THE INTEGRATION OF CAPITAL MARKETS: CORRELATION ANALYSIS

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1. Introduction

A rational investor can't ignore what happens outside the capital market, when guided in future capital investments. Every investor is interested in the evolution of a particular stock market, because it is closely linked to the development of its investment, of its future profitability. This was proven particularly in the context of the actual financial crisis. But what if an investor wants to diversify its portfolio also internationally? Should he consider each market as an independent cell or treat them as parts of the same living organism? Nobody can deny that global macroeconomic trends will influence each capital market to a greater or lesser extent. So these influences merge one with another, finally forming a common trend. So the question is how an investor should diversify its portfolio and whether this diversification has the expected outcome. Why? Because the level of interaction or independence between markets has, as mentioned, important consequences in terms of predictability, portfolio diversification and asset allocation. International portfolio diversification has begun to be treated in late 1960 and early 1970, when investors started to seek ways to diversify their portfolio also internationally. At that time there were no questions about the correlation of the capital markets, about the nature of the causal relationship established between them. Capital flows between countries, which were reduced or almost didn't exist at that time, have increased; policies of deregulation in the liberalisation of capital markets, coupled with technological information technological advances suggest that markets have become more and more integrated over time. The nature of correlation between countries is a key element in Markowitz's portfolio theory, the benefits of international diversification are well known, as low correlations between capital markets allow investors to build portfolios with improved risk-return relationship.

Evidence of volatility transmission can be found in the research of Gilmore and McManus (2001), who concluded that investors can benefit from international portfolio diversification, on the long-run cointegration relationships are not evident, yet they believe that the relationships between markets are changing, and this feature of capital markets is necessary to be considered by investors.

In the study of Gilmore, McManus and Lucey (2005), they argue that the markets are cointegrated in different periods, with episodes of instability between them, but on the long-run these markets are integrated and have a long-term causal relationship.

The same conclusion was reached by Oyefeso and Fraser (2005), they explained that there is a long run relationship between the markets, a common trend. So in the long-term they are perfectly correlated, while in the short-term the linkages between them are not very perceptible.

Thomas C. Chiang, Bang Nam Jeon and Huimin Li (2007) have applied in their study a conditional correlation model across nine countries and found empirical evidence supporting the contagion effect between markets, and so they demonstrate that the benefits of portfolio diversification are lost because all investors are exposed to the same systemic risk.

Schwebach, Olienyk and Zumwalt (2001) examined the correlation and volatility characteristics of 11 countries, and their study shows that the international portfolio diversification benefits changes from one period to another, so the conclusion of their studies vindicates that there is a linkage between markets, but this relationship is characterised by instability, and is influenced by external shocks.

Kearney and Poti, (2005) found a structural break in the series of the studied indices, which explains the fact that correlation was constant before the introduction of the Euro, after which it increased substantially.

Syriopoulus (2005) also studied the relationship between the capital markets. The methodology used indicates a volatility whose magnitude varies over time, but which is persistent over time and is transmitted through integrated markets. In this case the researchers conclude that international diversification is not effective because the size of the risk can not be reduced in conditions in which markets respond immediately to international shocks.

In another study Georgoutsos and Kouretas (2001), concluded that capital markets are sharing a common trend. This relationship first manifested itself in the early 1990s, bringing as an additional argument the fact that capital markets become more and more integrated, and there are imperceptible stochastic trends that distinguish them.

Canarella, Miller, and Pollard (2008), showed that there is a perceptible correlation between the analyzed markets, also volatility is transmitted among them, but the persistence of this varies over time, being influenced by shocks and external crises.

2. Methodology

In the first step the correlation coefficients were analyzed. Accordingly, from the logarithmic rates of return the covariances were estimated:

$$Cov(Z_A, Z_B) = \frac{1}{T} * \sum_{t=1}^{T}\left(R_{A,t} - \overline{R}_A\right)\left(R_{B,t} - \overline{R}_B\right)$$

,

Where T represents the number of observations, $R_{A,t}$ and $R_{B,t}$ are the logarithmic yields of the two indices A and B, while $\overline{R}_A$ and $\overline{R}_B$ are the moving averages of A respectively B (two indices which have a positive covariance tend to fluctuate in the same direction). But to have comparability between data the correlation coefficient was calculated, which is given by the following relationship: $\rho_{AB} = \frac{Cov(Z_A, Z_B)}{\sigma_A * \sigma_B}$, where σ_A and σ_B represent the standard deviation of the index A, respectively B. The correlation coefficient can be found within the interval [-1;1], a close value to -1 symbolises a strong negative correlation while one close to 1 a strong positive one. If the correlation coefficient takes a value close to 0, then we deal with a lack of correlation, which means that the two markets tend to evolve independently; with no relationship linking them.

After the correlation coefficients have been calculated for the whole period, the next step was to calculate the mobile correlation coefficients, which were ment to capture the correlation effect on windows of 50 days. For example the first correlation coefficient is calculated on a window of 50 observations,

i=1,...,50; then the following correlation coefficient comprises the following 50 observations, i=2,...,51, after the following formula: $\rho_{ABi} = \frac{Cov(Z_{Ai}, Z_{Bi})}{\sigma_{Ai} * \sigma_{Bi}}, i = \overline{1,50}$.

The next step was the Ljung-Box test, which was ment to determine the serial correlation of the studied series, followed by stationarity tests. A series is stationary if its values oscillate around a reference level. In the terminology of time series analysis, if a time series is stationary it is said to be integrated of order zero, I(0). A pure random walk is the simplest non-stationary series, and it is given by the following equation: $y_t = \mu + y_{t-1} + \varepsilon_t$, $\varepsilon_t \approx N(0, \sigma_\varepsilon^2)$, where μ represents the constant or the drift. It is non-stationary as $VAR(y_t) = t\sigma_\varepsilon^2 \to \infty$ as $t \to \infty$. The difference of order one will be a random walk Gaussian white noise:

$$\Delta y_t = \mu + \varepsilon_t, \varepsilon_t \approx N(0, \sigma_\varepsilon^2).$$

To determine stationarity the Augmented Dickey-Fuller and the Phillips-Perron tests were employed, the null hypothesis being: H_0: $\theta = 0$, (the series contains unit root) with the alternative H_1: $\theta < 0$ (the series is stationary). In the Kwiatkowski-Phillips-Schmidt-Shin test the null hypothesis is that the series is stationary and doesn't need to be differenced, while H_1 is the alternative hypothesis, which states that the series has an unit root and needs to be differenced to make it stationary.

To test cointegration first we need to see what cointegration is. If there are two variables, x_t and y_t ,(Engle, Granger, 1987), which are both nonstationary, but stationary in the first difference, then x_t and y_t are integrated of order one, x_t ~I(1), y_t ~I(1). These series will be cointegrated if their linear combination is having the form:

$z_t = x_t - ay_t$ with an (a) such that z_t is integrated of order zero, I(0); which usually is also I(1). If the two variables are cointegrated, there is an underlying long-run relationship between them, so in the shor-term the series may drift apart, but if they are cointegrated, they will move toward the long-term equilibrium through an error-correction mechanism.

The first applied test was the Granger test, with the approach proposed by Granger (1969), and specifies that X is cause for Y, or X helps in the prediction of Y. This methodology is supposed to quantify how much of the current level of variable Y can be explained by its historical values and then examines if adding variables such X_{t-i}, the explained variation increases.

To test the cointegration on the long-term between the variables we use Johansen methodology (1988). This methodology test the restrictions imposed by cointegration on a vector autoregression -VAR- model:

$$y_t = \mu + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t,$$

where y_t is a k-dimension vector of variables which are assumed to be I(1), but also can be I(0); A_i , from i=1,…p, represents the coefficient matrix, and ε_t is a k-dimension vector of residuals. If we subtract y_{t-1} from both of the sides of the above equation we get:

$$\Delta y_t = \mu + \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} \cdots + \Gamma_{p-1} \Delta y_{t-k} + \varepsilon_t$$

where $\Pi = \sum_{i=1}^{p} A_i - I$ and $\Gamma_i = -\sum_{j=i+1}^{p} A_i$.

Π and Γ_i are two matrices of n×n, while μ represents a deterministic trend. The cointegration relation depends crucially on the property of matrix Π, this determining the number of cointegrating vectors that exist between the variables of y_t, and it is known as the long-term impact matrix. Thus it is clear that Πy_{t-1} must be I(0) or zero, except that y_t is already stationary. There are three possible situations: $\Pi = \alpha\beta'$ has a reduced rank where 0 < r < k; $\Pi = \alpha\beta'$ has a rank of zero and $\Pi = \alpha\beta'$ has a full rank. Under the first situation α and β both have a rank of k×r, where r<k. There are r cointegration vectors $\beta' y_t$ which are stationary I(0) series. It is equivalent to having r common trends among y_t. The stationarity of $\beta' y_t$ implies a long-run relationship among y_t or a subset of y_t, while the variables in the cointegration vector will not depart from each other over time. $\beta' y_t$ are also error correction terms, in that, departure of individual variables in the cointegration vectors from the equilibrium will be subsequently reversed back to the equilibrium by a dynamic adjustment process called error correction mechanism-ECM. Under the second situation, there are no cointegration relationships among y_t and the equation, while the variables are already stationary under the third situation.

The Johansen procedure calculates the eigenvalues of Π through a maximisation procedure, using the Maximum Eigenvalue statistics and the Trace statics. The Maximum Eigenvalue statistics test the hypothesis "there are r cointegration relationships" against the alternative "there are r+1 is a cointegration relationships". The Maximum Eigenvalue statistics is:

$$\lambda_{max}(r, r+1) = -T \ln\left(1-\hat{\lambda}_{r+1}\right),$$

where $\hat{\lambda}_r$ is the eigenvalue corresponding to r cointegration vectors, and T represents the number of observations. The Trace statistics is calculated as follows:

$$\lambda_{trace} = -T \sum_{i=r+1}^{k} \ln(1-\hat{\lambda}_i),$$

and it's testing the hypothesis "there are at most r cointegration relationship" against the alternative "there are i cointegration relationships". So if there are no cointegration relationships between them then rank of the matrix Π will be zero, and the whole expression is equal to 0. The critical values of λ_{max} and λ_{trace} are those calculated by MacKinnon-Haug-Michelis (1999).

To determine the long-term relationship an another panel test was applied, developed by Pedroni (1995, 1997, 2001, 2004). He considers a regression of the form:

$$y_{it} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \cdots + \beta_{Mi} x_{Mi,t} + e_{i,t}$$

where T refers to the number of observations over time, N refers to the number of individual members in the panel, and M refers to the number of regression variables, where i=1,...N and t=1,..., T. y_{it} and x_{it} are considered to be integrated of order one I(1), for all the analyzed series of the panel. The parameter α_i represents the intercept, or fixed-effects, which are allowed to vary across individual members. The parameter $\delta_i t$ captures the deterministic trend. β_i is the slope coefficient, which also is allowed to vary across individual members, and e_{it} represents the errors of the series, which under the null hypothesis are also I(1). So the properties for the above regression are studied by Pedroni under the null hypothesis " the series in the panel are not correlated ", $H_0: \quad \gamma_i = 1$ with the alternative " the series in the panel are correlated." $H_1: \quad \gamma_i < 1$.

There are seven statistics proposed as follows

Panel υ-Statistic,Panel ρ-Statistic , Panel t-Statistic (non-parametric), Panel t-Statistic (parametric), Group ρ-Statistic, Group t-Statistic (non-parametric), Group t-Statistic (parametric).

The critical values are taken from Pedroni (1999), where the variant with seven regressors was chosen. In addition to the critical values for each test, the conclusion for all the tests can be interpreted by the following method: first we check the results of Panel υ-Statistics, this distribution is compared with the normal distribution, and the right tail of the distribution is used to reject the null hypothesis, and to accept the alternative hypothesis, that is the variables are cointegrated. So if results of the Panel υ-Statistics are positive, the results tend to plus infinity, then we reject the hypothesis in which $H_0: \quad \gamma_i = 1$, there series in the panel are not correlated, and accept the alternative $H_1: \quad \gamma_i < 1$, all the series in the panel are correlated. At the other six tests the result interpretation is similar, only that they diverge in terms of cointegration to minus infinity, so the tail shouls be elongated to teh left. This means that if the results are negative, the null hypothesis is rejected, and we accept that the analyzed series are cointegrated.

3. Empirical findings

The statistical data used in this study consist of the daily stock index closing prices in 19 markets, which were extracted from http://finance.yahoo.com/. The sample period is 04 January, 1999 to 30 December 2009, totalling 2593 daily observations for each series, on 10 years. The 19 stock indices in the markets under study are: AEX; BET; BSE30; BUX; BVSP; CAC40; DAX30; DJA; FTSE100; HSI; IBEX35; KS11; MERV; N225; PX50; RTS; SP500; STI; WIG. Based on daily quotations, the data was converted to daily logarithmic returns, and from now on these series will be used, (RAEX, RBET, RBSE30, RBUX, RBVSP, RCAC40, RDAX30, RDJA, RFTSE100, RHSI, RIBEX35, RKS11, RMERV, RN225, RPX50, RRTS, RSP500, RSTI, RWIG), which represents the variation of the logarithmic daily financial series, $R_t = \ln(P_t / P_{t-1})$, where P_t and P_{t-1} stand for the daily closing prices in two consecutive days. In this way the implications due to currency risk are avoided, which could introduce some distortions in the data.[1]

In a first phase the characteristics of the data were analyzed, wich shows that in most markets the negative shocks are more frequent than the positive ones (negative skewness). We can also see that the series are autocorrelated in almost all the cases, except KS11 index.

Regarding the stationarity results from the ADF, PP and KPSS tests, we can observe that in all three tests the results regarding the stationarity of the indices is the same, namely all observed series are nonstationary, at the first

[1] Empirical evidence suggests that currency risk could have a significant impact on the correlations between markets, thereby the reduction of the currency risk has resulted in an increase of cointegration between markets. (Fratzscher,2002).

differentiation they become stationary, so they are I(1); while the logarithmic series are stationary, I (0).

These tests were necessary because they verified the existence of unit root in the series, they had to be integrated in the same order. The next step was the calculation of the correlation coefficients as the application of the Granger test, both to see the relationships that emerge between the markets in the short term. With the help of the correlation coefficients four major nodes were found, that are closely linked in short term, a first node that includes the markets of developed countries in Europe, a second one which covers the capital markets of emerging countries from Europe, a third node in America and the forth one in Asia. Once these links were established, the Granger test identified how these markets are causing one another; the volatility is transmitted through America in Europe, then in Asia.

On the long-term the Johansen and Pedroni test were applied. Initially, the Johansen test was applied to all the analyzed indices, but the results have shown that, in the long-term, are not cointegrated, no cointegration relationship could be identified. All the results indicate a lack of cointegration between all the markets, because of this the Johansen test was also applied on concentrated groups of capital markets, which have at some degree common characteristics. The selected test groups consist of the following indices:

- *Group 1*: AEX, CAC40, DAX30, FTSE100, IBEX35, SP500, N225 - to test the cointegration between the most significant markets in Europe with the representative one in America, and also in Asia.
- *Group 2:* BET, BUX, DJA, PX50, RTS, SP500, WIG - to test the cointegration between the emerging markets studied in Europe with the ones in the USA.
- *Group 3:* BET, BUX, CAC40, DAX30, FTSE100, PX50, WIG - to test the cointegration between the emerging markets and the developed ones in Europe.
- *Group 4:* BSE30, DJA, HSI, KS11, N225, SP500, STI- to test the cointegration between the Asian markets with those in the USA.
- *Group 5:* BSE30, CAC40, DAX30, FTSE100, HSI, N225, STI - to test the cointegration between the developed markets in Europe with the ones in Asia
- *Group 6:* BET, BSE30, BUX, HSI, KS11, N225, PX50 – to test the cointegration between the emerging markets in Europe with the ones in Asia.
- *Group 7:* BVSP, CAC40, DAX30, DJA, FTSE100, MERV, SP500 - to test the cointegration between the markets in North and South America as the most representative in Europe.
- *Group 8:* BSE30, BVSP, HSI, KS11, MERV, N225, STI - to test the cointegration between the markets from South America with the markets in Asia.

Both, the Johansen and Pedroni tests identified that, in the long-term, groups one and four are definitively linked in the long-run, while the markets from groups two and five do not share a common long-term trend, namely Europe's emerging markets with the markets studied from USA and the developed markets in Europe with the stock markets in Asia. At group three, which includes Europe's emerging markets with the developed markets in Europe the Johansen test couldn’t identify any cointegration relationships, while the Pedroni test definitively shows on the long-term a common trend, the same result were found in groups seven and eight, while at group six the Pedroni test indicates no relationship while the Johansen test pleads for a common pattern. How investors are particularly interested in markets that are not integrated in the long term, groups two and five are the most engaging in terms of risk-return relationship. The benefits of international diversification can be found on the emerging markets in Europe investing concomitantly in the USA, or in the developed markets in Europe with those in Asia. Regarding those groups where the results are contradictory, we consider that these discrepancies are due to the different calculation methodology. The Johansen test is based on the results of only two tests, while the Perdoni test uses seven different tests for investigating the relationships between markets, so the Pedroni test is more powerful and has greater accuracy in determining the final outcome.

A final step was the calculation of mobile correlation coefficients, according to the methodology indicated earlier, to see the short-term dynamics of cointegration relations, totally 171 being obtained between 19 capital markets. These could be categorized in terms of different behaviour before and after of a shock, three final behaviours were being outlined:

a).- In the first model the capital markets have a minimal or no connection at all, and after the shock, during the financial crisis, the correlation between them amplifies. In the end between these markets portfolio diversification is not so efficient from the point of view of the investors, because the market risk is not diminished with international diversification. The same situation can be found between the markets AEX and WIG, BET and BSE, BET and BUX, BET and BVSP, BET and CAC40, BET and DAX30, BET and DJA, BET-FTSE100, BET and HSI, BET and IBEX35, BET and KS11, BET and MERV, BET and N225, BET and PX50, BET and RTS, BET and SP500, BET and STI, BET and WIG, BSE30 and BUX, BSE30 and BVSP, BSE 30 and CAC40, BSE30 and DAX30, BSE30 and DJA, BSE30 and MERV, BSE30 and PX50, BSE30 and SP500, BSE30 and SPI, BSE30 and WIG, BUX and BVSP, BUX and MERV, BUX and WIG, BVSP and PX50, BVSP and RTS, BVSP and WIG, CAC40 and MERV, CAC40 and PX50, CAC40 and RTS, CAC and STI, CAC40 and WIG, DAX30 and MERV, DAX40 and N225, DAX40 and WIG, DJA and MERV, DJA and PX50, DJA and WIG, FTSE100 and MERV, FTSE100 and PX50, FTSE100 and WIG, HSI and MERV, HSI and PX50, HSI and WIG, IBEX35 and MERV, IBEX and PX50, IBEX35 and WIG, MERV and WIG, N225 and PX50, N225 and RTS, PX50 and RTS, PX50 and WIG, RTS and WIG, SP500 and WIG, STI and WIG.

b).- The second type of capital markets are linked to a medium level one with another over time, the mobile correlation coefficients are volatile, no external shock can change this situation. This state characterizes the whole analyzed period, which for the investors on the capital market are good news, even if it is on the short term, they can take advantage of international diversification, the market risk can be reduced to an significant extent. The same situation characterizes the indices AEX and BVSP, AEX and BSE, AEX and DJA, AEX and HSI, AEX and KS11, AEX and MERV, AEX and N225, AEX and PX50, AEX and RTS, AEX and STI, BSE30 and FTSE100, BSE30 and HSI, BSE30 and IBEX35, BSE and KS11, BSE and N225, BSE30 and RTS, BUX and CAC40, BUX and DAX30, BUX and DJA, BUX and FTSE 100, BUX and HSI, BUX and IBEX35, BUX and KS11, BUX and N225, BUX and PX50, BUX and RTS, BUX and SP500, BUX and STI, BVSP and CAC40, BVSP and DAX30, BVSP and FTSE100, BVSP and HSI, BVSP and IBEX35, BVSP and KS11, BVSP and MERV, BVSP and N225, BVSP and STI, CAC40 and DJA, CAC40 and HSI, CAC40 and KS11, CAC40 and N225, DAX and DJA, DAX30 and HSI, DAX30 and K11, DAX30 and PX50, DAX40 and RTS, DAX40 and STI, DJA and FTSE100, DJA and HSI, DJA and IBEX35, DJA and KS11, DJA and N225, DJA and RTS, DJA and STI, FTSE100 and HSI, FTSE100 and KS11, FTSE100 and N225, FTSE100 and RTS, FTSE100 and SP500, FTSE100 and STI, HIS and IBEX35, HIS and KS11, HSI and RTS, HSI and SP500, IBEX35 and KS11, IBEX35 and N225, IBEX35 and RTS, IBEX35 and STI, KS11 and MERV, KS11 and PX50, KS11 and RTS, KS11 and SP500, KS11 and STI, KS11 and WIG, MERV and N225, MERV and PX50, MERV and RTS, MERV and SP500, MERV and STI, N225 and SP500, N225 and STI, N225 and WIG, PX50 and SP500, PX50 and STI, RTS and SP500, RTS and STI, SP500 and STI.

c).- A third situation arises between the markets where both the Pedroni as the Johansen tests identify long-term relationships, markets that are strongly correlated, no external shock changing this situation. These markets behave exactly the opposite way to the previous ones, so they in the short-term record high correlation coefficients, being integrated at a high level, moving almost simultaneously, the situation remaining similar even after the occurrence of the external shock. The same situation is encountered between the indices AEX and DAX30, AEX and FTSE100, AEX and IBEX35, AEX and SP500, BVSP and DJA, BVSP and SP500, CAC40 and DAX30, CAC40 and FTSE100, CAC40 and IBEX35, CAC40 and SP500, DAX and FTSE100, DAX30 and IBEX35, DAX30 and SP500, DJA and SP500, FTSE100 and IBEX35, HSI and N225, HSI and STI, IBEX 35 and SP500, KS11 and N225.

4. Conclusion

The relationship between the world's most representative capital markets was analyzed in this study. As stated earlier through international portfolio diversification gains can be achieved, if the different markets are not correlated. So the level of interaction or independence between markets has an important impact on the investments, in means of risk and return. The first tests applied were to check the stationarity of the series, such as the ADF, PP and KPSS. These tests were necessary because they verified the existence of unit root in the series, they had to be integrated in the same order. This was confirmed, all series were indeed integrated of order one. The next step was the calculation of the correlation coefficients as the application of the Granger test, both to see the relationships that emerge between the markets in the short term. With the help of the correlation coefficients four major nodes were found, that are closely linked in the short term. The Granger test identified how these markets are causing one another.

To test the long-term cointegration the Johansen and Pedroni tests were applied. Both identified those markets which, in the long run, are definitively not linked. This test detected that the markets in Europe with Asia, or the emerging markets in Europe with those in USA, are not sharing a common path in the long term. This means that even they, in the short term, follow a similar path, in the long one an investment strategy may be based on them. In the other markets international portfolio diversification is not efficient because the size of the risk can’t be reduced under the condition in which the markets respond almost immediately to international shocks. In the short term also mobile correlation coefficients were constructed, these could be categorized in terms of different behaviour before and after a shock, three final behaviours were being outlined. In the first model the capital markets have a minimal or no connection at all, and after the shock, during the financial crisis, the correlation between them amplifies. The second type of capital market are linked to a medium level one with another over time, the mobile correlation coefficients are volatile, but never reach high levels, no external shock can change this situation. The markets in the last category behave exactly the opposite way to the previous presented, so that in the short-term these record high correlation coefficients, being integrated at a high level, moving almost simultaneously, the situation remaining similar even after the occurrence of the external shock.

As we can see, the presence of cointegrating relationships has important implications for active portfolio management, in the long-run market comovements imply that the potential for attaining superior portfolios may be limited. International portfolio diversification is less effective across the cointegrated markets because the investment risk cannot be reduced and portfolio returns can exhibit a volatile behavior to internal or external shocks. But this study has found capital markets were investors can place their funds, and with the help of international diversification, these portfolios will have higher performances.

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