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Market integration and globalization of financial markets: Evidence from Portugal, Spain, UK, Japan and US

Abstract
This paper analyzes the stock market globalization on the basis of the price theory. This leads to the concept of market integration which, under the nonstationarity of price level variables, can be empirically tested by using cointegration techniques. An error correction model incorporating prices and returns is specified and empirically tested. The results show that the five stock markets under analysis are cointegrated and there is just one cointegrating vector that explains the long-run relationship between these markets. Market integration holds for the system as a whole but full price transmission is only accepted for some pairs. The results show that price movements between pairwise stock markets are usually highly nonlinear.

Keywords
Globalization; market integration; error correction model; nonstationarity; cointegration.

1. Introduction

The empirical analysis of market integration usually relies on the comparative study of the underlying price series. The theoretical background of these studies is primarily based on the notion of market and hence on the definition of integrated market. Several definitions state that the uniformity of prices (after allowing for different opportunity costs) over time is the main factor of a market (see, e.g. Stigler, 1969). Such definitions can be seen as long-run relationships in prices and allow for the construction of statistical tests of market integration based on causality, proportionality and other features.

The key element of market integration is the behavior of prices over time for a given commodity. For example, if two markets A and B are integrated then the price movements in A are transmitted to B and/or vice-versa. Under non-proportionality of price transmission, one can say that there is weak market integration. However, is price transmission is proportional (or full) one can say that there is strong market integration.

While the above mentioned notions are easy to understand, the empirical estimation of the models can be awkward if the price data exhibit stochastic nonstationarity. In fact, nonstationarity in price data can lead to misleading results and erroneous conclusions about the nature of the relationship of price transmission over time. On the other hand, differencing the series does not solve the problem adequately.

The models used in this study deal properly with the problem of nonstationarity in price data. The stochastic nature of nonstationarity is directly addressed. If nonstationarity of the data is present, then we assess whether there is any causality relationship between the data. We measure the extent of the effect of price changes only after this

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procedure is accomplished. Market integration tests can then be employed. Thus, in the sense of Stigler (1969), these tests can be seen as tests of the Law of One Price (see, e.g. Bentes, 2015).

The rest of the paper is organized as follows. In Section 2 we describe the methodology adopted in this study. Section 3 presents the data and results. Finally, Section 4 concludes.

2. Methodology

The empirical analysis conducted in this study involves the following four steps:

1. Testing for stochastic nonstationarity in the log-price index series
2. Testing for log-price index cointegration if the variables are nonstationary
3. Estimation of a Vector Error Correction (VEC) model if the variables are found to be cointegrated
4. Testing for proportionality in the long-run parameter estimates in order to verify whether strong market integration occurs

Stochastic nonstationarity of the variables may be a source of problems when we estimate the regression parameters using the OLS estimator (Granger and Newbold, 1974). Under these circumstances, one may obtain spurious regression results. Therefore, assessing the nonstationary features of the series is an important prior task in our analysis.

Nonstationarity is usually gauged using unit root tests. In our study, we rely on two types of unit root tests: the Augmented Dickey-Fuller (1979, 1981) test (ADF) and the Elliott-Rothenberg- Stock (1996) test (ERS). Both tests postulate the null hypothesis as H0: $\rho = 1$. ρ is the critical parameter to test for nonstationarity. The ADF test relies on the following regression:

$$\Delta x_t = \mu_0 + \mu_1 t + (\rho - 1)x_{t-1} + \sum_{k=1}^{p} \gamma_k \Delta x_{t-k} + \varepsilon_t , \tag{1}$$

where μ_0, μ_1, ρ and γ_k are parameters and $\varepsilon_t \sim iid(0, \sigma^2)$. Non-rejection of the null means that xt has a unit root (nonstationary). The alternative hypothesis in the ADF test is H1: $|\rho| < 1$. Rejection of the null implies that xt is trend stationary and under the alternative we have an AR(p+1) process. The major drawback of the ADF test is its low power when the process is stationary with roots close to unity.

The ERS test is based on the following data generation process:

$$x_t = d_t + u_t \; ; u_t = \rho u_{t-1} + v_t , \tag{2}$$

where dt denotes a deterministic component and vt is a non-observed zero mean stationary process. If the null H0: $\rho = 1$ is not rejected then xt is nonstationary. Otherwise, under the alternative, H1: $\rho = \rho^*$ where ρ^* is a real number smaller than one.

The unit root tests are usually applied to the series in levels (prices) and in first differences (returns). Non-rejection of the null in levels and rejection of the null in first differences implies that xt is integrated of first order [I(1)]. If nonstationarity is present, a regression between a set of xit variables can be trustworthy if and only if these variables are cointegrated.

Cointegration can be tested on the basis of a Vector Error Correction (VEC) model. This form has several advantages of which we may highlight the separation between long-run and short-run information and no need to assume a priori which variables are exogenous and which are endogenous. The VEC model can be specified as follows:

$$\Delta \mathbf{x}_t = \boldsymbol{\alpha}\boldsymbol{\beta}'\mathbf{x}_{t-1} + \sum_{k=1}^{p-1} \boldsymbol{\Gamma}_k \Delta \mathbf{x}_{t-k} + \boldsymbol{\mu} + \boldsymbol{\varepsilon}_t , \tag{3}$$

where $\boldsymbol{\alpha\beta}' = \sum_{k=1}^{p} \mathbf{A}_k - \mathbf{I}$ and $\boldsymbol{\Gamma}_k = -\sum_{j=k+1}^{p} \mathbf{A}_j$. Ak denote a set of p i-order matrices of model parameters, where each one is associated to an i-dimensional vector of endogenous lagged variables up to order p. The matrix $\alpha\beta'$ contains the system´s long-run information and Γk contains the short-run information. The elements of α measure the adjustment speed to equilibrium and the elements of β denote the long-run coefficients (cointegrating vectors). μ represents a vector of constants and εt is a random error term vector such that εt ~ iid(0, Ω). Finally, xt denotes an i-dimensional vector of nonstationary endogenous variables given in levels.

For a set of xt variables to be cointegrated it is necessary that there is at least one cointegrating vector in the system. This is the case when the rank (r) of $\alpha\beta'$ is greater than zero and smaller than the order (i) of $\alpha\beta'$, that is, $\alpha\beta'$ should contain at least one linearly dependent vector. The rank of $\alpha\beta'$ indicates how many long-run relationships exist in the system.

Johansen (1988, 1991) proposed two tests for the null hypothesis that the cointegrating rank is, at most, r (less than i): the trace test and the maximum eigenvalue test. In the former, the alternative hypothesis postulates that the rank is i and, in the latter H1 postulates that the rank is r+1. Gonzalo (1994) concluded that the Johansen tests are more powerful than the former single equation Engle-Granger tests.

Market integration in the weak form occurs if cointegration of a set of underlying nonstationary variables is observed. Therefore, the Johansen tests provide an adequate and fast way to test for (weak) market integration. However, more robust conclusions can be reached if full price transmission, or proportionality, is also present. Proportionality can be tested by imposing parameter restrictions in the long-run coefficient vector β. For example, full price transmission occurs between two markets if the null H0: β = (1, −1) is not rejected. The underlying test statistic follows a χ2(1) distribution. In the next section we present the data and the results obtained by implementation of the methodology here described.

3. Data and Results

Our empirical study relies on daily stock market indices (five days per week) for five countries starting on January, 4th 1999 until January, 21st 2009. The dataset comprises the price indices for Portugal, Spain, UK, Japan and the US. The data are the natural logarithms of the relative indices for these markets, where the base 100 was set at January, 4th 1999. All the series were converted to Euros using the underlying exchange rates. The series were collected in the Datastream database.

Table 1 presents some descriptive statistics in log-levels [ln(Pit)] of the five stock markets under analysis. Looking at the mean of the series one can see that all of them exhibit absolute gains over the time window analyzed except the Portuguese, where the average loss reaches about 15%. However, the average gains in Spain, UK and US are modest (2%-4%). The coefficient of variation shows a spread of 4%-5% around the mean of the series. Skewness is substantial in all cases except the Portuguese and is negative for the UK. Kurtosis indicates that the distribution of the log-price indices is slightly flatter than the Gaussian. The J-B test statistic rejects the null hypothesis of normality for all of them.

Table 1. Descriptive statistics in log-levels [ln(P_{it})]

	Portugal	Spain	UK	Japan	US
Mean	4.448250	4.626497	4.645590	4.824509	4.631055
Std. Deviation	0.241385	0.260225	0.197761	0.253729	0.205863
Coef. Variation	0.054265	0.056247	0.042570	0.052592	0.044453
Skewness	0.041660	0.282103	-0.615049	0.459567	0.272896
Kurtosis	2.242982	2.345118	2.521903	2.666213	2.519397
Jarque-Bera	63.3912	81.6625	190.3551	104.5072	57.8008
p-value	0.00000	0.00000	0.00000	0.00000	0.00000

Notes: Sample period 01/4/1999 – 01/21/2009.

A model that relates ln(Pit) (i = 1, …, 5) over time is nonspurious under the null of nonstationarity of the variables if and only if the log-price series are cointegrated. Nonstationarity is present if the series exhibit unit roots. Unit root tests in levels and in first differences for all the series are shown in Table 2.

Table 2. Unit root tests in levels and in first differences

Variable	ADF[a]	ERS[b, c]
Portugal	-0.918124	-0.853046
Spain	-0.257510	-1.144829
UK	-1.038174	-0.396646
Japan	-0.205460	-1.102453
US	-0.669334	-1.424645
Δ(Portugal)	-47.59665 **	-3.931103 **
Δ(Spain)	-52.54149 **	-4.485785 **
Δ(UK)	-23.65035 **	-4.523791 **
Δ(Japan)	-51.42647 **	-4.984853 **
Δ(US)	-55.56968 **	-4.243333 **

Notes: [a] MacKinnon (1996) critical values: -2.57 (1%). [b] Elliott-Rothenberg-Stock (1996, table 1): -3.48 (1%). [c] exogenous terms in levels: constant and deterministic trend. ** significant at 1%. Sample: 01/4/1999 – 01/21/2009. 2620 observations.

The ADF and ERS tests are designed to capture weak stationarity. In both cases the null hypothesis of nonstationarity of the variables in levels is not rejected but it is rejected at 1% for the variables in first differences. These results are consistent and show that the log-price series are integrated of first order, or I(1). Lag selection was set on the basis of the SBC information criterion (Schwarz, 1978). Thus, while the log-price series under analysis are nonstationary variables, the price returns are stationary. The analysis of market integration using price data has to be held in the context of cointegration and the method of Johansen will be used. The Johansen method is adequate for testing cointegration in a system of endogenous or feedback variables. The Johansen test statistics are presented in Table 3.

Table 3. Johansen cointegration tests

Rank	Eigenvalue	Trace Statistic[a]	Max. Eigenvalue Statistic[a]
$r = 0$	0.017061	106.7595 **	45.0867 **
$r \leq 1$	0.011054	61.6728	29.1216
$r \leq 2$	0.009082	32.5512	23.9044
$r \leq 3$	0.002908	8.6469	7.6306
$r \leq 4$	0.000388	1.0163	1.0163

Notes: [a] MacKinnon-Haug-Michelis (1999) *p*-values. Linear deterministic trend. 2 *lags* in the endogenous variables. ** significant at 1%. Sample: 01/4/1999 – 01/21/2009. 2620 observations.

The null hypothesis that $r = 0$ is rejected at 1% in both tests (trace and maximum eigenvalue) but the null $r \leq 1$ is not rejected at standard levels. Autocorrelation was controlled for using a VEC specification with 2 lags in the endogenous variables. A linear deterministic trend was also included in the VEC specification to account for possible trend stationarity. The results indicate that there is one cointegrating vector in the system.

The results of the Johansen tests lead to two conclusions: 1) the five log-price series under analysis are cointegrated, since $0 < r < 5$, and 2) there is only one single long-run mechanism that governs the relationships between these five markets, since $r = 1$. This is in line with the idea of stock market globalization, although pairwise relationships may vary greatly across markets. The results obtained corroborate the first condition for market integration on the light of the LOP, i.e. there is price transmission (contagion) between the five markets analyzed. This means that the five stock markets under analysis do appear to belong to the same market space over the period analyzed.

Given the results of the Johansen tests, a nonspurious regression model linking these five markets can be constructed. In order to account for the possibility of full log-price endogeneity, a Vector AutoRegressive model (VAR) can be specified. Furthermore, the VEC transformation will permit to disentangle the short and long-run information contained in the log-price data. Table 4 presents the results for the β and α parameter vectors, where the elements of β denote the long-run effects and the elements of α measure the adjustment speed to equilibrium.

Table 4. Vector error correction model

Variable	β	α
Portugal	1.000000	-0.000678
		(0.00206)
Spain	-2.071724 **	0.006417 *
	(0.19897)	(0.00259)
UK	1.174800 **	-0.002100
	(0.34522)	(0.00271)
Japan	0.352840 **	-0.013318 **
	(0.12960)	(0.00296)
US	-0.632353 *	-0.001653
	(0.29321)	(0.00323)
@Trend	0.000364 **	
	(5.2E-05)	
Constant	0.427071	
Log-*L*	41509.94	
AIC	-31.63660	
SBC	-31.48870	

Notes: Exogenous terms: constant and deterministic trend. Standard errors in (). 2 lags in the endogenous variables. ** significant at 1%. * significant at 5%. Sample: 01/4/1999 – 01/21/2009. 2620 observations.

The long-run coefficients are all significant at 1% or 5%. A constant and a linear trend were included in the model as exogenous terms in order to control for deterministic effects in the data. The linear trend coefficient is positive and significant at the 1% level, as well as the coefficients for Japan and the UK. The coefficients for Spain and the US are negative and significant at the 1% and 5% level, respectively. Recall that, by construction of the VEC model, a negative β coefficient estimate implies a positive shock in the long-run price relationship and vice-versa.

Turning now to the α coefficients, the estimates for Spain and Japan are significant at the 5% and 1% level, respectively. This means that the log-price indices for the Spanish and Japanese stock markets are endogenous and react to the cointegrating error following shocks to the system.[1] Positive shocks to the long-run price relationship increase the returns for the Spanish market and vice-versa for the Japanese one. As an example, for Japan the adjustment is about 1.3% per day.

In order to test for the second condition of market integration, we carried out tests of proportionality or full price transmission using parameter restrictions of the long-run cointegrating vectors. Proportionality of price transmission between two markets j and k (j ≠ k) can be tested under the null H0: (β1j, β1k) = (1, −1). The test statistic follows a χ2 distribution with one degree of freedom. If the null hypothesis is not rejected then market j and market k are integrated in the long-run, i.e. price transmission between these markets is proportional over time. The null hypothesis is rejected in all the cases except those reported in Table 5. Thus, shocks in the US stock market are proportionally transmitted to Portugal, UK and Japan. Shocks in the UK stock market are proportionally transmitted to Spain.

[1] A test of the null of $\alpha_{i1} = 0$ allows for assessing whether the dependent variable in equation i is exogenous. If the null hypothesis is rejected one says that the underlying variable is endogenous. The test H_0: $\alpha_{i1} = 0$ follows a χ^2 distribution with one degree of freedom.

Table 5. Pairwise proportionality tests

Market j	Market k	$\chi^2(1)$	p-value
Portugal	US	0.319700	0.571788
UK	US	3.630757	0.056721
Japan	US	0.592408	0.441490
Spain	UK	2.425351	0.119387

Notes: H_0: $\beta_{1j} = 1$, $\beta_{1k} = -1$ ($j \neq k$). 2 lags. Sample: 01/4/1999 – 01/21/2009. 2620 observations.

In summary, our results show that there is strong market integration between, on one hand, the US and on the other hand Portugal, UK and Japan. The same happens with regard to the UK and Spain. In the remaining combinations there is only support for stating that there is weak market integration since, while the first condition (price cointegration) holds the second condition (proportionality of price transmission) does not hold. In these cases, although the underlying markets belong to the same market space, they are not related in a linear way.

4. Conclusions

This paper investigates stock market integration in the context of the global economy using a theoretical framework based on price theory. The empirical modeling of market integration is complicated by the nonstationary nature of price data. A structure based on multivariate cointegration provides the right setting for such analysis, which involves the specification of a dynamic VEC model of prices and returns.

The results show that the five stock markets analyzed do belong to the same market space and long-run market integration occurs in the system but the evidence on proportionality of pairwise price transmission is limited. It seems, therefore, that pairwise market integration in this context contains several elements that point to nonlinearities or other types of complexities that drive the behavior of the markets or their agents and move them away from homogeneous linear price transmission. Thus, pairwise nonlinear movements must be examined in a different atmosphere.

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