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WP 5-99 July 1999

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Iberian Financial Integration*

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July 1999

Abstract

Pricing discrepancies in the Iberian stock markets are assessed. The estimation results suggest three conclusions. When considered individually each of the three stock markets considered, Frankfurt, Lisbon and Madrid Stock Exchanges, constitutes an almost perfectly integrated market. Even though the achieved level of integration between the three pairs of the stock markets considered is large, it can be improved upon. The level of integration achieved by the Iberian stock markets is lower than the one achieved between each Iberian market and the Frankfurt market.

1. Introduction

There is unanimity that with the globalization of financial markets, capital markets have become more integrated. The economic literature has taken part on this discussion. Many are the papers that propose integration measures and compute them for particular markets. The definition of integration, however, is ambiguous. In perfectly integrated international capital markets, the prices of all assets should react to the arrival of new information. Thus, some papers use this notion that integrated markets should fluctuate together, to conclude that low correlations between markets indicate segmentation. But, this is an imprecise and faulty definition since two stocks in the same exchange may have completely different

* For helpful comments I thank Chongwoo Choe, José Mata and Roberto Blanco. For help with the Madrid Stock Exchange data I thank Roberto Blanco and the Bank of Spain.

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behaviors. Alternatively, a more precise definition must focus on the pricing of the assets: international capital markets integration should be defined as a situation where assets with the same characteristics, but in different countries have the same price.

The assessment of capital market integration is important for several practical reasons. If national stock markets are segmented, international portfolios have higher value as some of the domestic systematic risk can be diversified away by investing internationally. Additionally, in case of segmentation, irrelevance propositions for corporate finance strategies become invalid. For instance, if a multinational firm has the opportunity to raise capital in Spain and Portugal, the cost of capital can be considerable different if these two markets are not fully integrated, making the decision non-trivial.

Another approach to measuring integration is to look for direct evidence of barriers to capital movements. Legal restrictions on capital movements or on the ownership of foreign assets can create differences between expected returns or prices across markets. In equity markets, segmentations could arise because of information effects, possibly due to differences in accounting rules, language barriers and so on. According to Hamao and Jorion (1994), documenting such barriers, however, is not sufficient to prove segmentation as prices are determined by the marginal investors who may find innovative ways around capital controls.

When the same asset is traded in two different markets, integration can be directly tested, because efficient markets imply that prices should be identical across markets. However, as that is not generally the case a different approach is required. Most people use notions of market integration that depend on the asset pricing model, making it impossible to test empirically market integration without testing at the same time the validity of the particular asset pricing model.[1,2] Thus, rejections could possibly occur because of misspecifications in the pricing model, or, alternatively because of auxiliary statistical assumptions. With the exception of Chen and Knez (1995), which was built on the seminal work by Hansen and Jagannathan (1991, 1994), all other existing notions of market integration lack a formal definition of "integrated markets".

The measurement theory of market integration developed by Chen and Knez

[1] See, among others, Adler and Dumas (1983), Campbell and Hamao (1992), Cho, Eun, and Senbet (1986), Errunza and Losq (1985), Jorion and Schwartz (1986), Solnik (1991) and Wheatley (1988) for studies on international asset pricing and market integration.

[2] For instance, the consumption based CAPM implies highly correlated consumptions between countries with highly integrated financial markets.

(1995) is independent of asset pricing models and has an intuitive definition of market integration. The basic idea underlying this theory is that closely integrated markets should assign similar prices to assets with similar payoffs. Thus, the market integration between two markets depends solely on the relationship between the pricing structures of the two markets. The value of the measure can be interpreted as how differently two markets price a similar portfolio with unitary payoff. To some extent it indicates the minimum amount of transactions costs or cross-border tariffs (or other market frictions) that are necessary to prevent investors from taking advantage of price differences between markets.

In this paper we assess the Iberian stock exchange markets integration according to the Chen -Knez measure. To achieve that goal we compute and compare the Iberian stock exchanges integration with the integration level of other markets.

Four pairs of financial markets are considered: (i) the Lisbon Stock Exchange and the Madrid Stock Exchange, (ii) the Frankfurt Stock Exchange and the Lisbon Stock Exchange, (iii) the Frankfurt Stock Exchange and the Madrid Stock Exchange, and (iv) the NASDAQ and the NYSE. The pair (i) represents the Iberian stock exchange markets. The estimates of the Chen-Knez measure are computed for the first three pairs of markets while the estimate for the last pair is borrowed from Chen and Knez (1995).

The results indicate that the Iberian stock exchange markets are the least integrated of those considered. Pairs (ii) and (iii) have similar integration measures. Nevertheless, all these three pairs of financial markets are substantially less integrated than the fourth pair, the pair NASDAQ and NYSE. In this sense, the financial integration of the European financial markets considered in the paper is still far from a "perfect integration".

There are pricing discrepancies within the Iberian financial markets. Common payoffs are priced somewhat differently, the minimum amount of cross-market frictions in the Iberian financial markets that is necessary to prevent investors from taking advantage of the pricing discrepancy between markets is 5.34 percentage points. For the pair Frankfurt-Lisbon arbitrage opportunities arise once cross-market frictions are below 3.71 percentage points, and for the pair Frankfurt-Madrid arbitrage opportunities occur once cross-market frictions are under 3.66 percentage points.

In order to validate the method used to calculate the Chen-Knez measure, the integration level of each market is computed. The results of the integration study of each market validate the method as all markets have a integration measure comparable to the one between the NASDAQ and NYSE markets. The Lisbon

Stock Exchange and the Frankfurt Stock Exchange being respectively, the most integrated and the least integrated of the three stock exchanges considered.

2. Review

In this section we present a condensed technical version of the financial integration theory that is used.[3] At any date t ($t = 1, ...$) there are two markets, A and B, with N_A and N_B traded assets. There are investors in each market and they are assumed to have optimal portfolios. This implies that in each market certain conditions between intertemporal marginal rates of substitution, prices and returns are satisfied.

For simplicity, we concentrate on securities transactions that take place at two dates, date t and date $t+\tau$, in market k $(= A, B)$. At date t securities are bought and at date $t+\tau$ their returns are received. Denote the price-return vector by $(\boldsymbol{\pi}_{k,t}, \mathbf{x}_{k,t+\tau})$. Let $mu_{j,t}$ be the equilibrium marginal utility of consumer j at date t, and let $\pi_{k,t} = \pi(x_{ik,t+\tau})$ be a pricing functional. A first order necessary condition for consumer j's optimal portfolio problem is

$$mu_{j,t}\pi(x_{ik,t+\tau}) = E_t(mu_{j,t+\tau}x_{ik,t+\tau}), \text{ for all } i = 1, ..., N_k, \ k = A, B, \qquad (2.1)$$

where E_t is the date t conditional expectation operator. If $mu_{j,t} > 0$, which happens if consumer j is not satiated, expression (**??**) can be rewritten as

$$\pi(x_{ik,t+\tau}) = E_t(d_{j,t+\tau}x_{ik,t+\tau}), \text{ for all } i = 1, ..., N_k, \ k = A, B \qquad (2.2)$$

where $d_{j,t+\tau} = \frac{mu_{j,t+\tau}}{mu_{j,t}}$. The variable $d_{j,t+\tau}$ is known by at least three designations: intertemporal marginal rate of substitution, discount factor and pricing kernel. Since the restrictions that will be derived apply to all consumers, the subscript j in the discount factor will be dropped.

After applying the law of iterated expectations to (**??**) we obtain an unconditional moment restriction

$$E(\pi(x_{ik,t+\tau})) = E(d_{t+\tau}x_{ik,t+\tau}), \text{ for all } i = 1, ..., N_k, \ k = A, B. \qquad (2.3)$$

Even though restriction (**??**) is weaker than restriction (**??**), attention will be concentrated on this unconditional moment restriction rather than on the conditional moment restriction (**??**), because it is easier to estimate unconditional moments

[3] For more details see Hansen and Jagannathan (1991) and Chen and Knez (1995).

than conditional moments.[4] We designate a stochastic discount factor d satisfying equation (**??**) for a given market k, as an admissible stochastic discount factor for the market k, and let D_k be the set of all admissible stochastic discount factors for market k.

We are interested in studying the implications of expression (**??**) to analyze the integration of markets. For this purpose we assume there are composite processes for each market $\{(\boldsymbol{\pi}_{At}, d_{At+\tau,}, \mathbf{x}_{At+\tau})\}$ and $\{(\boldsymbol{\pi}_{Bt}, d_{Bt+\tau}, \mathbf{x}_{Bt+\tau})\}$ that satisfy expression (**??**). Given that the data $(\boldsymbol{\pi}_{At}, \mathbf{x}_{At+\tau})$, and $(\boldsymbol{\pi}_{Bt}, \mathbf{x}_{Bt+\tau})$, for $t = 1, ..., T$, is finite, when studying market integration, the econometrician must assume that the composite processes are such that sample moments formed from the finite number of observations would converge to their population counterparts if the sample size would become larger.[5] Unless otherwise is stated, the unconditional expectation operator E is used below to represent the limit points of the time-series averages of the sample moments. For notational convenience, we omit the date t and date $t + \tau$ subscripts in most occasions.

A requirement for integration is that markets should assign the same price to securities with the same payoff. Since the dual of a pricing functional according to (**??**) is a stochastic discount factor, this implies that if markets are integrated then they share at least one discount factor.

An intuitive measure for market integration is based on the idea that two closely integrated markets should assign to a given payoff vector, prices that are similar, which implies that they should have similar discount factors. Formally one integration measure could be,[6]

$$a(A, B) \equiv \inf_{d_A \in D_A^+, d_B \in D_B^+} \|d_A - d_B\|^2, \tag{2.4}$$

where $D_A^+ \equiv \{d \in D_A : d \geq 0\}$ and $D_B^+ \equiv \{d \in D_B : d \geq 0\}$.

Define $\pi_A^+(x) \equiv E(xd_A^+), \forall x,$ & $\forall d_A^+ \in D_A^+$ and $\pi_B^+(x) \equiv E(xd_B^+), \forall x$ & $\forall d_B^+ \in D_B^+$. Hansen and Jagannathan (1994) established a pricing error interpretation for

[4] Since our measure of integration is computed using unconditional moments it overestimates the integration level, i.e. the "true" integration level is lower than the one we estimate.

[5] Hansen, Heaton and Luttmer (1995) specify the technical details under which the Law of Large Numbers can be applied to justify approximating population moments using time series averages.

[6] This measure is similar to the Chen and Knez (1995) strong integration measure. The existence of no arbitrage opportunities requires that all nonnegative payoffs that are strictly positive with positive probability have positive prices. Thus, no arbitrage opportunities exist if and only if $d_k > 0$.

$a(A,B)$. They show,

$$a(A,B) = \inf_{\left\{d_A^+ \in D_A^+, d_B^+ \in D_B^+\right\}} \sup_{\|x\|=1} \mid \pi_A^+(x) - \pi_B^+(x) \mid^2,$$

that is, the integration measure is the mini-max bound on the squared pricing differences in using the nonnegative stochastic discount factors of the two markets to price any conceivable unit norm payoff vector.

Chen and Knez (1995) describe a way to obtain estimates $a(A,B)$. The algorithm involves two steps. The first step calculates the minimum squared distance between a point in D_A^+, say $\hat{d}_A$, and the set D_B^+. Denote by $\hat{d}_B$, the stochastic discount factor in D_B^+, whose distance from $\hat{d}_A$ gives the minimum squared distance between $\hat{d}_A$ and D_B^+. The second step identifies the point in D_A^+ that gives the minimum squared distance between $\hat{d}_B$ and the set D_A^+. Restarting from that point in D_A^+, these two steps are repeated back and forth until a fixed point is reached. In the appendix we describe the algorithm in more detail.

There are at least two alternatives to obtain a good estimate of the market integration measures. One is to choose a large enough number of iterations. The other is to use a stopping rule that stops the iteration process, once in two successive iterations, the market integration measure does not go down much further. We chose the latter.

We now address the issue of how to implement the market integration measures. We adopt the ad-hoc procedure used by Chen and Knez (1995). The procedure has four steps. First, various sets of securities of dimension N in each market are chosen. Second, a set of securities in market A and a set of securities in market B are randomly selected. Third, the two measures are computed for this pair of sets. Fourth, the first three steps are repeated a large number of times to obtain a more general characterization of integration for the two markets.

3. Data Description

Weekly data for the years 1996 and 1997 were used to compute the integration measures. This period of analysis and frequency of data were determined mainly by the Lisbon Stock Exchange characteristics. Only recently has the Lisbon Stock Exchange recorded a sufficiently large volume of transactions.

The data for the Madrid Stock Exchange include the 92 most traded stocks in this period while the data for the Lisbon Stock Exchange have the 44 most traded stocks in this period. The data for the Frankfurt Stock Exchange include the entire series for this period from the DAX 100, which are 95. The days of the month were chosen to coincide, whenever possible, with the days: 1^{st}, 8^{th}, 16^{th}, and 23^{rd}. When the stock markets were not all simultaneously open on one of these four days, a different day was chosen. The general rule was to choose the day immediately before, and if that was not possible to choose the day immediately after, and if none of these were possible to choose the day two days before, etc. Such procedure resulted in 97 observations for each stock.

For each stock the total rates of return were used. The total return of an asset includes its dividend plus the capital gain. Both, total returns as well as stocks prices were denominated in a common currency, the US dollar.

4. Estimation Results

Each pair of stock markets is considered separately. Different subsets of assets are chosen from each stock market and the integration measure across each pair of subsets is estimated. Initially we chose the number of assets in each subset to be 10. This means that 10 stocks from each stock exchange in the pair were selected to form markets A and B and the integration measure was computed for them.

The choice of subsets with dimension equal to 10 stocks was to facilitate the comparison of our results with those obtained for the NYSE and NASDAQ by Chen and Knez (1995). The comparison with the integration measure for the NYSE and NASDAQ is important since these are closely integrated markets.[7]

It follows immediately from its definition that the integration measure is not invariant to the size of the market. The size of the market (number of assets included in each subset) affects the value of the integration measure. The larger the size of the market the higher will tend to be the value of the integration measure. For instance, for the NYSE and NASDAQ the value of the integration almost doubles when the size of the market increases from 10 to 20 assets.

The estimated values for the integration measure depend on the specific stocks chosen. To control for such bias, the Chen and Knez (1995) randomization method is used. The method has three steps: (i) select 10 assets from each pair of stock markets, which form a pair of asset submarkets; (ii) following the algorithm described in the appendix to compute $a(A, B)$ for the two submarkets described in (i); (iii) assemble the values obtained in (ii), and repeat steps (i) and (ii) for 500 different draws.

[7] Their result is not entirely comparable to ours for two reasons: they used a larger time period and used portfolios instead of individual assets.

The purpose of the exercise is to test two things: (i) whether the Lisbon Stock Exchange and Madrid Stock Exchange are perfectly integrated; (ii) whether the pair of Stock Exchanges considered in (i) is more integrated than the pair Frankfurt-Lisbon or the pair Frankfurt-Madrid.

The stopping rule used was the same as in Chen and Knez (1995). The iteration process in the algorithm stops once the sum of absolute changes in the estimated integration measure for the last five iterations is less than 0.05 basis points. As can be seen from Figure 1 this stopping rule is quite adequate.

The estimation results are reported in Table 1 and the histogram of the estimates in figure 2. For the pair Lisbon-Madrid the mean value is 4.35 basis points, and the median is 1.68 basis points. Since the 95% confidence intervals for the mean and median do not include zero, these two markets are not perfect integrated in the statistical sense. To obtain some sense whether the markets can be considered as perfect integrated in economic terms, we would need to compare them with two markets which one may expect to be perfectly integrated, like the NYSE and the NASDAQ. Chen and Knez (1995) report a mean value of 0.25 basis points for the referred pair of stock markets. Since the value found for the pair Lisbon-Madrid is over 17 times bigger, one may conclude that the Iberian stock exchanges are not perfectly integrated in economic terms either.

Table 1
Summary Statistics of the Market Integration Measure
(basis points)

Statistics	Lisbon-Madrid	Frankfurt-Lisbon	Frankfurt-Madrid
mean	4.35	2.79	3.21
95% confidence interval for mean	[3.70;5.00]	[2.48;3.10]	[2.88;3.53]
median	1.68	1.48	1.81
95% confidence interval for median	[1.33;2.04]	[1.14;1.90]	[1.55;2.21]
Range	52.17	22.90	21.81
22nd smallest	0.11	0.11	0.10
22nd largest	29.52	14.50	13.92

The mean value for the pairs of financial markets Frankfurt-Lisbon and Frankfurt-Madrid are smaller than the mean value for the pair Lisbon-Madrid. Statistically the mean value for the pair Lisbon-Madrid is different from the mean values for the remaining pairs of markets, since the 95% confidence interval for the mean of the pair Lisbon-Madrid does not intersect the 95% confidence intervals for the remaining pairs of markets.[8] Moreover, the means of the pairs Frankfurt-Lisbon and Frankfurt-Madrid as well as the median of all the pairs of markets considered are not statistically different as the 95% confidence intervals overlap.

We repeated the exercise above for the case when the subsets are of dimension 44, i.e. subsets with size equal to the size considered for the Lisbon Stock Exchange. As the value of the integration measure increases with the size of the subsets, we obtained an upper bound on the cross-market frictions per unit norm of common payoff that are necessary to prevent investors from taking advantage of the pricing inconsistencies. The average value found, when 20 different combinations were considered per pair of Stock Exchanges, were: 5.34 percentage points for the pair Lisbon-Madrid, 3.71 percentage points for the pair Frankfurt-Lisbon and 3.66 percentage points for the pair Frankfurt-Madrid. The cross-market frictions for the Iberian financial markets are 1.63 percentage points above the highest among the two other pairs considered. Thus, in this case also, the level of integration achieved by the financial markets in the Iberian Peninsula is lower than the level of integration between each Iberian market and the Frankfurt market.

[8] This is the case under the assumption that the integration measures accross pairs of markets are independent.

In order to validate the method used to assess market integration for pairs of Exchanges, the integration of each market was also studied. Table 2 shows the results of that estimation. When considered alone each market has a high degree of integration, as all statistics indicate low levels of frictions in each stock market. The Lisbon Stock Exchange is the most integrated and the Madrid Stock Exchange is the least integrated of the three stock exchanges considered.

Table 2

Summary Statistics of the Market Integration Measure for each Exchange (basis points)

Statistics	Lisbon	Madrid	Frankfurt
mean	0.13	0.74	0.37
95% confidence interval for mean	[0.06;0.20]	[0.57;0.91]	[0.28;0.46]
median	0.0033	0.033	0.019
95% confidence interval for median	[0.0026;0.0044]	[0.026;0.047]	[0.015;0.024]
Range	9.01	12.60	8.82
22nd smallest	2.2E-5	0.0002	9.8E-5
22nd largest	0.29	5.71	2.31

5. Conclusion

In this article we apply the measurement framework of Chen and Knez (1995) to study cross-market relations between the Iberian stock exchange markets. The estimation results suggest that the two exchanges are not that closely integrated. That is they violate perfect integration, i.e. there is no pricing rule that is simultaneously consistent with both markets, and either cross-market arbitrage or cross-market frictions exist. Moreover, the integration levels between the Frankfurt Stock Exchange and either the Lisbon or Madrid Stock Exchange are larger than the integration level of the Iberian Stock Exchange markets. For a portfolio that includes the 44 most traded stocks in the Lisbon Stock Exchange the estimate for the Iberian integration is 5.34 percentage points. Finally, when considered individually each of the three stock markets considered constitutes an almost perfectly integrated market.

A. Appendix

A.1. Algorithm

In each of the two steps of the algorithm the problem that must be solved is

$$\min_{d_k \geq 0} \|d_k - d_{k'}\|^2 \text{ s.t. } E(d_k\mathbf{x}) = E\boldsymbol{\pi}_k, \text{ for } k, k' = A, B \text{ and } k \neq k'. \tag{A.1}$$

According to Hansen and Jagannathan (1994) it is easier to obtain solutions for the dual problem of (**??**). The exploration of the familiar saddle point property of the Lagrangian enable us to rewrite the primal problem (**??**) as

$$\max_{\boldsymbol{\lambda} \in R^{N_k}} \min_{d_k \geq 0} \{E[(d_k - d_{k'})^2] + 2\boldsymbol{\lambda}' E(d_k\mathbf{x}) - 2\boldsymbol{\lambda}' E\boldsymbol{\pi}_k\}. \tag{A.2}$$

The portion of the objective function that contains d_k can be written as

$$\begin{aligned} E[(d_{k'} - d_k)^2] + 2\boldsymbol{\lambda}' E(d_k x) &= E[(d_{k'} - \boldsymbol{\lambda}'\mathbf{x} - d_k)^2] - \\ &\quad \boldsymbol{\lambda}' E(\mathbf{x}\mathbf{x})\boldsymbol{\lambda} + 2\boldsymbol{\lambda}' E(d_{k'}\mathbf{x}) \end{aligned} \tag{A.3}$$

Since only the first term on the right hand side of (**??**) depends on d_k, the value of d_k that solves the inner minimization problem in (**??**) is the one that minimizes the first term on the right hand side of (**??**). That value of d_k is $(d_{k'} - \boldsymbol{\lambda}'\mathbf{x})^+$, where the notation h^+ denotes $\max[h, 0]$. The dual problem to (**??**) is obtained by substituting this value of d_k on the saddle-point problem (**??**),[9]

$$\max_{\lambda \in R^{N_k}} E({d_{k'}}^2) - E[(d_{k'} - \boldsymbol{\lambda}'\mathbf{x})^+]^2 - 2\boldsymbol{\lambda}' E\boldsymbol{\pi}_k. \tag{A.4}$$

We now describe the algorithm, for which Chen and Knez (1995) proved convergence:

Step 0. Let $\mathcal{I}$ be the number of iterations. For the first iteration set $d_{At+\tau} = \mathbf{x}_{At+\tau}(\frac{1}{T}\sum_{t=1}^{T} \mathbf{x}_{At+\tau}\mathbf{x}'_{At+\tau})^{-1}\boldsymbol{\pi}_{At}$. Set $I = 1$.

Step 1. Compute $a_T(d_A^I, D_B^+) = \max_{\boldsymbol{\lambda}_B \in R^{N_B}} \frac{1}{T}\sum_{t=1}^{T}[(d_{At+\tau}^I)^2 - [(d_{At+\tau}^I - \boldsymbol{\lambda}_B\mathbf{x}_{Bt+\tau})^+]^2 - 2\boldsymbol{\lambda}_B\boldsymbol{\pi}_{Bt}]$, $d_B^I = (d_A^I - \boldsymbol{\lambda}_B\mathbf{x}_B)^+$;

Step 2. Compute $a_T(d_B^I, D_A^+) = \max_{\boldsymbol{\lambda}_A \in R^{N_A}} \frac{1}{T}\sum_{t=1}^{T}[(d_{Bt+\tau}^I)^2 - [(d_{Bt+\tau}^I - \boldsymbol{\lambda}_A\mathbf{x}_{At+\tau})^+]^2 - 2\boldsymbol{\lambda}_A\boldsymbol{\pi}_{At}]$, $d_A^I = (d_B^I - \boldsymbol{\lambda}_A\mathbf{x}_A)^+$;

Step 3. Let $I = I + 1$. Repeat steps 1 and 2 for a preset number of times and stop.

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[9] Since $(\lambda' x - d_{k'})^+ = (-\lambda' x + d_{k'})^+ - (-\lambda' x + d_{k'})$, the objective function in (**??**) after we substitute the solution for d_k is $E\{[(\lambda' x - d_{k'})^+]^2\} - \lambda' E(xx)\lambda + 2\lambda' E(d_{k'}x) - 2\lambda' E\pi_k$. Because $E\{[(\lambda' x - d_{k'})^+]^2\} = E({d_{k'}}^2) - E[(d_{k'} - \lambda' x)^+]^2 + \lambda' E(xx)\lambda - 2\lambda' E(d_{k'}x)$, the objective function in in (**??**) can be rewritten as (**??**).

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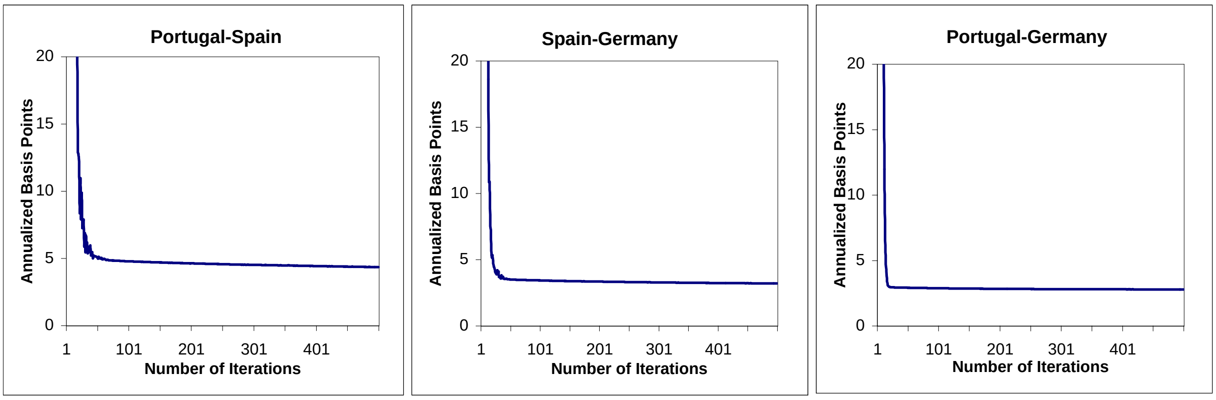

Figure 1: Convergence paths for the market integration measures

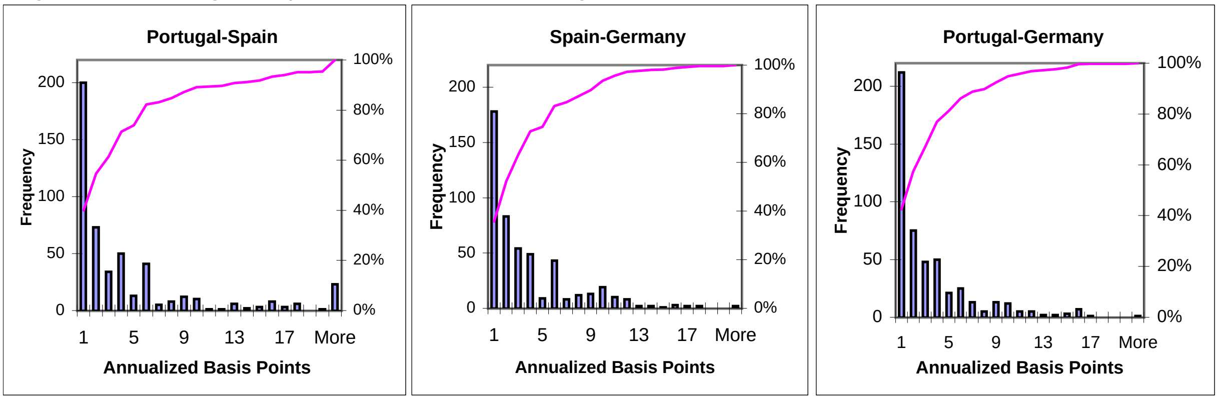

Figure 2: Histograms for the integrations measures

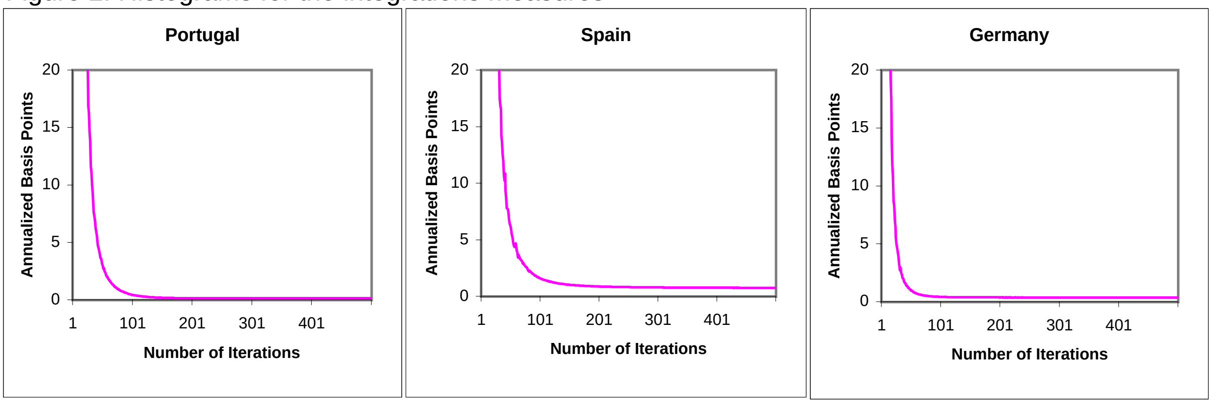

Figure 3: Convergence paths for the integration measures of each stock market

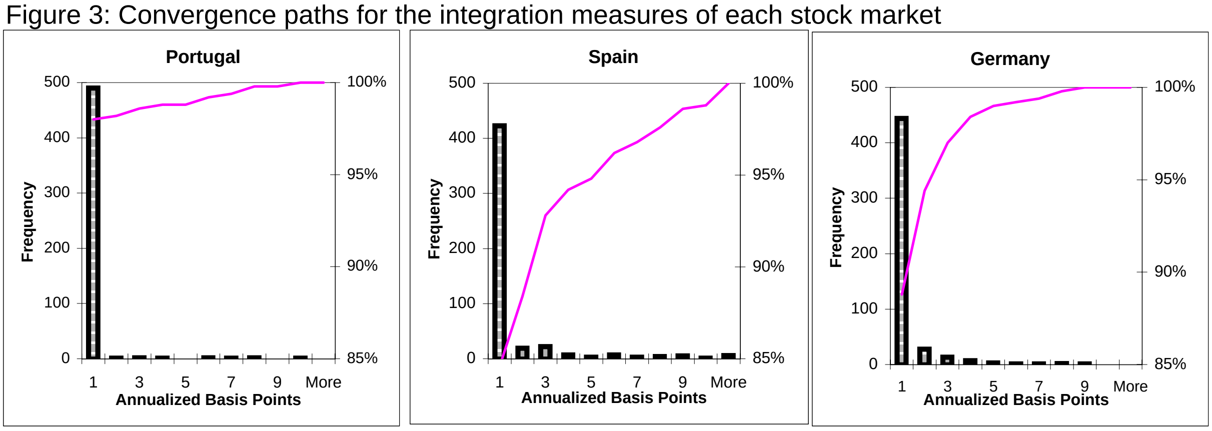

Figure 4: Histograms for the integration measures of each stock market