INTERNATIONAL JOURNAL OF BUSINESS, 15(3), 2010 ISSN: 1083–4346

Stock Market Integration in the EURO Area: Segmentation or Linear Modelling Misspecification?

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ABSTRACT

This article studies stock market integration in the Euro Area (Germany, Austria, Belgium, Spain, Finland, France, Ireland, Italy, the Netherlands and Portugal). Using linear and nonlinear modeling, we investigate the extent to which stock markets are integrated or not. Our findings indicate the superiority of nonlinear tools over linear techniques in testing financial integration. Indeed, while linear tools and traditional unit root tests highlight the segmentation between most of the stock markets, nonlinear cointegration tests point to significant nonlinear integration and mean reversion in stock prices. Nonlinear modeling identifies a structural shift following the introduction of the Euro, defines an on-off threshold model to characterize integration between these stock markets and points to the misspecification of linear modeling.

JEL Classification: *G15, F36, C5*

Keywords: *Linear modeling misspecification; Stock market integration; Structural shift*

I. INTRODUCTION

Determining the extent to which stock markets are integrated is an empirical question which has a decisive impact on a number of issues pertaining to financial market theory. In general, stock markets are said to be perfectly integrated if they enable investors to exchange stocks that share the same characteristics under the same conditions regardless of the investor's location and if they allow domestic and foreign firms access to similar external financing. Financial Integration (FI) has obvious economic and financial implications. It offers improved opportunities for risk reduction and diversification, leads to better allocation of capital across investment options, an increase in liquidity, and greater economic growth.

FI has recently been stepped up worldwide, especially in Europe.[1] In fact, stock markets in the Euro Area (EA) have shown evidence of significant FI over the last few decades, with considerable development, particularly after the introduction of the Euro. Several factors can account for this increase in FI in EA stock markets. Firstly, the standardization of information and the harmonization of infrastructures as well as financial instruments, legislation, regimentation, taxes, rules and regulations have led to fast convergence between the financial systems of the different member states. Secondly, the restructuring of European banking business, the liberalization process, the implementation of the Financial Service Action Plan, and rapid transmission of information via the European Central Bank (ECB) and the European System of Central Banks have helped to develop a single financial service market in the EA (e.g., Baele *et al*., 2004). Thirdly, the removal of restrictions and barriers on capital movements, the synchronization in business cycles, and the suppression of exchange rates, exchange-rate risk and cross-border restrictions on investor activities, may have substantially accelerated FI in the region.

As Worthington *et al*. (2003) noted, only a few studies in the literature have examined European capital market integration in the EU as a whole. These studies suggest greater integration between the main European stock markets in recent years, suggesting that interdependence among EA markets has increased with the stepping up of economic integration following the move to a single currency. Espitia and Santamaria (1994) identified high correlation between daily equity returns in all the markets. Chung and Lai (1999) however, pointed to significant long-term comovements in French, German and Italian stock market indices, but no evidence of cointegration with Belgium and the Netherlands. Meric and Meric (1999) show an increase in the long-term of price comovements and a decrease in international diversification benefits for the twelve largest European equity markets. Worthington et *al.* (2003) studied the FI hypothesis before, during and after the adoption of the Euro using various econometric tools: Granger-causality tests, generalized variance decomposition and cointegration techniques. The authors identified significant linkages between European markets. They showed that the European equity markets they studied were closely linked and integrated both before and after the transition to the Euro. Finally, Hardouvelis *et al.* (2006) investigated whether the convergence process of European economies toward Economic and Monetary Union has led to increased FI using an international capital asset pricing model (CAPM), which allows for a time-varying degree of integration that measures the importance of EU-wide risk relative to country-specific risk. They found significant degree of recent FI between the main European stock markets.

Overall, most of the empirical studies have suggested significant FI phenomenon between the main stock markets (Germany, France, the UK, and Switzerland) but mixed results concerning the smaller equity markets (Belgium, Ireland, Austria, Norway, and the Netherlands). In addition, FI seems to correlate with advances in EU economic convergence, and much of the FI is spread across the whole EU rather than simply being limited to the members who belong to the EA and the transition to Euro. Some studies have shown a net increase in FI in this area while others have pointed to the weakness of the FI and to segmentation. The latter attribute this to a number of technical and legal difficulties and barriers, significant differences between the infrastructures of the markets, and securities preventing FI in this area. They also cite some mergers such as NYSE-EURONEXT and NASDAQ-OMX as unfavorable factors to FI in the EA. To sum up, there is no unanimous position with regard to FI properties and the statistical process characterizing FI in the EA.

Earlier studies have mainly employed two methodological approaches in testing for stock market integration in the EA: asset pricing models and linear cointegration tests. The results obtained from the first approach are highly sensitive to the validity of the assumed financial models. In fact, testing for FI on the basis of a financial model (CAPM and multifactor models for example) incorporates two aspects: the integration of the markets studied and the validity of the model used. However, it is now widely known that available financial models are often miss-specified and thus the results obtained from this approach need to be regarded carefully. In this paper, we choose to investigate FI in the EA within the framework of cointegration tests. Using this approach, we do not need to assume any specific financial model since we test for common stochastic trends among EA stock market indices. The sources of the common trends are systematic factors that simultaneously impact stock markets in the EA and thus reflect the FI process. The more stock market indices are cointegrated, the stronger the evidence of integration.

Using two types of modeling, linear and nonlinear tools, our paper attempts to clarify whether EA stock markets are integrated or not. The answer to this question is important as it has clear implications for European financial and economic policies. In addition to the nonlinear FI tests for the EA stock markets we propose, this paper contributes to the literature by searching for the sources of the mixed conclusions arising from previous studies on FI in the EA. This can help us to understand whether the mixed results from previous studies are due to the segmentation between stock markets in the region or to the weaknesses in the methods used. Our reasoning is that most of the previous empirical studies on FI in the EA have used linear modeling techniques. These methods limit FI dynamics to being linear and continuous with constant speed over time. However, the introduction of the Euro, the recent increase in the number of investors, the ongoing market liberalization and the present financial crisis may have induced some asymmetry, irregularity and nonlinearity in the FI process, invalidating the linear framework. Thus, one of the main contributions of this study is the use of new nonlinear econometric techniques to investigate FI in the EA.

The remainder of the article is organized as follows. The second section briefly explains the empirical tests used. The key empirical results are reported in the third section and in the last section, we offer some concise conclusions.

II. ECONOMETRIC MODELING

We start from the proviso that stock markets are integrated if their stock prices are linearly cointegrated, meaning that they may diverge in the short-term but as long as they retain some common properties they will converge to equilibrium in the long-term. This equilibrium is defined by the long-term linear cointegration relationship, while the short-term stock price dynamics is reproduced using a Linear Error Correction Model (LECM). First, we check the FI hypothesis by linear techniques. But, since we could wrongly reject the FI hypothesis because of the weakness of these techniques in apprehending nonlinearities in the market integration process, we then apply more robust nonlinear tests. In particular, we use nonlinear adjustment tests introduced by Luukkonen et *al.* (1988) and developed by Van Dijk et *al.* (2002). This offers an approach that enables us not only to check FI in the presence of market frictions, but also to specify a time-varying FI process that is active per regime only when stock price deviations exceed a certain threshold.

We briefly describe the main steps of our econometric methodology. First, we check the linear cointegration hypothesis. Two variables, X_t and Y_t (here respectively European and national stock market indices in logarithms), that are I(1), could be linearly cointegrated in the long-term if a linear z_t combination between them is stationary. The long-run cointegration relationship is then given as follows:

$$\hat{z}_t = Y_t - \hat{a}_0 - \hat{a}_1 X_t \qquad (1)$$

where $\hat{z}_t$ is the residual series, $\hat{a}_0$ and $\hat{a}_1$ are the estimators of the cointegration relationship. The linear short-term dynamics of stock prices is reproduced through a LECM:

$$\Delta Y_t = \alpha_0 + \lambda\ \hat{z}_{t-1} + \sum_{i=1}^{p} \alpha_i\, \Delta Y_{t-i} + \sum_{j=0}^{p} \beta_j\, \Delta X_{t-j} + \varepsilon_t \qquad (2)$$

where λ is the linear adjustment term defining the linear mean-reversion speed.

But, this modeling may not be suitable for investigating FI between stock markets since several FI characteristics can escape from the traditional linear cointegration tests. To reproduce and apprehend the main properties of the FI process, we propose nonlinear cointegration tests that are more robust than linear tools. In practice, we implement Van Dijk et al.'s (2002) two-step techniques. In the first step, we test for linear cointegration using traditional unit root tests. In a second step, we implement nonlinear adjustment tests. In particular, we apply Lagrange Multiplier tests (LM) developed by Luukkonen et *al.* (1988) to the residuals of the linear cointegration relation.[2] The rejection of linearity indicates a nonlinear mean reversion in the data, which could conclude in favor of FI even if the linear cointegration hypothesis is rejected. Indeed, this suggests that FI is checked only by regime to some extent. For instance, we could imagine two regimes in the stock market integration process. In the first regime, no adjustment takes place and the stock price is generally distanced from the financial market equilibrium, i.e., the whole EA stock market. Stock price deviations from the equilibrium last a very long time, can be divergent and have a unit root, even though they do not necessarily follow a random walk. In the second regime, stock price adjustment is relatively active. Its speed depends on the price disequilibrium size and its deviations approach a white noise. Overall, stock price deviations may follow a nonlinear process that is mean-reverting with a convergence speed that varies directly with the size of the stock price deviations from the equilibrium.

III. EMPIRICAL RESULTS

A. Data and Preliminary Results

The data consists of the monthly stock market index closing prices of the Euro-10 member states (Germany, Austria, Belgium, Spain, Finland, France, Ireland, Italy, the Netherlands and Portugal) and the European stock index. All indices are obtained from Morgan Stanley Capital International (MSCI) and encompass the period from January 1970 to December 2007.[3] In addition, to test the impact of the transition to a single currency and the application of new financial directives on FI, two time-series sub-periods are retained: January 1970 - December 1999 and January 2000 - December 2007. Besides the comparison between the countries studied, this enables to test the hypothesis whereby the introduction of the Euro has increased FI in the EA.

To do this, we began by performing bivariate and multivariate cointegration tests to check FI using Engle and Granger's (1987) two-step estimation techniques and the standard Johansen (1988) method. We also conducted nonlinear modeling tests to capture the possible asymmetry and nonlinearity that characterize the comovements of the EA stock markets.[4] Precisely, we first studied the European and national stock price integration order for the two sub-periods. Inspection of their graphs suggests that stock price indices are not *a priori* stationary. More importantly, the graphs also suggest that comovements between stock prices have been stronger in periods of crises, particularly in the last few years, although comovements are more illustrious and distinguished for certain stock markets than for others (Austria, Belgium, Germany, France and the Netherlands). We then tested for the presence of unit root in the series using Dickey-Fuller (1981) and Phillips-Perron (1997) tests and showed that none of the stock price series was found to be integrated of one order (I(1)) for the two sub-periods.[5] Second, we explored the statistical properties of the Euro-10 stock equity returns, computed their descriptive statistics and retained several conclusions.[6] The symmetry and normality hypothesis are firmly rejected for all stock market returns over the two sub-periods. The negativity of skewness for all of the EA markets can be associated with possible nonlinearity and asymmetry in stock price dynamics. The reduction of standard deviations over the second sub-period is an indicator of FI between these markets.

Third, we investigated the correlation between the national stock returns and the European market returns before and after the transition to a single currency in order to determine the effect of the Euro's adoption on FI in the EA (Tables 1 & 2). From Table 3, we note that not many stock market indices appear to correlate strongly with the European stock market index. Accordingly, strong evidence of FI is suggested for France, Germany and the Netherlands, since their correlation coefficients are closer to the unity. For the other markets, FI is somewhat partial or weak. However, after the introduction of the Euro, correlations between national and European market returns increased significantly as indicated by Meric and Meric (1999), Chung and Lai (1999), Worthington, Katsuura and Higgs (2003) among others.

Table 1: Correlation matrix over the sub-period 1970 – 1999

	Europe	Germany	Austria	Belgium	Spain	Finland	France	Ireland	Italy	The Neths	Portugal
Europe	1.00	0.84*	0.61	0.70	0.74	0.54	0.82*	0.69	0.58	0.87*	0.56
Germany	0.84*	1.00	0.65	0.67	0.55	0.44	0.76	0.51	0.52	0.74	0.41
Austria	0.61	0.65	1.00	0.38	0.41	0.33	0.48	0.44	0.39	0.56	0.44
Belgium	0.70	0.67	0.38	1.00	0.50	0.27	0.69	0.52	0.42	0.68	0.41
Spain	0.74	0.55	0.41	0.50	1.00	0.49	0.58	0.57	0.55	0.58	0.59
Finland	0.54	0.44	0.33	0.27	0.49	1.00	0.34	0.43	0.43	0.43	0.31
France	0.82*	0.76	0.48	0.68	0.58	0.34	1.00	0.45	0.47	0.69	0.41
Ireland	0.69	0.51	0.44	0.52	0.57	0.43	0.45	1.00	0.37	0.62	0.49
Italy	0.59	0.52	0.39	0.42	0.55	0.43	0.46	0.37	1.00	0.46	0.36
The Netherlands	0.87*	0.75	0.56	0.68	0.58	0.43	0.69	0.62	0.46	1.00	0.53
Portugal	0.56	0.41	0.44	0.41	0.59	0.31	0.41	0.49	0.36	0.53	1.00

Table 2: Correlation matrix over the sub-period 2000 – 2007

	Europe	Germany	Austria	Belgium	Spain	Finland	France	Ireland	Italy	The Neths	Portugal
Europe	1.00	0.94*	0.60	0.82*	0.87*	0.63	0.97*	0.70	0.85*	0.92*	0.73
Germany	0.94*	1.00	0.54	0.77	0.84*	0.53	0.93*	0.69	0.82*	0.90*	0.69
Austria	0.60	0.54	1.00	0.71	0.54	0.11	0.56	0.52	0.53	0.55	0.49
Belgium	0.82*	0.77	0.71	1.00	0.68	0.30	0.78	0.66	0.69	0.80*	0.67
Spain	0.86*	0.84*	0.54	0.68	1.00	0.47	0.84*	0.67	0.76	0.78	0.75
Finland	0.63	0.54	0.12	0.30	0.46	1.00	0.63	0.35	0.51	0.53	0.44
France	0.97*	0.93*	0.56	0.78	0.84*	0.63	1.00	0.65	0.86*	0.92*	0.73
Ireland	0.71	0.69	0.52	0.66	0.67	0.35	0.65	1.00	0.53	0.67	0.54
Italy	0.83*	0.82*	0.53	0.69	0.76	0.51	0.86*	0.54	1.00	0.81*	0.71
The Netherlands	0.93*	0.90*	0.55	0.80*	0.78	0.53	0.92*	0.67	0.81*	1.00	0.68
Portugal	0.74	0.69	0.49	0.67	0.75	0.44	0.73	0.54	0.71	0.68	1.00

(*) indicates the most significant and strongest correlation between stock prices.

Thus, FI is *a priori* confirmed for France, Germany, the Netherlands, Belgium, Spain and Italy at least. Fourth, to extend this modeling, we applied cointegration tests which are more powerful than correlation tests and yield dynamic analysis over the short and long-term.

Table 1 reports the bilateral correlations between the stock indexes of the EA over the first sub-period. We show strong evidence of correlation between French, German and Dutch indexes and the European prices. Table 2 presents the bilateral correlations between the stock indexes of the EA but over the second sub-period. Bilateral correlation and correlation with the MSCI European index are more important and significant. Besides, other indexes are more significantly correlated between one another and with the European index.

The time-varying dynamics of all stock market prices in logarithm over the two sub-periods, not presented here in order to conserve spaces but available upon request, show that the Euro-10 markets under consideration have followed more similar patterns in the second sub-period.

Table 3 summarizes the results of the nonlinear cointegration tests that check the null hypothesis of linear cointegration against its alternative of nonlinear cointegration. The test is carried out for several values of the parameter of delay (d) and conducted over the two sub-periods. For each *p*-value that is under 5% (respectively 10%), the null hypothesis of linear cointegration is rejected at the 0.05 level (respectively 0.10), but the optimal value of d is that for which the null hypothesis is the most rejected (the *p*-value is minimum).

Table 3

Nonlinear cointegration tests (*p*-values)

	Ger.	**Aus.**	**Belg.**	**Spain**	**Finland**	**France**	**Ireland**	**Italy**	**The Neths.**	**Portugal**
Panel A: First sub-period: January 1970 – December 1999										
p	2	1	3	2	2	3	2	1	3	2
d = 1	0.12	0.13	0.10**	0.34	0.12	0.04	0.34	0.22	0.09*	0.22
d =2	0.03	0.20	0.12	0.23	0.34	0.12	0.23	0.32	0.38	0.45
d =3	0.01*	0.12	0.33	0.12	0.64	0.03*	0.14	0.11	0.11	0.13
d =4	0.04	0.52	0.55	0.56	0.17	0.02	0.19	0.23	0.23	0.47
d =5	0.23	0.34	0.21	0.83	0.39	0.34	0.32	0.45	0.10	0.17
Panel B: Second sub-period: January 2000 – December 2007										
d = 1	0.0*	0.12	0.05	0.12	0.13	0.06	0.23	0.12	0.23	0.13
d =2	0.02	0.15	0.01*	0.07	0.23	0.00	0.13	0.14	0.34	0.23
d =3	0.04	0.16	0.02	0.16	0.14	0.04	0.46	0.09	0.10	0.43
d =4	0.01	0.25	0.14	0.04*	0.32	0.08	0.12	0.03*	0.05*	0.10**
d =5	0.03	0.11	0.23	0.28	0.68	0.07	0.36	0.12	0.21	0.11

(*) and (**) indicate statistical significance at the 0.05 and 0.10 levels, respectively.

B. Linear Cointegration Tests

We first carried out Engle and Granger's procedure and checked for linear cointegration by testing the stationarity of the residuals from the long-term relationship between European and individual stock market indices. Our findings highlight different results among the various countries and between the sub-periods. According to the linear cointegration tests, cointegration and the FI hypotheses are only improved for France, at the 10% level. When comparing the estimated ADF statistics with those of Engle and Yoo (1987), the linear cointegration hypothesis is indeed rejected for all the other indices, indicating that these markets are somewhat segmented[7]. Over the second sub-period, the linear cointegration hypothesis is verified for France, Germany and the Netherlands at the 5% level, and for Belgium, Spain, Italy, Portugal and Ireland at the 10% level, indicating FI for these markets. This suggests a positive effect of the Euro on the FI process for France and Portugal and highlights the FI increase after 1999. However, the stock markets in the other EA member states appear to remain segmented after the adoption of the Euro, indicating that their integration process and dynamism remained similar and relatively unchanged before and after the transition to the single currency.

An interesting avenue for research would be to focus on how trustworthy these findings are. It would also be useful to check whether EA stock markets are still really segmented in spite of the adoption of a single currency, or whether they are relatively integrated and FI is increasing thanks to the Euro, and whether the linear modeling techniques used to investigate FI benefits have generated inaccurate findings since they are biased. Indeed, even though several studies have focused on FI, this question has not been appropriately addressed and developed to date. To do this, we examined FI by multivariate cointegration analysis and by more robust tools (nonlinear cointegration tests), and compared the obtained results.

One advantage of Johansen's approach is that it allows us to check cointegration in a multivariate framework, so that we can simultaneously test for linkages between European and EA stock market price indices. Johansen's approach tests for a number of cointegration relations using Johansen's Trace test (1988). In view of our findings, we reject the null hypothesis of "no cointegration" for both periods and we accept the alternative hypothesis of "at most two cointegration equations" over the second sub-period (2000-2007). This provides evidence of partial FI between the EA stock markets but the estimation of the Vectorial Error Correction Model (VECM) does not indicate significant evidence of comovements toward the equilibrium for certain countries, even though estimation results of VECM are more significant after 1999. The latter finding means that FI between European countries increased after the adoption of the Euro.[8] Overall, FI appears to be stronger after 1999. However, the poor compatibility of Johansen tests with those of correlation tests and the Engle-Granger approach seems to corroborate the literature review described above regarding the absence of unanimous conclusions regarding FI of the EA member states when linear modeling is used. In order to check whether this conclusion is due to the misspecification of linear modeling or rather because stock markets are really segmented in spite of the adoption of the Euro, the last step in our FI investigation was to apply more robust tests: nonlinear cointegration tests.

C. Testing FI with Nonlinear Cointegration Tests[9]

We adopted Van Dijk et *al.*'s (2002) approach to carry out the tests in order to check the degree of FI between EA countries. We applied these nonlinearity tests to examine whether stock price adjustment dynamics are symmetric or asymmetric, linear or nonlinear. Indeed, a structural shift in stock price adjustment can imply discontinuities in stock price dynamics and lead us to conclude against FI. However, stock markets can be integrated by regimes and this structural change is simply due to a transition from one regime to another. Our findings show that nonlinear cointegration tests are more robust than the usual cointegration techniques. Indeed, the application of LM_3 tests over the two sub-periods yielded a number of important results. Concerning the first sample, linearity is rejected for France and Germany at the 5% level and for Belgium and the Netherlands at the 10% level, suggesting a significant nonlinear mean reversion of their stock market indices toward equilibrium. These results are consistent with those of Richards (1995), Kwan, Sim and Cotsomitis (1995), and Chung and Lai (1999) among others, who point to strong evidence of FI and linkages between the largest stock markets but weak or mixed results for smaller markets.

For the second sub-period, the results are statistically more significant, indicating a considerable increase of FI in the EA. Indeed, the French and German stock markets are integrated more strongly since linearity is rejected far more for all the possible values of the delay parameter d, highlighting significant comovements of their stock prices toward the European market index. Some FI proof is also found for the Netherlands. Globally, our findings show strong evidence of a positive impact of the adoption of the Euro for Belgium, Italy and Spain since their stock markets became statistically and significantly more integrated after 1999. FI hypothesis is retained for Portugal at the 10% level. However, FI is not accepted for Ireland, Finland and Austria. This may be due to the size factor of their stock markets.

Our findings supplant then those of linear tools to investigate the FI hypothesis between the Euro-10 stock markets, suggesting strong evidence of FI and comovements between these markets and indicating a structural break that occurs *a priori* after 1999 and an increase in FI in this area. They also have major implications for international portfolios since for most of the members, the transition to a single currency offers better opportunities for risk sharing and diversification, better allocation of capital and increase in liquidity, and more interdependence between stock markets. It reflects the impact of financial linkages between member states in the region thanks to the standardization of information, the harmonization of infrastructures and financial instruments, the implementation of the Financial Service Action Plan, and the centralization of information by the ECB.

Finally, these results highlight the weaknesses and misspecifications of the linear tools commonly used to check FI. Indeed, our results show an on-off FI process that is activated by regime when stock price deviations exceed a certain threshold conditioned by the level and degree of harmonization between the EA member states' financial systems. In the first regime (before 1999), stock markets are relatively segmented and stock prices deviate from the European market index because of the importance of heterogeneity and differences between the member states' financial systems and quotations. In the second regime, notably after the transition to the Euro, the different attempts to harmonize and liberalize involve common European financial systems and rules stimulating FI. This type of FI mechanism can escape from linear modeling and lead to serious erroneous results with respect to FI.

IV. CONCLUSION

This paper studied FI between EA stock markets over four decades using linear and nonlinear techniques. Our results suggest threshold stock market integration between most of the EA stock markets. As Meric and Meric (1999), Worthington *et al.* (2003) and Hardouvelis *et al.* (2006) indicated, FI has increased, notably following the adoption of the Euro. Using recent developments in nonlinear modeling, we highlight strong evidence of a structural break after 1999 and significant nonlinear mean-reversion for stock market prices. To extend this research, the nonlinear mean-reversion in stock prices needs to be modeled.

ENDNOTES

1. FI has been an ongoing goal for the European Union (EU) for a number of years (Worthington, Katsuura and Higgs, 2003).
2. The implementation of nonlinear adjustment tests (LM tests) is briefly described in the first appendix. For more details, see Van Dijk, Teräsvirta and Franses (2002).
3. For Finland, Portugal and Ireland, data have been available since January 1982 and January 1988 respectively.
4. All empirical results are presented in appendices.
5. The results of the unit root tests are available upon request.
6. These results are also available upon request.
7. We do not report results of linear cointegration tests to save space, but the latter are available upon request.
8. The estimation results of VECM are not reported in detail to save space, but are also available on request.
9. We don't present these tests to save space, see Van Dik et al. (2002) for more details about these tests.

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