be found.

Several studies claiming that the global financial integration dominates the intra-regional financial integration in East Asia can be found in the literature. Different analyses have been conducted in order to identify the factors responsible for the slow pace of financial integration within the East Asian region.

Gravity models are frequently used to assess the degree of financial integration between two countries. In their basic specifications they relate the level of bilateral financial integration to the size of the economy and the financial market positively and to the distance between the countries negatively. For example, adding several explanatory variables to the usual gravity model, A. Garcia-Herrero, D.Yang and P. Wooldridge (2008) show that limited liquidity in Asian financial markets helps to explain why regional financial integration lags behind global financial integration. Moreover, B. Eichengreen and Y.C. Park (2003) provide an analysis of Asian financial integration in a European mirror suggesting that the very different levels of economic development in Asia and Europe, along with other differences in regional circumstances, such as the distance between countries, the presence of a common language or of a shared land border, can be considered a good explanation of the difference in financial integration between the two regions. In particular, they consider the incompleteness of a free trade area, the "weakly institutionalized" and multi-polar process of integration the main reasons of the low level of regional financial integration in East Asian and the main differences between the European and the East Asian process of integration.

Furthermore, I. Yu, L. Fung, C. Tam (2008) provide an assessment of financial market integration in different dimensions through the use of various price-based indicators, looking into price convergence, sensitivity, co-movement, cycle synchronisation and return correlation as evidence of integration. The picture that emerges from their empirical results is not completely uniform, even if most of the times a weak integration of both equity and bond markets in East Asia is found. Moreover, they find that the price convergence process appears to be more complete in the mature markets[10] of the region than those in the emerging Asia. Finally, their correlation analysis suggests that the level of integration of Asia's equity markets is higher than the integration of its bond markets.

1.2 Use of correlation, cointegration and Granger-causality as indicators of financial integration

The field of financial market integration represents a remarkably broad area of research in financial economics. Over time, several econometric methodologies have emerged to assess the degree of financial integration, in particular by testing the presence of international linkages between markets.

The analysis of cointegration is one in a number of traditional methods for estimating the extent of financial market integration. In several research pieces[11], cointegration analysis is used in order to assess the presence of a long-run equilibrium relationship among the variables, whereby the series do not deviate too much from each other. Cointegration means that the series share a common stochastic trend over time and that stationary linear combination of two or more integrated variables can be found. The analysis by Kasa (1992)[12] is one of the first examples of cointegration analysis applied to assess equity market integration of US, Japan, England, Germany, and Canada. Monthly and quarterly data from January 1974 to August 1990 are used to compute Johansen (1991) tests for common trends. The results indicate the presence of a single common trend driving these countries' stock markets. Moreover, O. Ceylan (2006) assesses the long-term stock market integration with the European Union and the US in the cases of Romania, Croatia, Bulgaria and Turkey over the

[10] Hong Kong, Japan, South Korea, Singapore.
[11] See, for example, I. Yu, L. Fung, C. Tam (2008). See also O. Ceylan (2006).
[12] Kasa, K., (1992).

period 2000-2005 using the Johansen cointegration test. In particular, he finds that these stock markets still do not have a long-run equilibrium despite the general economic convergence. Furthermore, R. Click and M. G. Plummer (2003) analyze the presence of cointegration between equity markets of Indonesia, Malaysia, Philippines, Singapore and Thailand in the period after the 1997-1998 Asian financial crisis. Their empirical results indicate that the ASEAN-5 stock markets are not completely segmented by nation. Nevertheless, only one cointegrating vector is found, so that ASEAN-5 stock markets are integrated in the economic sense, but integration is not complete. A. C. Worthington, M. Katsura and H. Higgs (2003) provide another example of the use of cointegration in order to assess the level of integration between European financial markets before and after the introduction of the single currency. Applying the Johansen test for cointegration and Granger causality tests in order to analyze the presence of long-run relationships and short-run causal linkages, they find that there has been an increase in European financial integration, both within and outside the single currency area after the Maastricht Treaty signed in 1992 end entered into force in 1993. The main problem linked to the use of cointegration analysis in order to examine the degree of financial integration is that it does not give any indication about the dynamics of convergence. A partial solution to this problem is provided in this study by the implementation of the cointegration test over different sub-periods.

Finally, a Granger-causality analysis can be implemented in order to test the presence of one (or more) leading market(s) within the European and the East Asian regions and to assess the presence of short-run relationships between financial markets. A.C. Worthington, M. Katsura and H. Higgs (2003) used a Granger-causality test in order to test the presence of short-run relationships between European equity markets before, during and after the adoption of the single currency in January 1999. They find that the French market is the most influential market before and after 1999. Moreover, they claim that, although large equity markets remain the most influential, the lower causal relationships between these and at least some middle (Belgium, Spain and Netherland) and small (Ireland, Luxembourg, Finland and Norway) equity markets suggests that opportunities for international portfolio diversification in European equity markets still exists. One problem associated with the use of Granger-causality is that it does not provide an indication of the dynamic properties of the system of variables[13].

[13] Worthington, A. C., M. Katsura and H. Higgs (2003).

2. Data sources

Seven European economies and ten Asian economies are covered in this study, namely Belgium, France, Germany, Italy, The Netherlands, Spain and United Kingdom for Europe and China, Hong Kong, Indonesia, Japan, Malaysia, the Philippines, Singapore, South Korea, Taiwan and Thailand for East Asia.

As previously highlighted, United States are used as a proxy for the external world. Moreover, regional indicators are considered for the equity market analysis: the Euro STOXX Broad Index - representing large, middle and small capitalisation companies of twelve Eurozone countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal and Spain – and the MSCI AC (All Countries) Far East - a free float-adjusted market capitalization weighted index designed to measure the equity market performance of the Far East, including both developed and emerging markets. Table 2.1 contains a list of the benchmark equity indices used in the study.

Table 2.1: Benchmark equity indices

Equity market	Benchmark index
Europe	
Belgium	Bel Mid Index
France	CAC 40 Index
Germany	DAX 30 Index
Italy	MIB Index
The Netherlands	AEX Index
Spain	IBEX 35 Index
United Kingdom	FTSE 100 Index
Eurozone	Euro STOXX Broad Index
East Asia	
China	Shanghai A Stock Index, Shenzhen A Stock Index
Hong Kong	Hang Seng Index
Indonesia	Jakarta SE Composite Index
Japan	Nikkei JASDAQ Average Index
Malaysia	KLSE Composite Index
Philippines	Philippine SE Composite Index
Singapore	Straits Times Index
South Korea	KOSDAQ Composite Index
Taiwan	TSE Composite Index
Thailand	SET Index
Far East MSCI	Far East MSCI, All countries Index
World influence	
United States	Dow Jones Industrial Average

Source: Ecowin, Reuters.

The historical series have different starting points, due to differences in the availability of data. Table A1 in the Appendix contains details about the data starting dates. All the series considered in this study contain daily data[14] and end on 27 July 2009.

3. Co integration analysis: investigating the presence of long-term relations

Co-integration analysis is used in order to assess the presence of a long-run equilibrium relationship among the variables, to detect the possible presence of a common stochastic trend over time. In particular, a linear combination of two or more non-stationary series may be stationary. If such a stationary linear combination exists, the non-stationary time series are said to be cointegrated. As in I. Yu, L. Fung, C. Tam (2008) and in other studies, the presence of a long-term relationship between two or more markets can be used as an indicator of market integration. Moreover, the more cointegrating relationships are found, the higher the cointegration between the financial markets in the group. But cointegration does not imply high correlation: two series can be cointegrated and yet have a very low level of correlation.

In this study, the test of cointegration is implemented using two different methods. Firstly, the Engle and Granger method is used in order to test for cointegration in the equity market and in the bond market. Secondly, the historical series of equity indices and 10-year government bond returns are modelled as Vector Autoregressive and the results of the Johansen test for cointegration are provided.

The Engle-Granger Testing Procedure is a two-step method to assess the presence of cointegration between variables. In the first step, the model is estimated using the Ordinary Least Square method. In particular, all the direct and inverse regressions are considered. The second step consists in testing the stationarity of residuals for each regression run in step 1. If the residuals are stationary, the series are cointegrated. The presence or the absence of a unit root in the residuals can be tested again using the Augmented Dickey Fuller Test or the Phillips-Perron Test[15]. It must be highlighted that the Engle-Granger test for cointegration is biased towards cointegration, since in the first step the model is estimated using OLS method, which minimizes the variance of the residuals and makes them more stationary.

The Johansen test for cointegration is a maximum likelihood approach for testing cointegration which assumes that the cointegrated system can be modelled as a Vector Autoregressive model of order *p* with Gaussian errors. In this study, the series of the equity

[14] Daily data – five days per week.
[15] For analytical figures see the Appendix.

indices and the bond returns are firstly modelled as an Unrestricted VAR[16] within each region and then a Johansen cointegration test is implemented. For a more detailed explanation of the Johansen procedure, see the Appendix and Johansen (1991).

3.1 Co integration analysis in the equity markets

Before proceeding with the cointegration analysis, the non-stationarity of all the series of equity indices has to be tested. Augmented Dickey Fuller test or a Phillips-Perron test may be performed to verify the presence of a unit root in the series. The analysis of the presence of unit roots can be implemented either on each single series or jointly within the European and the East Asian regions. Table 3.1 contains the test statistics and the p-values of the group unit root tests for equity indices series within Europe and East Asia. The null hypothesis of these tests assumes the presence of individual unit root processes within the group. From the values of the statistics and the p-values, all the series are non-stationary. In particular, the second part of the table shows that they are all integrated of degree one, since the unit root test on the first difference leads to rejecting the presence of unit roots.

Table 3.1 Group unit root test – equity indices

		ADF – Fisher Chi-square		PP – Fisher Chi-square	
		Statistic	p-value	Statistic	p-value
Level	European countries	3.47824	0.9979	5.34578	0.9804
	East Asian countries	12.7175	0.9407	14.8747	0.8676
First diff.	European countries	1843.74	0.0000	897.090	0.0000
	East Asian countries	2770.08	0.0000	2480.39	0.0000

The first step to assess the presence of cointegration through the Engle-Granger Testing Procedure is to run all the possible regressions taking the equity index of one country as the dependent variable and using all the other variables as regressors. Seven regressions are performed, the residuals of each regression are saved and tested for stationarity.

Table 3.2 contains the values of the test statistics and the p-values of the ADF unit root test on the residuals. The first column shows the variable used as dependent variable in the regressions. The models are estimated taking the series both in levels and in logarithms. No

[16] Hereinafter the notation VAR identifies an Unrestricted Vector Autoregressive.

trend and no intercept are included in the test equation. The fact that the Engle-Granger Testing Procedure is biased towards the acceptance of cointegration has to be taken into account.

Table 4.2 Stationarity test for the residuals – Engle-Granger Testing Procedure
European countries – equity indices

	ADF Unit root test					
	Levels			Logarithms		
Dependent variable	statistics	0.05 critical value	p-value	statistics	0.05 critical value	p-value
Bel Mid	-4.703871	-1.941044	0.0000	-3.210027	-1.941105	0.0013
CAC40	-5.922849	-1.941044	0.0000	-5.746043	-1.941044	0.0000
DAX30	-4.245821	-1.941044	0.0000	-3.419960	-1.941077	0.0006
FTSE100	-6.444822	-1.941028	0.0000	-7.162549	-1.941028	0.0000
MIB	-5.992707	-1.941028	0.0000	-6.104688	-1.941028	0.0000
AEX	-3.977140	-1.941028	0.0001	-4.924881	-1.941028	0.0000
IBEX35	-3.053804	-1.941028	0.0022	-3.019174	-1.941028	0.0025

Note: All the regressions are run over an adjusted sample starting on 2 January 2003.

As shown in table 3.2, the historical series of equity indices co-move following a common stochastic trend and a long-run equilibrium relationship seems to exist among the variables – both if the series are taken in levels and in logarithms. This is confirmed by the test statistics being lower than the critical values and the p-values are also very low. The number of cointegrating relationships within the group of variables indicates the extent of market integration[17].

In order to assess the extent of market integration, Bel Mid Index, CAC40, DAX30, MIB, AEX, IBEX35 and FTSE100 are modelled as a Vector Autoregressive. The best specification[18] is a Vector Autoregressive with three lags for each variable.

Table 3.3 contains the results of the co integration test. It reports the results for testing the number of co integrating relations. In particular, it reports the so-called trace statistics[19]: the first column is the number of co integrating relations under the null hypothesis, the second column is the test statistic, and the last two columns are the 5% and 1% critical values. As it is clear from the table, the test indicates the presence of one co integrating equation at level 0.05.

[17] See Yu, I., L. Fung, C. Tam (2008).

[18] Various criteria to select the lag order of an unrestricted VAR are considered. In particular, five criteria are considered: sequential modified LR test statistic (each test at 5% level), Final prediction error, Akaike information criterion, Schwarz information criterion, Hannan-Quinn information criterion. The model selected by the majority of the five criteria is here adopted. In the case in which two of the criteria are minimized by a model and two other criteria are minimized by another model, the model which minimizes the Akaike information criteria is selected.

[19] See the Appendix for analytical details.

Table 3.3 Co integration test – Johansen Testing Procedure
European countries – equity indices

Unrestricted Co integration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None *	168.7782	150.5585	0.0031
At most 1	115.6427	117.7082	0.0670
At most 2	77.00857	88.80380	0.2611
At most 3	47.74787	63.87610	0.5176
At most 4	26.40222	42.91525	0.7152
At most 5	12.40151	25.87211	0.7835
At most 6	4.989794	12.51798	0.5978

Note: The sample is adjusted and starts on 15 January 2003.

Dropping the series of the Bel Mid Index from the VAR model, it is possible to implement the Johansen co integration before and after the introduction of the Euro. In this way, the adjusted pre-Euro sample contains observations from January 1998 to December 1998, while the adjusted post-Euro sample contains observations from January 1999 to July 2009. In the first sub-period, a VAR model containing one lag for each variable is considered. In this case, the trace test indicates the absence of co integrating equations between the series. In the second sub-period, a VAR model containing one lag is again found to be the best specification. In this case, the trace test suggests the presence of two co integrating equations at level 0.05. The results of the co integration analysis before and after January 1999 can be found in the Appendix, suggesting that an increase in the extent of integration between European equity markets can be recorded after the introduction of the single currency[20].

In order to assess if a deeper integration is achieved **within the EMU**, the historical series of the FTSE100 is dropped and the other indices are again modelled as a Vector Autoregressive. Then, the Johansen co integration test is implemented before and after the introduction of the single currency. The p-values and the test statistics of the trace test can be found in the Appendix. In the first period, a VAR containing one lag for each variable is found to be the best specification and the co integration test indicates the absence of co integrating equations. On the contrary, a high level of integration is achieved after January 1999. In this second period, the historical series of CAC40, DAX30, MIB, IBEX35 and AEX are modelled as a Vector Autoregressive containing six lags for each variable. As shown by tables in the Appendix, the trace test indicates a complete integration between the EMU equity markets, since a unique stochastic trend seems to drive the five indices considered.

[20] See also Worthington, A. C., M. Katsura and H. Higgs (2003).

Analogously, it is possible to test the presence of a long-run equilibrium relationship between **equity indices in East Asia**. Again, following the Engle-Granger Testing Procedure, all the possible regressions between the eleven East Asian equity indices are run, the residuals of each regression are saved and tested for stationarity.

Table 3.4 contains the values of the test statistics and the p-values of the PP unit root test on the residuals. The first column shows the variable used as dependent variable in the regressions. Due to an insufficient number of observations the presence of unit roots cannot be assessed using the ADF test. No trend and no intercept are included in the test equation. The fact that the Engle-Granger Testing Procedure is biased towards the acceptance of co integration has to be taken into account.

Table 3.4 Stationarity test for the residuals – Engle-Granger Testing Procedure
East Asian countries – equity indices

	PP Unit root test					
		Levels			Logarithms	
Dependent variable	statistics	0.05 critical value	p-value	statistics	0.05 critical value	p-value
Shanghai	-6.777425	-1.941060	0.0000	-7.309404	-1.941060	0.0000
Shenzhen	-5.587322	-1.941060	0.0000	-6.640522	-1.941060	0.0000
Hong Kong	-4.338499	-1.941060	0.0000	-3.335092	-1.941060	0.0009
Indonesia	-5.693779	-1.941060	0.0000	-5.350109	-1.941060	0.0000
Japan	-3.575197	-1.941060	0.0004	-3.177725	-1.941060	0.0015
Malaysia	-5.109298	-1.914060	0.0000	-5.005256	-1.941060	0.0000
Philippines	-3.763901	-1.941060	0.0002	-4.100845	-1.941060	0.0000
Singapore	-3.400858	-1.941060	0.0007	-4.013499	-1.941060	0.0001
South Korea	-4.059932	-1.941060	0.0001	-2.819811	-1.941060	0.0047
Thailand	-4.016395	-1.941060	0.0001	-4.542635	-1.941060	0.0000
Taiwan	-4.700601	-1.941060	0.0000	-4.184147	-1.941060	0.0000

Note: All the regressions are run over an adjusted sample starting on 30 June 2000.

The historical series of equity indices co-move following a common stochastic trend and a log-run equilibrium relationship seems to exist among the variables. The test statistics are indeed lower than the critical values and the p-values are very low.

Furthermore, the specification of the equations[21] used by the ADF and PP tests for unit roots has a key role and can strongly affect the results.

In order to analyze the extent of equity market co integration, the historical series of the eleven equity indices considered in this study are modelled as a VAR and then a Johansen test

[21] The specification no trend and no intercept is suggested by the graphical analysis of the residuals. If the option trend and intercept is chosen, evidence of co integration is found between European equity indices but not between East Asian equity indices.

for co integration is implemented. The best specification is a Vector Autoregressive model containing only one lag for each variable.

Table 3.5 Co integration test – Johansen Testing Procedure
East Asian countries – equity indices

Unrestricted Co integration Rank Test (Trace)			
Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None *	332.7254	285.1425	0.0001
At most 1 *	239.2425	239.2354	0.0500
At most 2	175.2738	197.3709	0.3560
At most 3	121.8743	159.5297	0.8162
At most 4	75.36779	125.6154	0.9942
At most 5	52.29785	95.75366	0.9950
At most 6	33.61397	69.81889	0.9951
At most 7	20.40870	47.85613	0.9887
At most 8	10.18628	29.79707	0.9774
At most 9	2.587566	15.49471	0.9824
At most 10	0.184576	3.841466	0.6675

Note: The sample is adjusted and starts on 4 July 2000.

Table 3.5 reports results for testing the number of co integrating relations. In particular, the trace test suggests the presence of two integrating equations at level 0.05.

In order to understand if this feature is due to an increase in equity market integration in East Asia in the recent years, the co integration analysis is developed **over two sub-periods**. Due to unavailability of data, the historical series of South Korea KOSDAQ Composite Index and of Taiwan TSE Composite Index are dropped. Once again, the 1997-1998 Asian financial crisis is used as a threshold. The adjusted pre-crisis sample contains observations from September 1993 to June 1997, while the adjusted post-crisis sample contains observations from January 1999 to July 2009. Tables A4.5 and A4.6 in the Appendix contains the results of the co integration analysis before and after the Asian financial crisis. In the first sub-period, a VAR model containing one lag for each variable is again considered. In this case, the test indicates the absence of co integration between the series. In the second sub-period, a VAR model containing two lags for each variable is found to be the best specification and the presence of one co integrating equation only at level 0.05 is indicated.

The Johansen co integration analysis over the two sub-periods suggests that relatively high level of co integration within East Asian equity indices – higher than the level of co integration within Europe – is due to a significant increase in the integration between equity markets within the region after the 1997-1998 Asian financial crisis. This feature confirms what is found in the literature[22].

BOX B.1 Integration of equity markets between regions

In section 3.1 co integration is performed in order to analyze the level of integration between equity markets within the European and the East Asian region. In order to access the level of integration between the two regions and of the two regions with the external world, a co integration analysis can be developed between the historical series of the Euro STOXX Broad Index, the MSCI AC Far East and the US Dow Jones Industrial Average. Due to lack of data for the previous period, the presence of co integration can be tested only from July 2004. Both the Engle-Granger Tasting Procedure and the Johansen co integration test are used.

Firstly, the Engle-Granger method is applied. All the possible regressions between the three equity indices are run, the residuals of each regression are saved and tested for stationarity. Table B1.1 contains the values of the test statistics, the 0.05 critical values and the p-values of the unit root tests of the residuals. The ADF test is implemented to test the stationarity of the series.

Table B1.1 Stationarity test for the residuals – Engle-Granger Testing Procedure Regional equity indices and US

	ADF Unit root test					
	Levels			Logarithms		
Dependent variable	statistics	0.05 critical value	p-value	statistics	0.05 critical value	p-value
Euro Stoxx Broad Index	-3.391232	-3.413941	0.0530	-3.760157	-3.413941	0.019000
US DJIA	-4.998976	-3.413941	0.0002	-5.410812	-3.413941	0.0000
MSCI AC Far East	-2.578699	-1.941100	0.0097	-2.821436	-1.941100	0.004700

Note: All the regressions are run over an adjusted sample starting on 4 July 2004.

Although biased towards the acceptance of co integration, the levels of the p-values and of the test statistics do not clearly indicate the presence of co integration between the series.

The results of the Johansen method of testing for co integration are reported in table B1.2. In order to develop the Johansen testing method and analyze the extent of equity market co integration between regions, the historical series of the three equity indices considered are modelled as a VAR. The best specification is a Vector Autoregressive model containing three lags for each variable. If it exists, the co integration relationship between the regional markets and with the external world is definitely weak.

[22] See, for example, Yang, J., J. W. Kolari and I. Min (2003).

Table B2.2 Co integration test – Johansen Testing Procedure East Asian countries – equity indices			
Unrestricted Co integration Rank Test (Trace)			
Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None *	35.61618	35.01090	0.0430
At most 1	13.66666	18.39771	0.2025
At most 2	3.412901	3.841466	0.0647

Note: The sample is adjusted and starts on 12 July 2004.

As shown by table B2.2, the trace test indicates the existence of one co integrating equation. Generally speaking, no great evidence of cointegration between the European, the East Asian and the US equity markets can be found. This means that the integration between global equity markets is far from being completed.

3.2 Co integration analysis in the bond markets

In order to perform the co integration analysis in the bond market, the non-stationarity property of the returns of 10-year government bonds must be established. Again, a joint Augmented Dickey Fuller Test and a joint Phillips-Perron test are used to test for the presence of unit roots. Table 3.6 contains the test statistics and the p-values of the group unit root tests for the series of 10-year government bond returns within Europe and East Asia. As it is clear from the values of the statistics and the p-values, all the series are non-stationary. In particular, the second part of the table shows that they are all integrated of degree one.

Table 3.6 Group unit root test – 10-year government bond returns

		ADF – Fisher Chi-square		PP – Fisher Chi-square	
		Statistic	p-value	Statistic	p-value
Level	European countries	5.31902	0.8824	4.81119	0.9883
	East Asian countries	22.2955	0.3247	21.9062	0.3456
First diff.	European countries	828.585	0.0000	658.303	0.0000
	East Asian countries	2034.23	0.0000	2024.77	0.0000

As in the equity market case, in order to test for the presence of co integration in the European bond markets through the Engle-Granger Testing Procedure, all the possible regressions between the government bond returns of the European countries are run. The residuals of each regression are saved and tested for stationarity using an ADF unit root test.

Table 3.7 contains the values of the test statistics and the p-values of the ADF unit root test on the residuals. The first column shows the variable used as dependent variable in the regressions. The series are taken both in levels and in logarithms. No trend and no intercept are included in the test equation. The very low p-values suggest the presence of co integration between the series.

Table 4.7 Stationarity test for the residuals – Engle-Granger Testing Procedure
European countries – 10-year government bond returns

	ADF Unit root test					
	Levels			Logarithms		
Dependent variable	statistics	0.05 critical value	p-value	statistics	0.05 critical value	p-value
Belgium	-5.356455	-1.940901	0.0000	-5.533025	-1.940901	0.0000
France	-5.478969	-1.940907	0.0000	-5.405970	-1.940907	0.0000
Germany	-10.08726	-1.940901	0.0000	-8.310225	-1.940904	0.0000
Italy	-11.00848	-1.940898	0.0000	-7.973705	-1.940901	0.0000
Netherlands	-8.057626	-1.940901	0.0000	-7.561001	-1.940901	0.0000
Spain	-10.43783	-1.940901	0.0000	-8.353306	-1.940901	0.0000
UK	-8.137935	-1.940901	0.0000	-8.453138	-1.940901	0.0000

Note: All the regressions are run over an adjusted sample starting on 3 June 1991.

In order to assess the extent of the market co integration – indicated by the number of co integrating relationships (through the examination of the number of co integrating vectors) the Johansen co integration test is implemented. The historical series of the 10-year government bond returns of the seven European countries considered in this study are modelled as a VAR. A model containing eight lags for each variable is found to be the best specification. Table 3.8 contains the values of the statistics for the trace test for co integration, the values of the 0.05 critical values and the p-values.

Table 3.8 Co integration test – Johansen Testing Procedure
European countries – 10-year government bond returns

Unrestricted Co integration Rank Test (Trace)			
Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None *	213.4739	125.6154	0.0000
At most 1 *	131.5830	95.75366	0.0000
At most 2	69.21898	69.81889	0.0558
At most 3	34.86956	47.85613	0.4549
At most 4	8.921388	29.79707	0.9920
At most 5	2.485399	15.49471	0.9854
At most 6	0.884810	3.841466	0.3469

Note: The sample is adjusted and starts on 14 June 1991.

Evidence of a relatively **high level of co integration between European bond markets is found over the whole period**. The trace test indeed indicates the presence of two co integrating equations in the system of variables at level 0.05. It is possible to claim the existence of a higher level of integration between government bond markets than between equity markets within Europe. Only one co integrating equation is indeed found in the case of equity markets.

In order to asses if there is a difference in the level of integration between bond markets before and after the introduction of Euro, the Johansen co integration analysis is implemented in two different sub-samples. The first sub-period ranges from June 1991 to December 1998, while the second one ranges from January 1999 to July 2009. The results of the co integration test before and after the introduction of the single currency are shown by tables A3.8 and A3.9 in the Appendix. In the first sub-period, a VAR model containing five lags for each variable is found to be the best specification. In this case, the trace test indicates the presence of only one co integrating equation at level 0.05. In the second sub-period, a VAR model containing eight lags for each variable is considered and the test for co integration suggests the presence of three co integrating equations in the system of variables.

The Johansen co integration analysis over the two sub-periods indicates that t**he relatively high level of co integration between bond markets in Europe is mainly attributable to an increase recorded after the introduction of the single currency**. The certainty that this increase is related only to the introduction of the single currency is not possible to have. Nevertheless, this could be analyzed in more detail in further studies.

In order to assess if a deeper integration is achieved within the EMU, the historical series of the UK government bond returns is dropped and the other variables are again modelled as a Vector Autoregressive. Then, the Johansen co integration test is implemented before and after the introduction of the single currency. The p-values and the test statistics of the trace test can be found in the Appendix. In the two periods, the historical series of the five EMU countries considered in this study are modelled as a Vector Autoregressive containing eight lags for each variable. The trace test indicates the presence of four co integrating equations at 0.05 level in the second period and zero in the first period. This suggests that, although there has been a relevant increase in the level of integration between government bond returns in Europe, **a slightly more intense integration has been achieved within the monetary union**.

An analogous analysis is developed to test the presence of a long-run equilibrium relationship between the government bond returns **in East Asia**. Again, following the Engle-Granger Testing Procedure, all the possible regressions between the ten bond returns series considered in East Asia are run, the residuals of each regression are saved and tested for stationarity. Table 3.9 contains the values of the test statistics and the p-values of the PP unit root test on the residuals. The fact that the Engle-Granger Testing Procedure is biased towards the acceptance of co integration has to be considered. Once more, the specification with no trend and no intercept is suggested by the graphical analysis of the residuals.

Table 3.9 Stationarity test for the residuals – Engle-Granger Testing Procedure
East Asian countries – equity indices

	PP Unit root test					
		Levels			Logarithms	
Dependent variable	statistics	0.05 critical value	p-value	statistics	0.05 critical value	p-value
China	-5.250722	-1.941497	0.0000	-4.853920	-1.941497	0.0000
Hong Kong	-3.755328	-1.941497	0.0002	-3.564248	-1.941497	0.0004
Indonesia	-4.759430	-1.941497	0.0000	-4.295158	-1.941497	0.0000
Japan	-3.391890	-1.941497	0.0007	-2.945153	-1.941497	0.0032
Malaysia	-5.039307	-1.941097	0.0000	-4.803789	-1.941497	0.0000
Philippines	-2.090764	-1.941497	0.0352	-1.761182	-1.941497	0.0743
Singapore	-4.746624	-1.941497	0.0000	-4.357149	-1.941497	0.0000
South Korea	-3.136269	-1.941497	0.0017	-2.870735	-1.941497	0.0041
Thailand	-3.305551	-1.941497	0.0010	-3.248011	-1.941497	0.0012
Taiwan	-3.601283	-1.941497	0.0003	-3.300814	-1.941497	0.0010

Note: All the regressions are run over an adjusted sample starting on 14 May 2003.

The fact that some p-values are higher than 0.01 or 0.05 – namely in the case of Philippines – and that the Engle-Granger Testing Procedure is intrinsically biased towards the acceptance of co integration suggest that, if a co integration relationship exists between the government bond series within East Asia, it must be relatively weak.

In order to find further empirical evidence and to assess the extent of market integration, a Johansen co integration analysis is developed. If all the series are considered and the system is modelled as a Vector Autoregressive with one lag for each variable, the results of the co integration test are those contained in table 3.10. Looking at the p-values and at the levels of the test statistics, **it is clear that no co integrating relationships between the government bond returns can be found in East Asia**.

Table 3.10 Co integration test – Johansen Testing Procedure
East Asian countries – 10-year government bond returns

Unrestricted Co integration Rank Test (Trace)			
Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None	168.8221	239.2354	0.9924
At most 1	116.3218	197.3709	0.9999
At most 2	78.09965	159.5297	1.0000
At most 3	54.32212	125.6154	1.0000
At most 4	31.80201	95.75366	1.0000
At most 5	20.03284	69.81889	1.0000
At most 6	9.655348	47.85613	1.0000
At most 7	4.923840	29.79707	1.0000
At most 8	2.198499	15.49471	0.9919
At most 9	0.406470	3.841466	0.5238

Note: The sample is adjusted and starts on 22 May 2003.

Due to unavailability of data it is not possible to compare the results of co integration analysis before and after the 1997-1998 Asian financial crisis. Nevertheless, if the historical series of the Indonesian and the Chinese 10-year government bond returns are dropped, a comparison between the period **before 2003 and after 2003** is feasible and, therefore, it is possible to assess if a difference in the level of integration between the two sub-periods exists. The launch of the inaugural Asian Bond Fund in June 2003 is used as a threshold. In particular, the first sub-period ranges from November 2001 to June 2003, while the second one ranges from June 2003 to July 2009. The results of the co integration test before and after the June 2003 are shown by tables A3.11 and A3.12 in the Appendix. The findings in the first sub-period do not differ from those in the second. In both cases, a VAR model containing one lag for each variable is indeed found to be the best specification and the trace test indicates the absence of co integration relationships in the system of variables.

It was not possible to find evidence of the presence of co integration between bond markets in the East Asian region. As in I. Yu, L. Fung, C. Tam (2008), the co integration analysis developed in this study indicates that the degree of **integration of Asia's equity markets is more advanced than the integration of its bond markets**.

Evidence of the huge lag in the process of bond market integration within East Asia can be therefore found, despite a number of initiatives that have been implemented in the recent years in order to boost the development of an Asian Bond Market.

BOX B.2 Development of the Asian Bond Market

ASEAN+3, APEC, EMEAP and other regional groups have coordinated most of the region-wide efforts to promote the Asian bond market and some initiatives towards the achievement of this goal have been adopted. The first step was the Chiang Mai Initiative in May 2000, which consisted of swap arrangements aimed at providing short-term liquidity support if any of the ASEAN+3 countries faced balance of payments problems. Secondly, in 2003 ASEAN finance ministers launched the Asian Bond Markets Initiative (ABMI), agreeing on the establishment of working groups with the purpose of harmonizing various financial standards, regulatory systems and tax treatment throughout the region. Finally, EMEAP promoted the Asian Bond Fund Initiative with the aim of increasing regional cooperation and widening the domestic and regional bond markets. In June 2003, EMEAP launched the first stage of ABF (ABF1), which invested in US dollar denominated bonds issued by Asian sovereign and quasi-sovereign issuers in EMEAP economies. Managed by the Bank for International Settlements, the inaugural Asian bond fund was a US$1 billion issue. Building on the success of ABF1, the Asian Bond Fund 2, which invested around US$ 2 billions in local currency bonds, was launched in 2005.

4. Granger-causality test: investigating the presence of short-term relations

The Granger approach to the question of whether a variable – e.g. x – causes another – e.g. y - is to see how much of the current y can be explained by past values of y and then to see whether adding lagged values of x can improve the explanation[23]. In economics, Granger-causality is one of the most widely applied methods in applied research.

In this study, **the Granger-causality test is implemented in order to test the presence of one – or more – leading market(s) within the European and the East Asian regions** and to **assess the presence of short-run relationships between equity indices and between government bond returns.**

The result of the causality test can be affected by the lag order considered. This caveat must be taken into account while interpreting the results. Moreover, in interpreting the results of this test, it must be always taken into account that the fact that a variable – e.g. y – Granger-causes another variable – e.g. x - does not imply that x is the effect or the result of y. Indeed, Granger-causality measures precedence and information content and not causality in the more common use of the term. Saying it differently, the Granger test assess whether movements in one variable systematically precede movements in another variable and Granger-causality indicates whether including the past values of a variable in the information set can improve the forecast of another variable.

[23] For analytical details see the Appendix.

Granger and Newbold (1974) demonstrate that if the data generating process of the variables is characterized by integration, the regression analysis on which the Granger test is based can lead to spurious results. To solve this problem, it is possible to transform the data by differencing - incurring in the loss of long run information - or by using a VECM (Vector Error Correction Model). Since the long-run relationships have been extensively analyzed in Section 3, the first differences of the historical series are considered in this section[24].

4.1 Granger-causality analysis in the equity markets

As mentioned above, the pre-condition for applying Granger-causality test is to ascertain the stationarity of the variables. Since all the variables considered in this study are integrated of order one[25], the test is applied to the first difference of the historical series. In order to assess the influence of the external world in the short term, also the first difference of the US Dow Jones Industrial Average is computed.

Firstly, the test is implemented to assess the presence of short-term relationships between the European equity indices over the whole sample. As in section 3, the number of lags considered for each variable is chosen on the base of sequential modified LR test statistic, final prediction error, Akaike information criterion, Schwarz information criterion, Hannan-Quinn information criterion. The first differences of the eight equity indices – seven European and the DJIA – are modelled as a Vector Autoregressive with eight lags for each variable. The p-values of the tests are contained in table 4.1. The tests indicate Granger-caused by row to column and Granger-causality by column to row.

Table 4.1 VAR Granger-causality test – European countries – equity indices

	DBELGIUM	DFRANCE	DGERM	DITALY	DNETH	DSPAIN	DUK	DUS	caused by
DBELGIUM	-	0.0000	0.0013	0.0160	0.0002	0.0013	0.1411	0.0000	5
DFRANCE	0.0254	-	0.0037	0.2035	0.0283	0.0648	0.1599	0.0000	2
DGERM	0.2928	0.0000	-	0.0606	0.0004	0.2521	0.2698	0.0000	3
DITALY	0.0687	0.0004	0.0297	-	0.0319	0.0316	0.0854	0.0000	2
DNETH	0.0089	0.0000	0.0484	0.2240	-	0.0168	0.1021	0.0000	3
DSPAIN	0.0416	0.0000	0.0007	0.4236	0.0047	-	0.0280	0.0000	4
DUK	0.0106	0.0003	0.0066	0.3230	0.0335	0.0080	-	0.0000	4
DUS	0.3796	0.0003	0.0004	0.0800	0.0000	0.0021	0.3869	-	4
causes	1	7	5	0	4	3	0	7	**27**

Note: Eight lags are considered for each variable. A 0.01 level of significance is used.

[24] Hacker, R. S. and A. Hatemi-J (2006).
[25] See Section 4 for more details.

As it is clear from the table, twenty-seven short-term relationships out of forty-nine possible linkages are found between the European equity markets if the whole period is considered and if a significance level of 0.01 is used. In particular, the DAX30 and the CAC40 seem to have the strongest influence, so that the French and the German equity markets can be considered as leaders within the region. In particular, the very low levels of p-values indicate that the CAC40 Granger-causes all the other equity indices, while the DAX30 Granger-causes the behaviour of Bel Mid Index, CAC40, IBEX35, FTSE100 and DJIA. This is in line with the findings by A. C. Worthington, M. Katsuura and H. Higgs (2003) who, analyzing data from Morgan Stanley Capital International (MSCI) ranging from 1 January 1988 to 18 February 2000, indicate that France has the strongest influence within the region. Moreover, not surprisingly the US equity market seems to play a leading role and to Granger-cause the behaviour of all the European equity markets considered here. As previously mentioned, Granger-causality measures precedence and information content and not the fact that one variable is the direct effect of another.

In order to assess if and how the number of short-term relationships between European equity indices changed **after the introduction of the single currency,** the Granger test is implemented before and after 1 January 1999. Due to unavailability of data before 1999, the historical series of Bel Mid Index is dropped. Again, the first difference of the seven equity indices – six European and the DJIA – are modelled as a Vector Autoregressive and the Granger-causality test is implemented. In the first sub-period the lag length selection criteria suggest a model with zero lags for each variable as the best specification, which means that no short-term relations can be found between the variables. In the second sub-period, a Vector Autoregressive containing one lag for each variable is found to be the best specification. The p-values of the tests are contained in table 4.2.

Table 4.2 VAR Granger-causality test – European countries – equity indices
After 1 January 1999

	DFRANCE	DGERM	DITALY	DNETH	DSPAIN	DUK	DUS	caused by
DFRANCE	-	0.0345	0.4315	0.5348	0.1686	0.5369	0.0000	1
DGERM	0.0008	-	0.7664	0.2240	0.6045	0.8178	0.0000	2
DITALY	0.0005	0.4971	-	0.3753	0.9907	0.8543	0.0000	2
DNETH	0.0000	0.2779	0.8255	-	0.3681	0.1984	0.0000	2
DSPAIN	0.0000	0.2779	0.8255	0.3681	-	0.1984	0.0000	2
DUK	0.0097	0.4650	0.7464	0.4597	0.2274	-	0.0000	2
DUS	0.7367	0.0086	0.5262	0.4396	0.0279	0.1696	-	1
causes	5	1	0	0	0	0	6	**12**

Note: One lag is considered for each variable. A 0.01 level of significance is used.

Under the new specification – one lag for each variable and sample period ranging from 1 January 2009 to 27 July 2009 – twelve Granger-causality linkages are found out of thirty-six possible relations. The French equity market seems to act as the leading market within the region. Five out of five Granger-causality relationships within Europe are indeed found in the case of CAC40. This means that the values of all the European equity indices here considered can be better predicted at time *t* if past values of CAC40 are included in the information set. Again, the external equity market – here represented by the US DJIA - is confirmed as the leader among the others, affecting all the European indices here considered – CAC40 included. The shift from a situation with no short-term relationships between the first differences of the equity indices considered to one recording twelve short-term relationships suggests an increase in the level of equity market integration within Europe and between Europe and the external world after the introduction of the Euro.

Two caveats must be considered. Firstly, it must be always taken into account that **Granger-causality measures precedence and information content** and not causality in the more common use of the term. Secondly, a comparison between the numbers of short-term relationships under different specifications can lead to hasty conclusions because the number of Granger-causality relations **can be affected by the number of lags** considered in the VAR.

An analogous analysis is developed to assess the presence of **short-term relationships between East Asian equity markets and between these ones and the external world**. Firstly, the Granger-causality analysis is developed over the whole sample and then in different sub-periods[26].

The first differences of the twelve equity indices – eleven East Asian and the DJIA – are modelled as a Vector Autoregressive and a model with six lags for each variable is found to be the best specification. The p-values of the tests are contained in table 4.5. Again, the tests indicate Granger-caused by row to column and Granger-causality by column to row. Twenty short-term relationships out of one hundred and twenty possible Granger-causality linkages are found if the whole period is considered and if a significance level equal to 0.01 is used. Although the comparison between results obtained under different specifications must be done cautiously, this feature provides more evidence of a lower level of integration of equity markets in East Asian than in Europe.

[26] For the definition of the sub-samples see Section 3.

Moreover, the low p-values indicate that Singapore Granger-causes the behaviour of the Shanghai A Stock Index, the Shenzhen A Stock Index, the PSE Index and the TSE Composite Index at level 0.01. Although the fact that Singapore's Straits Times Index is found to Granger-cause four out of eleven other equity indices deserves to be mentioned, this does not allow defining it as the leading market of the region. Quite surprisingly, the US Dow Jones Industrial Average Index does not act as a leading country neither. Therefore – with very few exceptions - **a general independence of the East Asian equity indices must be recorded in the short-term, both with respect to the other East Asian equity markets and to the US one.**

In order to assess if and how the number of short-term relationships between East Asian changed after the 1997-1998 Asian financial crisis, the test is implemented before and after 1 January 1999[27]. Due to unavailability of data before 1999, the historical series of the Taiwanese index is dropped. Again, the first difference of the eleven equity indices – ten East Asian and the DJIA – are modelled as a Vector Autoregressive and the Granger-causality test is implemented. In the first sub-period the lag length selection criteria suggest a model with zero lags for each variable as the best specification, which means that no short-term causality relations can be found between the variables. In the second sub-period, a Vector Autoregressive containing six lags for each variable is again found to be the best specification. The p-values of the tests are contained in table 4.6. Sixteen short-term relationships out of one hundred possible Granger-causality linkages are found if a significance level equal to 0.01 is used.

The shift from a situation with no short-term relationships between the first differences of the equity indices to one recording sixteen short-term relationships suggests an increase in the level of equity market integration within East Asia and between East Asian countries and the external world after the 1997-1998 Asian financial crisis. This finding confirms what found by J. Yang, J. W. Kolari and I. Min (2003). In particular, using generalized impulse response analysis and co integration analysis, they demonstrate that both short-run causal linkages and long-run co integration relationships among the US, Japanese and ten Asian emerging stock markets were strengthen after the 1997-1998 crisis.

Notwithstanding, **the lack of a leading market seems to characterize East Asian equity markets also after the Asian financial crisis**. Together with the already mentioned

[27] Insufficient number of observations does not allow to estimate the VAR before July 1997. Therefore, it is possible only to analyze the change between the 1989-1998 period and the 1999-2009 period.

differences in the level of development and integration, this feature represents one of the most relevant differences between the European and the East Asian equity markets systems.

Table 4.5 VAR Granger-causality test – East Asian countries – equity indices

	DHK	DIND	DJAP	DMYR	DPHIL	DSHANGHAI	DSHENZHEN	DSING	DSKOR	DTHAI	DTWN	DUS	caused by
DHK	-	0.0512	0.6999	0.2579	0.4075	0.0001	0.0011	0.4774	0.2308	0.2961	0.5519	0.8523	2
DIND	0.0006	-	0.5161	0.2300	0.1013	0.2175	0.6458	0.0425	0.9182	0.0407	0.6262	0.0973	1
DJAP	0.4736	0.0237	-	0.1226	0.1073	0.6338	0.4250	0.7587	0.6162	0.8640	0.0053	0.0000	2
DMYR	0.6142	0.0063	0.0664	-	0.5477	0.0156	0.0221	0.8241	0.5142	0.0389	0.6621	0.9013	1
DPHIL	0.0620	0.5271	0.2180	0.0225	-	0.3139	0.0780	0.0021	0.1079	0.0000	0.6511	0.4293	2
DSHANGHAI	0.0620	0.5271	0.2180	0.0225	0.3139	-	0.0780	0.0021	0.1079	0.0000	0.6511	0.4293	2
DSHENZHEN	0.1511	0.4700	0.2147	0.0053	0.3967	0.0000	-	0.0038	0.1699	0.0002	0.7248	0.6692	4
DSING	0.4185	0.0528	0.3069	0.6487	0.1016	0.0000	0.0001	-	0.6612	0.0385	0.4774	0.7728	2
DSKOR	0.3017	0.9147	0.0371	0.1365	0.8799	0.7524	0.7545	0.4683	-	0.5359	0.0546	0.3173	0
DTHAI	0.7154	0.6280	0.3790	0.0984	0.1304	0.6181	0.6930	0.0467	0.0087	-	0.6639	0.8018	1
DTWN	0.4035	0.0905	0.3299	0.0032	0.3013	0.1400	0.2544	0.0030	0.0002	0.2642	-	0.0203	3
DUS	0.1216	0.0406	0.9238	0.6335	0.8589	0.0525	0.0882	0.0668	0.6499	0.0445	0.8746	-	0
causes	1	1	0	2	0	3	2	4	2	3	1	1	**20**

Note: Six lags are considered for each variable. A 0.01 level of significance is used.

Table 4.6 VAR Granger-causality test – East Asian countries – equity indices
After 1997-1998 Asian financial crisis

	DHK	DIND	DJAP	DMYR	DPHIL	DSHANGHAI	DSHENZHEN	DSING	DSKOR	DTHAI	DUS	caused by
DHK	-	0.0654	0.4131	0.0214	0.5602	0.0000	0.0002	0.4564	0.9547	0.1175	0.3321	2
DIND	0.0020	-	0.5768	0.3240	0.2915	0.1202	0.4395	0.0479	0.6256	0.0013	0.0948	2
DJAP	0.1501	0.2727	-	0.1293	0.8636	0.3886	0.5223	0.4066	0.0002	0.4712	0.0016	2
DMYR	0.0785	0.0314	0.4312	-	0.3127	0.0603	0.0310	0.3774	0.4598	0.0256	0.3838	0
DPHIL	0.7990	0.1055	0.8499	0.2092	-	0.4871	0.5788	0.0199	0.3093	0.3466	0.1889	0
DSHANGHAI	0.2153	0.8951	0.6396	0.0040	0.0513	-	0.0623	0.0113	0.0400	0.0003	0.1113	2
DSHENZHEN	0.2228	0.8032	0.5584	0.0033	0.0689	0.0000	-	0.0217	0.0794	0.0012	0.5211	3
DSING	0.1395	0.0800	0.5409	0.7723	0.4501	0.0000	0.0000	-	0.8344	0.0522	0.4122	2
DSKOR	0.9159	0.0238	0.0096	0.0212	0.2391	0.7408	0.6927	0.9033	-	0.0261	0.8726	1
DTHAI	0.7100	0.2328	0.6739	0.0526	0.0473	0.3575	0.4805	0.0005	0.3469	-	0.3838	1
DUS	0.8177	0.0127	0.8093	0.1937	0.9854	0.0815	0.1171	0.0059	0.3029	0.0965	-	1
causes	1	0	1	2	0	3	2	2	1	3	1	**16**

Note: Six lags are considered for each variable. A 0.01 level of significance is used.

4.2 Granger-causality analysis in the bond markets

As shown in Section, all the historical series of 10-year government bond returns considered in this study are integrated of order one. Therefore, the Granger-causality test is applied to the first difference of the historical series. In order to assess the influence of the external world in the short term, also the first difference of the US 10-year Treasury bond returns is included in the analysis.

Firstly, the test is implemented to assess the presence of short-term relationships between the European equity indices over the whole sample. The first differences of the eight series of government bond returns – seven European and the US Treasury bond returns – are modelled as a Vector Autoregressive with eight lags for each variable. The p-values of the tests are contained in table 4.7.

Table 4.7 VAR Granger-causality test – European countries – 10-year government bond returns

	DBELGIUM	DFRANCE	DGERM	DITALY	DNETH	DSPAIN	DUK	DUS	caused by
DBELGIUM	-	0.1557	0.0000	0.0998	0.0352	0.4225	0.2166	0.2445	1
DFRANCE	0.3970	-	0.0000	0.0002	0.0546	0.0049	0.3044	0.4434	3
DGERM	0.1824	0.5522	-	0.0238	0.8179	0.0100	0.5632	0.2747	0
DITALY	0.1087	0.0138	0.0000	-	0.0606	0.0000	0.1932	0.7048	2
DNETH	0.2502	0.1957	0.0000	0.0427	-	0.3350	0.5235	0.3188	1
DSPAIN	0.1614	0.0000	0.0000	0.0000	0.0023	-	0.0184	0.7916	4
DUK	0.2994	0.1283	0.0000	0.0659	0.0181	0.1050	-	0.0265	1
DUS	0.6118	0.6499	0.0000	0.6459	0.0786	0.6109	0.1345	-	1
causes	0	1	7	2	1	2	0	0	**13**

Note: Eight lags are considered for each variable. A 0.01 level of significance is used.

Thirteen short-term relationships out of forty-nine possible Granger-causality linkages are found if the whole period is considered and if a significance level equal to 0.01 is used.

As it is clear from the table, over the period 1989-2009 the German government bond market has acted as a leader among the other government bond markets considered here, the US one included. Seven out of seven Granger-causality relationships within Europe are indeed found in the case of German government bond returns. This means that the European government bond returns here considered and the US Treasury bond returns can be better predicted at time *t* if the past values of the German government bond returns are included in the information set.

In contrast with the findings of the equity markets analysis, the external bond market – here again represented by the US 10-year Treasury bond returns – does not seem to influence the behaviour of the European bond markets in the short-run. In particular, the null hypothesis that the US 10-year Treasury bond returns does not Granger-cause the other European bond returns is never rejected if a level of significance equal to 0.01 is used; it is rejected only once – in the case of UK – if a 0.05 level of significance is adopted.

In order to assess if and how the number of short-term relationships between European government bond markets changed after the introduction of the single currency, the test is implemented before and after 1 January 1999. In the first sub-period the lag length selection criteria suggest a model with four lags for each variable as the best specification, while in the second sub-period, a Vector Autoregressive containing seven lags for each variable is selected. The p-values of the tests are contained in table 4.8 and 4.9.

Table 4.8 VAR Granger-causality test – European countries – 10-year government bond returns Before 1 January 1999

	DBELGIUM	DFRANCE	DGERM	DITALY	DNETH	DSPAIN	DUK	DUS	caused by
DBELGIUM	-	0.3106	0.0000	0.2266	0.0000	0.2152	0.7558	0.4176	2
DFRANCE	0.9483	-	0.0000	0.5531	0.0000	0.1440	0.3861	0.3192	2
DGERM	0.4477	0.3834	-	0.3864	0.3254	0.0279	0.2255	0.3004	0
DITALY	0.5399	0.2518	0.0000	-	0.0015	0.0016	0.8669	0.3020	3
DNETH	0.6786	0.2057	0.0000	0.6110	-	0.0174	0.5127	0.1819	1
DSPAIN	0.3979	0.0096	0.0000	0.0426	0.0000	-	0.5179	0.6384	3
DUK	0.6971	0.3186	0.0000	0.2181	0.0065	0.0072	-	0.1240	3
DUS	0.0514	0.1130	0.0000	0.2947	0.0647	0.9081	0.6768	-	1
Causes	0	1	7	0	5	2	0	0	**15**

Note: Four lags are considered for each variable. A 0.01 level of significance is used.

Table 4.9 VAR Granger-causality test – European countries – 10-year government bond returns After 1 January 1999

	DBELGIUM	DFRANCE	DGERM	DITALY	DNETH	DSPAIN	DUK	DUS	caused by
DBELGIUM	-	0.0016	0.0000	0.0008	0.5646	0.0154	0.3778	0.0082	4
DFRANCE	0.1582	-	0.0000	0.0018	0.6185	0.0012	0.0893	0.0013	4
DGERM	0.0193	0.0024	-	0.6628	0.6782	0.0000	0.6655	0.0011	3
DITALY	0.1499	0.0012	0.0000	-	0.8208	0.0298	0.0473	0.0004	3
DNETH	0.1137	0.0092	0.0000	0.0206	-	0.0262	0.3213	0.0045	3
DSPAIN	0.3730	0.0010	0.0000	0.0272	0.7657	-	0.1413	0.0300	2
DUK	0.2277	0.0008	0.0000	0.0616	0.0802	0.0045	-	0.0010	4
DUS	0.2063	0.1555	0.0000	0.1345	0.0145	0.4131	0.3552	-	1
Causes	0	6	7	2	0	3	0	6	**24**

Note: Seven lags are considered for each variable. A 0.01 level of significance is used.

Although the comparison between results obtained under different specifications must be done cautiously since the Granger-causality test can be affected by the number of lags included in the models, **it seems reasonable to claim that there has been an increase in the**

level of integration after the introduction of the single currency. In particular, the system of the seven European bond markets and the external market counts fifteen Granger-causality linkages over the period 1989-1998 and twenty-four over the period 1999-2009. This feature is in line with what found by N. L. Laopodis (2008)[28]. Using daily nominal total returns on MSCI 10-year government bond indices from ten Euro area countries and four non-Euro countries[29] over the periods 1995-2000 and 2001-2006 and developing a Granger-causality analysis, he demonstrates that in the post-Euro period a greater number of bivariate causality linkages can be found both among the Euro and the non-Euro bond markets – if compared to the pre-Euro period.

Although Germany maintains its leading role in the bond markets, over the last ten years a great influence by France and the US is recorded on the other European government bond returns. Six out of seven possible Granger-causality linkages are indeed found both in the case of France and in the case of the US. Therefore, if compared to the pre-Euro period, the European bond markets, on the one hand, seem to be more integrated among themselves; on the other hand, they have become less independent from the behaviour of the US Treasury bond returns.

An analogous analysis is developed to investigate the presence of short-term relationships **between East Asian 10-year government bond returns and between these ones and the external world.** In this case, the results are immediate. Both if the whole sample period is considered or if different sub-periods are analyzed[30], the lag length selection criteria suggest a model with zero lags for each variable as the best specification, which means that no short-term causality relations can be found between the variables. Saying it differently, there is no reason to model the first differences of the historical series of government bond returns here considered as a Vector Autoregressive because each variable seems not to depend on the past values of the others.

Moreover, this finding – together with the results of the co integration test in Section 3 - indicates that the **East Asian government bond markets considered in this study are characterized by a lack of short-term and long-term relationships.**

Relatively different results can be found if only the countries which are members of ASEAN are considered. Among the ten East Asian economies considered in this study, Indonesia,

[28] See, for example, Laopodis, N. T. (2008).

[29] Austria, Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Denmark, Norway, UK and US.

[30] For more details on the definition of the sub-periods see Section 2.

Malaysia, the Philippines, Singapore and Thailand are members of ASEAN[31]. The first differences of the historical series of government bond returns of these countries and that of the US Treasury bond returns can be indeed modelled as a Vector Autoregressive model containing eight lags for each variable if the whole period is considered. A VAR Granger-causality test is therefore implemented and the p-values are contained in table 4.10.

Table 4.10 VAR Granger-causality test – ASEAN countries – 10-year government bond returns

	DIND	DMYR	DPHIL	DSING	DTHAI	DUS	caused by
DIND	-	0.6844	0.3210	0.1773	0.0018	0.5782	1
DMYR	0.1508	-	0.9943	0.0780	0.2180	0.0000	1
DPHIL	0.0007	0.3496	-	0.4867	0.2643	0.0295	1
DSING	0.5965	0.1171	0.5341	-	0.0060	0.0000	2
DTHAI	0.5617	0.2812	0.6935	0.2109	-	0.7480	0
DUS	0.2533	0.4077	0.0663	0.0538	0.2860	-	0
causes	1	0	0	0	2	2	**5**

Note: Eight lags are considered for each variable. A 0.01 level of significance is used.

Although five short-term relationships are found out of the twenty-five possible Granger-causality linkages and so a certain level of integration is traceable, **it is not possible to identify a leader among the bond markets of the area.** However, the external bond market seems to have a not negligible influence in the region. In particular, the US Treasury bond returns Granger-cause two out of five ASEAN bond markets – if a 0.01 significance level is adopted – and three out of five ASEAN bond markets – if a 0.05 significance level is adopted. In any case, the Indonesian and the Thai bond market seem to be independent from what happens in the US bond markets. Saying it in more accurate terms, the 10-year government bond returns of Indonesia and Thailand cannot be better predicted at time *t* if past returns of the US Treasury government bond are included in the information set.

5. Conclusions

A growing number of studies trying to extract lessons for the East Asian financial integration process from the European one can be found in the literature. However, the differences in the degree of development and in the institutional framework of the European and the East Asian financial markets must be taken into account and any comparison between the two regions should be interpreted cautiously. A preliminary empirical assessment of the level of

[31] Indonesia, Malaysia, the Philippines, Singapore and Thailand were actually the funding members of the ASEAN in 1967.

integration of financial markets in the two regions is unavoidable and this study tries to provide an overview of the European and the East Asian financial scenarios.
The analysis of co-movements in the financial markets is used in this study to estimate the level of financial integration in Europe and East Asia. In particular, the analysis is developed through the use of co integration and Granger-causality approaches to assess the presence of short-term and long-term relationships between equity markets and between bond markets within the two regions. The main findings can be summarized as follows.

i) Engle-Granger and Johansen co integration analyses are developed in Section 3 in order to assess the presence of long-run relationships between equity and between bond markets in the two regions. All the series are found to be non-stationary; in particular, they are all integrated of degree one.

In *equity markets*, incomplete integration is recorded within European countries: one co integrating relation is indeed found if all the series and the whole period are considered. The co integration analysis suggests that there has been an increase in the number of co integrating equations after the introduction of the Euro in 1999. In particular, **if EMU countries alone are considered, complete integration between equity markets is found,** since a unique stochastic trend seems to drive the five EMU equity indices considered. The results for the East Asian region indicate the presence of long-run relationships between equity markets, even if the integration is far from complete. An increase in the number of co integrating equations – from zero to two - is found after the 1997-1998 Asian financial crisis. A co integration analysis is developed also between the regional indices - namely the Euro STOXX Broad Index, the MSCI AC Far East and the US Dow Jones Industrial Average. **No decisive evidence of co integration is found between these indices, suggesting that also the integration between global equity markets is far from being complete.**

In *bond markets*, evidence of a relatively high level of co integration between European countries is found over the whole period, which is mainly attributable to an increase that occurred **after the introduction of the single currency**. In particular, the number of co integrating equations increased from one to three after January 1999 – if the European countries are considered – and from zero to four – if only the EMU countries are considered. Therefore, a more intense integration has been achieved within the monetary union after the introduction of the Euro. On the contrary, **in the case of East Asia, the co integration**

analysis indicates the absence of long-term relationships between the government bond markets in the region. Moreover, evidence of an increase over time of co integration between government bond returns is not found either.
Last but not least, the co integration analysis developed in this study suggests that in East Asia
the level of long-term integration of equity markets is more advanced than that of its bond markets, whilst in Europe it is the opposite.

ii) A Granger-causality analysis is developed in Section 4 in order to assess the presence of short-term relationships between equity markets and between bond markets within the two regions and to investigate whether one – or more - market behaves as a leader. With regards to the **equity markets, Germany and France seem to have the strongest influence within Europe. The US equity market plays also a leading role**, Granger-causing the behaviour of all the European equity markets considered. Moreover, a shift from a situation with no short-term relationships to one recording twelve short-term relationships confirms the fact that an increase in the level of equity market integration within Europe and between Europe and the external world occurred after the introduction of the Euro. **The analysis of the East Asian region provides evidence of a lower level of integration of equity markets in East Asian than in Europe. The lack of a leading market** – either within or outside the region - characterizes the East Asian equity markets scenario and represents one of the most relevant differences between the European and the East Asian equity markets systems.
Looking at the results **for bond markets**, over the period 1989-2009 the German government bond market has acted as a leader, whilst the external bond market does not seem to have influenced the behaviour of the European bond markets in the short-run. The comparison between to the pre-Euro period and the post-Euro period indicates that the European bond markets, on the one hand, seem to be more integrated among themselves after January 1999; on the other hand, in recent years several short-term relationships are found also between the European government bond returns and the US Treasury bond returns. In the case of East Asian bond markets, no short-term causality relations can be found between the variables. If only the countries which are members of ASEAN are considered, a certain level of integration is traceable, although it is not possible to identify a leader among the bond markets of the area. However, the external bond market seems to have a not negligible influence in the region.

To sum up, the empirical analysis developed in this work confirms that **in Europe financial market integration is significantly more advanced than in East Asia.** Moreover, a remarkable increase of short and long-run relationships in European bond and equity markets is traceable after the Euro was introduced. Furthermore, the parallel analysis of East Asia points out that **financial integration in Asia is still at its very early stages, despite an increase in the level of integration of equity markets in the last ten years.** East Asian bond markets display little evidence of co-movement, even after the attempts at formalising closer ties, as illustrated in the Chiang Mai initiatives and Asian Bond Market Initiative. Finally, as suggested by previous works[32], the level of integration between bond markets is found to be higher than between equity markets within Europe, whist it is the opposite in the East Asian region.

One of the main challenges if not the biggest one for Asian financial market integration will be to find a market leader (or a limited number of market leaders) with a significant influence in the region. Japan was not able to play this role in the Nineties. China has the potential for it, but its financial system is still under-developed and unsophisticated so that it may take time before such a leader emerges.

[32] See, for example, Yu, I., L. Fung and C. Tam (2008). See also Cappiello, L., R. F. Engle and K. Sheppard (2003).

References

Baele, L., A. Ferrando, P. Hördal, E. Krylova and C. Monnet (2004), *Measuring Financial Integration in the Euro Area*, Occasional Paper Series No 14, European Central Bank.

Bertoldi, M. and C. Gaye (2008), *Economic and monetary integration in East Asia: Are there lessons to be learned from Europe's experience?*, in Quarterly Report on the Euro Area, vol. 7, No 1.

Cappiello, L., R. F. Engle and K. Sheppard (2003), *Asymmetric Dynamics in the Correlations of Global Equity and Bond Returns*, Working Paper No 204, European Central Bank.

Ceylan, O. (2006), *A Co-integration Analysis Approach to European Union Integration: the Case of Acceding and Candidate Countries*, European Integration Online Papers.

Click, R. and M. G. Plummer (2003), *Stock Market Integration in ASEAN after the Asian Financial Crisis*, The International Centre for Study of East Asian Development, Kytakyushu, Working Paper Series, vol. 2003-06.

Croci, M. (2004), *Country Pair-Correlations as a Measure of Financial Integration: the Case of the Euro Equity Markets*, Quaderni di Ricerca n.201, Universita' Politecnica delle Marche, Dipartimento di Economia.

Eichengreen, B. and Y. C. Park (2004), *Why Has There Been Less Financial Integration in Asia than in Europe?*, Monetary Authority of Singapore, Staff Paper No. 28.

Fratzscher, M. (2002), *Financial Market Integration in Europe: On the Effects of EMU on Stock Markets*, International Journal of Finance and Economics, 7, 165-193.

Garcia-Herrero, A., D. Yang and P. Wooldridge (2008), *Why is There So Little Regional Financial Integration in Asia?*, in Regional Financial Integration in East Asia, BIS Papers No 42, pp. 38-61.

Granger, C. W. J. and P. Newbold (1974), *Spurious Regressions in Econometrics*, Journal of Econometrics 2, 111-120.

Hacker, R. S. and A. Hatemi-J (2006), *Tests for Causality between Integrated Variables Using Asymptotic and Bootstrap Distributions: Theory and Applications, Applied Economics*, 38:13, 1489-1500.

Hardouvelis, G. A., D. Malliaropulos and R. Priestley (2006), *EMU and European Stock Market Integration*, Journal of Business, vol.79, No.1.

Johansen, S. (1991), *Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models*, Econometrica, vol.59, No 6, pp. 1551-1580.

Kasa, K. (1992), *Common Stochastic Trends in International Stock Markets*, Journal of Monetary Economics, 29, 95-124.

Kim, S.J, B.M. Lucey and E. Wu (2005), *Dynamics of Bond Market Integration Between Established and Accession European Union Countries*, International Financial Markets, Institutions and Money, 16, 41-56.

Laopodis, N. T. (2008), *Government Bond Market Integration within European Union*, International Research Journal of Finance and Economics, ISSN 1450-2887 Issue 19.

Park, Y. C. and C. Wyplosz (2008), *Monetary and Financial Integration in East Asia: the Relevance of European Experience*, European Commission Economic Papers 329.

Pasadilla, G. O. (2008), *Financial Services Integration in East Asia: Lessons from the European Union*, Asia-Pacific Research and Training Network on Trade Working Paper Series, No 53.

Soares da Fonseca, J. (2008), *The Co-integration of European Stock Markets after the Launch of the Euro*, Panoeconomicus, 3, 309-324.

Worthington, A. C., M. Katsura and H. Higgs (2003), *Financial Integration in European Equity markets: The Final Stage of Economic and Monetary Union (EMU) and its Impact on Capital Markets*, Economia 54(1), pp. 79-99.

Worthington, A.C. and H. Higgs (2007), *Assessing Financial Integration in European Union equity markets, 1990-2006: Panel Unit Root and Multivariate Cointegration and Causality Evidence*, University of Wollongong, School of Accounting and Finance Working Paper series No 07/10.

Yang, J., J. W. Kolari and I. Min (2003), *Stock Market Integration and Financial Crises: The Case of Asia*, published in Applied Financial Economics, vol. 13, Issue 7 July 2003 , pages 477 – 486.

Yu, I., L. Fung and C. Tam (2008), *Assessing the Integration of Asia's Equity and Bond Markets*, in Regional Financial Integration in East Asia, BIS Papers No 42, pp. 1-37.

Appendix A: Tables

Table A1 Data starting date

Equity market	Equity market indices	Bond market indices
Europe		
Belgium	31 Dec. 2002	29 Dec. 1989
France	29 Dec. 1989	29 Dec. 1989
Germany	1 Oct. 1996	29 Dec. 1989
Italy	31 Dec. 1997	1 March 1991
The Netherlands	29 Dec. 1989	29 Dec. 1989
Spain	29 Dec. 1989	3 June 1991
United Kingdom	29 Dec. 1989	29 Dec. 1989
Eurozone	22 March 2000	-
East Asia		
China	2 Jan. 1992 (Shanghai) 4 Jan. 1993 (Shenzhen)	3 June 2002
Hong Kong	29 Dec. 1989	29 Oct. 1996
Indonesia	29 Dec. 1989	14 May 2003
Japan	30 Sept. 1993	29 Dec. 1989
Malaysia	1 Jan. 1990	3 Oct. 2001
Philippines	1 Jan. 1990	16 Jan. 2001
Singapore	29 Dec. 1989	29 June 1998
South Korea	1 July 1996	5 Feb. 2001
Taiwan	30 June 2000	16 April 1999
Thailand	29 Dec. 1989	15 Sept. 1999
Far East MSCI	1 July 2004	-
World influence		
United States	29 Dec. 1989	29 Dec. 1989

Table A3.1 Cointegration test – Johansen Testing Procedure
European countries before Euro – equity indices

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None	81.04643	95.75366	0.3306
At most 1	49.17621	69.81889	0.6731
At most 2	32.21481	47.85613	0.6003
At most 3	18.57585	29.79707	0.5237
At most 4	7.644093	15.49471	0.5042
At most 5	3.725475	3.841466	0.0536

Note: The sample is adjusted and ranges from 9 January 1998 to 30 December 1998.

Table A3.2 Cointegration test – Johansen Testing Procedure
European countries after Euro – equity indices

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None *	163.5522	117.7082	0.0000
At most 1 *	106.7087	88.80380	0.0014
At most 2	57.12483	63.87610	0.1622
At most 3	27.15836	42.91525	0.6719
At most 4	14.51831	25.87211	0.6146
At most 5	4.075217	12.51798	0.7312

Note: The sample is adjusted and ranges from 5 January 1999 to 27 July 2009.

Table A3.3 Cointegration test – Johansen Testing Procedure
EMU countries before Euro – equity indices

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None	52.74917	69.81889	0.5163
At most 1	30.99920	47.85613	0.6665
At most 2	17.15548	29.79707	0.6285
At most 3	10.05355	15.49471	0.2766
At most 4	3.772947	3.841466	0.0521

Note: The sample is adjusted and ranges from 9 January 1998 to 30 December 1998.

Table A3.4 Cointegration test – Johansen Testing Procedure
EMU countries after Euro – equity indices

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None *	63.28649	60.06141	0.0261
At most 1 *	43.98928	40.17493	0.0197
At most 2 *	28.58311	24.27596	0.0135
At most 3 *	15.52106	12.32090	0.0141
At most 4 *	4.151072	4.129906	0.0494

Note: The sample is adjusted and ranges from 18 January 1999 to 27 July 2009.

Table A3.5 Cointegration test – Johansen Testing Procedure
East Asian countries before 1997-1998 Asian financial crisis – equity indices

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None	180.7873	228.2979	0.8547
At most 1	134.2134	187.4701	0.9653
At most 2	95.02822	150.5585	0.9948
At most 3	66.03142	117.7082	0.9984
At most 4	43.87315	88.80380	0.9991
At most 5	23.99521	63.87610	0.9999
At most 6	13.49974	42.91525	0.9997
At most 7	6.705257	25.87211	0.9957
At most 8	1.323647	12.51798	0.9952

Note: The sample is adjusted and ranges from 7 September 1993 to 21 December 1998.

Table A3.6 Cointegration test – Johansen Testing Procedure
East Asian countries after 1997-1998 Asian financial crisis – equity indices

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None *	263.5248	228.2979	0.0004
At most 1	172.9884	187.4701	0.2130
At most 2	113.9222	150.5585	0.8254
At most 3	72.31020	117.7082	0.9877
At most 4	46.15544	88.80380	0.9974
At most 5	24.16412	63.87610	0.9999
At most 6	7.263365	42.91525	1.0000
At most 7	3.645196	25.87211	1.0000
At most 8	1.053518	12.51798	0.9987

Note: The sample is adjusted and ranges from 6 January 1999 to 27 July 2009.

Table A3.7 Cointegration test – Johansen Testing Procedure
European countries before Euro – 10-year government bond returns

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None *	142.5996	125.6154	0.0030
At most 1	77.32816	95.75366	0.4579
At most 2	48.79116	69.81889	0.6893
At most 3	25.89060	47.85613	0.8928
At most 4	12.90909	29.79707	0.8957
At most 5	2.884338	15.49471	0.9719
At most 6	0.587103	3.841466	0.4435

Note: The sample is adjusted and ranges from 11 November 1991 to 23 December 1998.

Table A3.8 Cointegration test – Johansen Testing Procedure
European countries after Euro – 10-year government bond returns

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None *	220.6288	125.6154	0.0000
At most 1 *	139.0855	95.75366	0.0000
At most 2 *	76.69904	69.81889	0.0127
At most 3	38.91632	47.85613	0.2636
At most 4	15.57190	29.79707	0.7420
At most 5	7.160754	15.49471	0.5591
At most 6	0.569853	3.841466	0.4503

Note: The sample is adjusted and ranges from 15 January 1999 to 27 July 2009.

Table A3.9 Cointegration test – Johansen Testing Procedure
EMU countries before Euro – 10-year government bond returns

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None	83.59127	95.75366	0.2549
At most 1	51.04563	69.81889	0.5918
At most 2	28.58148	47.85613	0.7879
At most 3	10.36268	29.79707	0.9745
At most 4	1.750345	15.49471	0.9976
At most 5	0.146957	3.841466	0.7015

Note: The sample is adjusted and ranges from 14 June 1991 to 23 December 1998.

Table A3.10 Cointegration test – Johansen Testing Procedure
EMU countries after Euro – 10-year government bond returns

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None *	206.1519	107.3466	0.0000
At most 1 *	125.6998	79.34145	0.0000
At most 2 *	70.32278	55.24578	0.0014
At most 3 *	36.82741	35.01090	0.0316
At most 4	15.05148	18.39771	0.1382
At most 5	1.702714	3.841466	0.1919

Note: The sample is adjusted and ranges from 15 January 1999 to 27 July 2009.

Table A3.11 Cointegration test – Johansen Testing Procedure
East Asian countries after 2003 – 10-year government bond returns

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None	125.6711	159.5297	0.7312
At most 1	77.31844	125.6154	0.9899
At most 2	45.65908	95.75366	0.9997
At most 3	23.03961	69.81889	1.0000
At most 4	11.85046	47.85613	1.0000
At most 5	4.395134	29.79707	1.0000
At most 6	0.865930	15.49471	1.0000
At most 7	0.017978	3.841466	0.8932

Note: The sample is adjusted and ranges from 7 November 2001 to 1 June 2003.

Table A3.12 Cointegration test – Johansen Testing Procedure
East Asian countries after 2003 – 10-year government bond returns

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	p-value
None	118.0413	159.5297	0.8840
At most 1	85.34607	125.6154	0.9379
At most 2	55.30613	95.75366	0.9860
At most 3	34.64321	69.81889	0.9922
At most 4	17.69546	47.85613	0.9981
At most 5	9.606991	29.79707	0.9855
At most 6	2.716916	15.49471	0.9782
At most 7	0.446019	3.841466	0.5042

Note: The sample is adjusted and ranges from 2 June 2003 to 27 July 2009.

Appendix B: Theoretical figures

B.1 testing for unit roots: ADF and PP tests

Consider a simple AR(1) process:

$$y_t = \rho y_{t-1} + x_t' \delta + \varepsilon_t \quad (1)$$

where x_t are optional exogenous regressors which may consist of constant, or a constant and trend, ρ and δ are parameters to be estimated, and the ε_t are assumed to be white noise. If $|\rho| \geq 1$, y is a non-stationary series and its variance increases with time. If $|\rho| < 1$, y is a stationary series. Two tests are used in this study to assess the presence of unit roots in the series: the Augmented Dickey-Fuller test and the Phillips-Perron test.

B.1.1 ADF Test for unit root

After subtracting y_{t-1} from both sides of equation (1) it is possible to test the null hypothesis of $\alpha = 0$ in the following equation:

$$\Delta y_t = \alpha y_{t-1} + x_t{}' \delta + \varepsilon_t \quad (2)$$

where $\alpha = \rho - 1$ using a conventional *t*-test based on a conventional *t*-ratio:

$$t_\alpha = \frac{\hat{\alpha}}{(se(\hat{\alpha}))}.$$

Dickey and Fuller (1979) show that under the null hypothesis of a unit root, this statistic does not follow the conventional Student's t-distribution so that the conventional critical values are not applicable. Simulations by Dickey and Fuller (1979) and MacKinnon (1991, 1996) provide a series of critical values for the test statistic in question.

The simple Dickey-Fuller unit root test described above is valid only if the series is an AR(1) process. If the order of integration is higher than one, the assumption of white noise disturbances ε_t is violated. The Augmented Dickey-Fuller (ADF) test assumes that the *y* series follows an AR(*p*) process. *p* lagged difference terms of the dependent variable *y* are added to the right-hand side of the test regression in (2):

$$\Delta y_t = \alpha y_{t-1} + x_t{}' \delta + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \ldots + \beta_p \Delta y_{t-p} + u_t$$

This augmented specification is then used to test the null hypothesis of $\alpha = 0$ using a *t*-test.

B.1.2 PP Test for unit root

Phillips and Perron (1988) propose a method of controlling for serial correlation when testing for a unit root. The PP method estimates the non-augmented DF test equation (1). Through a modification of the *t*-ratio of the α coefficient, the serial correlation does not affect the asymptotic distribution of the test statistic. The PP test statistic is defined as follows:

$$\tilde{t}_\alpha = t_\alpha \left(\frac{\gamma_0}{f_0} \right)^{\frac{1}{2}} - \frac{n(f_0 - \gamma_0)(se(\hat{\alpha}))}{2 f_0^{\frac{1}{2}} s}$$

where *n* is the sample size, $\hat{\alpha}$ is the estimate, and t_α the *t*-ratio of α, $se(\hat{\alpha})$ is coefficient standard error, *s* is the standard error of the test regression, γ_0 is a consistent estimate of the error variance in (2), f_0 is an estimator of the residual spectrum at frequency zero.

B.2 Johansen methodology and trace test for correlation

The purpose of the cointegration test is to determine whether a group of non-stationary series are cointegrated. Cointegration means that the two or more non-stationary series share a common stochastic trend over time and that a stationary linear combination of them exists. The methodology developed by Johansen is considered in this study in order to test for cointegration. Consider a VAR of order *p*:

$$y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + Bx_t + \varepsilon_t$$

where y_t is an kx1 vector of variables that are integrated of order one – commonly denoted I(1) –, x_t is a *d*-vector of deterministic variables and ε_t is an kx1 vector of innovations. The VAR can be rewritten as,

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \varepsilon_t$$

where:

$$\Pi = \sum_{t=1}^{p} A_i - I, \qquad \Gamma_i = -\sum_{j=i+1}^{p} A_j \ .$$

If the coefficient matrix Π has reduced rank $r<k$, then there exist kxr matrices α and β, each with rank r such that $\Pi = \alpha\beta'$ and $\beta' y_t$ is stationary. r is the number of cointegrating relations and each column of β is the cointegrating vector. Johansen's method is to estimate the Π matrix from an unrestricted VAR and to test whether it is possible to reject the restrictions implied by the reduced rank of Π.

The trace statistic tests the null hypothesis of presence of r cointegrating relations against the alternative of k cointegrating relations, where k is the number of endogenous variables, for r=0,1,…,k-1. The trace statistic for the null hypothesis of r cointegrating relations is computed as follows:

$$J_{trace} = -T \sum_{i=r+1}^{k} \log(1-\lambda_i),$$

where λ_i is the *i-th* largest eigenvalue of the matrix Π.

B.3 Granger causality test

The Granger-causality test assesses the prediction ability of time series models, which means that it tests whether including the past values of a variable in the information set can improve the forecast of another variable. If the variables in question are cointegrated, Granger-causality is tested using an Error Correction Model defined as follows:

$$\Delta y_t = \gamma_0 + \sum_{i=1}^{r} \psi_i \Theta_{it-1} + \sum_{i=1}^{m} \gamma_i \Delta y_{t-i} + \varepsilon_t ,$$

where Θ contains r individual error-correction terms, r are long-term cointegrating vectors found through the Johansen procedure, ψ and γ are parameters to be estimated.

If there is no cointegrated relationship, the Granger-causality test is based on the following VAR model:

$$\Delta y_t = \gamma_0 + \sum_{i=1}^{m} \gamma_i \Delta y_{t-i} + \varepsilon_t .$$

In Section 5, the variables are considered in first differences in order to avoid that the regression analysis on which the Granger test is based leads to spurious results. So a VAR Granger-causality test is implemented.

If the null hypothesis $\gamma_{ijl} = 0$, where i=1,2,…,m and m indicates the number of variables considered in the VAR, is rejected – the p-values associated with the F-statistics are lower than the critical values - the j-th variable Granger-causes the l-th variable and current changes in the l-th variable can be explained by past changes in the j-th variable.