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Links between the Eurozone Stock Markets: A New Perspective, Considering the Capitalization Level

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ABSTRACT

This paper examines short-term and long-term linkages among stock markets within EMU, taking into account the business capitalization. According to this objective, we have analysed four capitalization segments, corresponding to the Micro, Small, Mid and Large Caps indices, in the period between November 2007 and December 2013.

In order to identify the existence of interdependencies and short-term links between the European indices, we have used a vector autoregressive error-correction model, the concept of Granger causality and the impulse-response functions. We have concluded that the Large Cap described relatively autonomous movements and contained information that helped to explain the changes in other indices.

With regard to the existence of long-term connections, the usual cointegration tests were used, which showed that the segment index of the largest capitalizations described a different route compared to the indices of the two segments with smaller capitalizations. This proves to be particularly important for an international portfolio diversification strategy.

Keywords: European stock markets; cap segments; vector autoregressive; cointegration.
JEL classification: G11; G15.
MSC2010: 91G10; 91G50.

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Relación entre los índices bursátiles europeos: una nueva perspectiva a partir de los niveles de capitalización

RESUMEN

Este artículo analiza las relaciones y las interdependencias a corto y largo plazo entre los mercados de valores de la eurozona, teniendo en cuenta el nivel de capitalización. De acuerdo con este objetivo, se analizaron cuatro segmentos de capitalización correspondientes a los índices de micro, pequeñas, medianas y grandes capitalizaciones en el período comprendido entre noviembre de 2007 y diciembre de 2013.

Con el fin de identificar la existencia de interdependencias y relaciones a corto plazo entre los índices europeos, se ha recurrido a un vector autorregresivo con mecanismo corrector de errores, al concepto de causalidad de Granger y a funciones de impulso-respuesta. Se concluyó que el índice *Large Cap* describe movimientos relativamente autónomos y que contiene información que ayuda a explicar los cambios en otros índices.

En cuanto a la existencia de relaciones a largo plazo, se utilizó las habituales pruebas de cointegración, lo que ha permitido entender que el índice para el segmento de las grandes capitalizaciones describe un comportamiento diferente en comparación con los índices de los dos segmentos de capitalización más pequeños. Este resultado es particularmente importante para una posible estrategia de diversificación de la cartera de inversiones en una perspectiva internacional.

Palabras claves: mercados bursátiles europeos; segmentos de capitalización; vectores autorregresivos; cointegración.
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1. INTRODUCTION

The links between international stock markets have inspired a large number of studies, partly encouraged by the pioneering work of Grubel (1968). Early works on this subject did not always produce overlapping conclusions. Ripley (1973) concluded that there was a certain degree of interdependence between markets open to investments and foreign capital. On the other hand, Granger and Morgenstern (1970), Agmon (1972) and Branch (1974) found no significant evidence of lead-lag relationships between international stock markets. For his part, Bertoneche (1979), when studying the links between the stock markets of the USA, Germany, Belgium, the UK, the Netherlands, France and Italy in the period between 1969 and 1976, identified a high degree of segmentation between the seven markets studied by him, which favoured the adoption of international diversification strategies. In the same vein, Roll (1988) concludes that the links between international stock markets were weak.

Bibliography on the theme of stock market links highlights the stock market crash of October 1987 as a key element in bringing markets together. In this context, we highlight the works of Eun and Shim (1989), Lau and McInish (1993) and Arshanapalli *et al.* (1995), among others.

Eun and Shim (1989) identified significant interdependencies between nine large international stock caps. Jeon and Von-Furstenberg (1990) found a significant increase in international stock market co-movements, as a consequence of the 1987 crash. Similarly, Lau and McInish (1993), using daily information on the period between 1986 and 1989, identified changes in the structure of the lead-lag co-movements in international stock markets, after the occurrence of the crash. Furthermore, Arshanapalli *et al.* (1995) concluded that the crash helped to create more similar and nearby responses among global stock markets. The statistical confirmation of lead-lag type effects, such as those seen in the above-mentioned studies, can be understood as a violation of the efficient market hypothesis since, according to Fama (1970), price behaviour is equivalent to a random walk process, implying the non-predictability of asset prices, which is partly counteracted with confirmation of such effects.

Later studies have emphasized a gradual strengthening of the links between international stock markets and highlighted the role of the main market capitalization of the US market, by demonstrating the ability to help explaining movements in other markets.

Hassan and Atsuyuki (1996) resorted to daily information on the period from 1984 to 1991, in order to study the dynamic linkages between the US, Japan, the UK and Germany, and they concluded that there are significant relationships between these markets. In the short term, the US market proved the most exogenous before and after the 1987 crash. In the long run, it is identified a cointegration relationship between the four markets, with implications in terms of international diversification opportunities. Peiro *et al.* (1998) studied the links between the stock markets of New York, Tokyo and

Frankfurt in the time-lapse from 1990 to 1993 and concluded that the former is the most influential stock market and the Japanese market may prove more sensitive to international shocks. Similarly, Ozdemir and Cakan (2007) studied the US, Japan, France and the UK markets between 1990 and 2006, using the concept of Granger causality, and concluded that the US market leads the remaining markets.

Goetzmann *et al.* (2005) showed that the correlation structure of the world stock markets has varied considerably over the past 150 years, and was particularly strong in periods of financial and economic integration. Similarly, Bekaert *et al.* (2007) emphasized the importance of market integration in the global context due to the processes of liberalization of capital markets, stock markets and the respective banking systems, facilitating the further development of international linkages between markets.

In Europe, the introduction of the single currency produced empirical evidence that the correlations between stock market indexes, representative for the Eurozone, have increased considerably. They were, however, unstable in time and higher in "bear market" periods, with implications in terms of diversification reduction within the investment portfolio - see Cappielo *et al.* (2006), for example.

More recently, other scientific studies highlighted the role of the recent global financial crisis (GC) as a determining element in bringing the stock markets together. Using Granger causality tests and impulse-response functions, Tudor (2011) concluded that the links between stock markets of Central and Eastern Europe and the US market have increased with the emergence of this crisis. Similarly, Mandigma (2014) concluded that there was a strengthening of dynamic links between Southeast Asian countries and the US market.

In order to study the possible existence of interdependencies between markets and to seek diversification benefits, the previously mentioned studies considered some of the most representative international indexes. But in either case, these indexes basically represent the largest companies in their respective markets, ignoring companies with lower capitalization levels.

With regard to investment diversification, individual and institutional investors search for expanding investment alternatives at international level but also those arising from a possible advantage provided by companies of different capitalization levels. According to portfolio theory, based on binomial risk-return, if Small Caps yields do not correlate perfectly with those of Large Caps, investors can obtain benefits if they always adopt a diversification strategy based on company size. The benefits are a better relationship between risk and profitability; i.e., reducing the risk associated with the investment portfolio, without penalizing its profitability.

According to Petrella (2005) and Eun *et al.* (2006), company size is an important factor in the behaviour of market yields. If Large Cap yields are fundamentally explained by factors of global nature, Small Cap yields are mainly explained by idiosyncratic factors. According to these authors, this difference in the generating mechanism of yields can be explained by the fact that large companies (multinationals in some cases) develop activity in several countries and have an international shareholder base. On the other hand, small businesses, with a more locally focused activity, have a more limited international exposure. Consequently, it must be assumed that the yields of the smallest and the largest capitalizations are not perfectly correlated, which brings advantages to investors who adopt a strategy based on "size diversification". However, this line of argument is only valid if the time structure of market links, reflected in the correlation between Small and Large Cap yields, is stable and does not show asymmetrical behaviour; i.e., in periods of bear market the correlation between yields is not higher than the one in bull market periods.

The main purpose of this study involves the analysis of short-term and long-term links between daily yields of different size company stock indexes in the space defined by the Eurozone. The overwhelming majority of the studies has tended to focus successively on the use of indexes dominated by large companies, so our job is to fill a lack in terms of empirical research and study the degree of connection between the yields of companies with different levels of market capitalization, using representative indexes from four cap segments: micro, small, mid, and large caps.

In terms of structure, this research continues in Section 2 with a description of the data and methodology. The third sections deals with the presentation of empirical results and 4 with the presentation of the summary and key findings.

2. DATA AND METHODOLOGY

2.1 Data

Our analysis is based on daily data, for a period of time of about six years, and uses four European stock indexes corresponding to four cap segments: *Micro Cap, Small Cap, Mid Cap* and *Large Cap*. The data used in this study were provided by Morgan Stanley Capital International and encompass the sample period of 30/11/2007 to 05/12/2013, translated in 1543 everyday observations.

The series of index closing values were transformed into yield logarithmic series, instant or continuously compounded, through the following expression:

$$r_t = \ln P_t - \ln P_{t-1} \quad (1)$$

in which r_t is the return rate in day t, and P_t and P_{t-1} are the series closing values in the moments t and $t-1$, respectively.

2.2 Methodology

In order to study the short-term connections between the selected stock exchange indexes and the direction of influence between these, we resorted to the concept of Granger causality, introduced by Granger (1969) and later made popular by Sims (1980), specifically to the *VAR Granger Causality/Block Exogenety Wald Tests*, developed from a vector autoregression, whose theoretical basis is presented below.

In order to further study the short-term connections between the stock markets, we have also considered generalized impulse-response functions, introduced by Koop *et al.* (1996) and Pesaran and Shin (1998), to improve the understanding of the results of the chain reactions that occurred in the indexes. This approach has advantages over the traditional orthogonalized impulse-response analysis since the results do not depend on the ordering of variables in the VAR model.

The study of long-term connections between the indexes involves consideration of the concept of cointegration, introduced by Granger (1981). According to this author, if two or more sets are not stationary individually, but a linear combination of these is stationary, the series is said to be cointegrated. A cointegration relationship between series may happen in the long run, even if in the short run these series do not have a convergent behaviour, but they recover the same trend in the long run.

In general, two alternatives are considered for testing cointegration: One encompasses the Engle-Granger test, which is used to study simple series; the other uses the Johansen approach, which is especially useful in the multivariate case.

After testing series integration, using, for example, unit root tests, you can apply the Johansen approach.

Considering Y_t as the index vector, and assuming that it has the following VAR representation:

$$Y_t = z + \sum_{i=1}^{p} \Pi_i Y_{t-1} + u_t \tag{2}$$

where:

z is a vector of endogenous variables $(n \times 1)$;

u is a white noise error vector $(n \times 1)$;

and Π_i is a coefficient matrix $(n \times n)$.

The VAR model for the error correction mechanism is given by:

$$\Delta Y_t = z + \sum_{i=1}^{p-1} B_i \Delta Y_{t-i} + \Pi Y_{t-1} + u_t \tag{3}$$

in which Y_t is a column vector, of parameters $N \times 1$, of dependent variables, integrated of order one; μ is a deterministic parameter vector; and u_t is an innovation column vector, of $N \times 1$ size.

Before applying the Johansen test, the VAR models should be transformed in a vector error correction (VEC) in the form:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{n-1} \Gamma_i \Delta Y_{t-i} + \mu + u_t \tag{4}$$

where Y_t is an integrated variables vector, I(1), ΔY_t are variables I(0), Δ is the first difference operator, B is a matrix of coefficients $(n \times n)$ and Π is a matrix $(n \times n)$, in which r determines the number of cointegrating vectors between variables.

The Johansen cointegration test is based on Π matrix analysis. If Π is defined by $r = n$, the variables are stationary in levels; if $r = 0$, there is no cointegration between variables.

The Johansen cointegration approach uses the trace (λ_{trace}) and maximum eigenvalue $(\lambda_{\max})$ tests, based on the likelihood ratio. The statistics are expressed as follows:

$$\lambda_{trace} = -T \sum_{i=r+1}^{k} \log(1 - \lambda_i) \tag{5}$$

The trace test tests the null hypothesis that the number of cointegrating vectors is r against the alternative hypothesis of being $r+1$.

The maximum eigenvalue test is given by:

$$\lambda_{\max} = -T \log(1 - \lambda_{r+1}) \tag{6}$$

The maximum eigenvalue tests the hypothesis that the number of cointegrating vectors is larger than r, against the alternative hypothesis of being $r+1$.

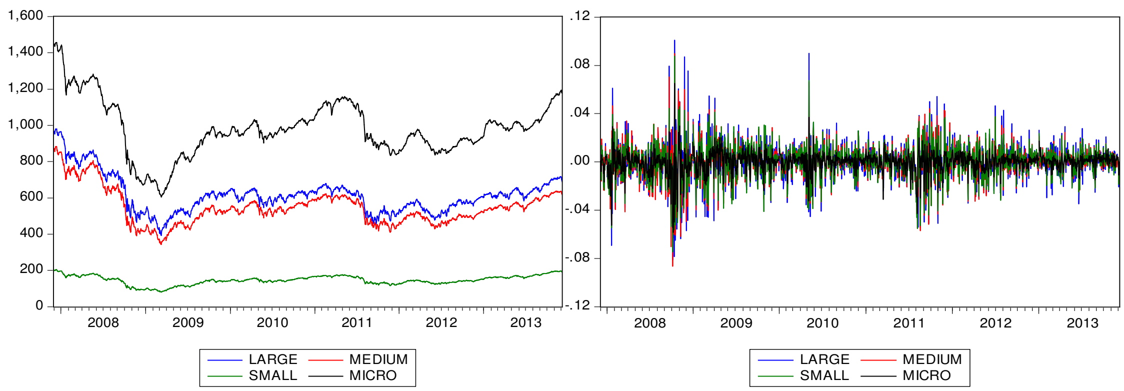
In both tests, T sets the number of observations and λ_i the eigenvalues, estimated and ordered in decreasing order.

When there is a discrepancy in the results produced by the two statistics, we follow the recommendations of Johansen (1991), Kasa (1992), Serletis and King (1997) and Hubrich *et al.* (2001), which promotes the importance of trace statistics, given the maximum eigenvalue, as it is more reliable.

3. EMPIRICAL RESULTS

Let us appreciate the index series evolution in levels and respective yields. Figure 1 shows the evolution of the four stock market indexes in levels (left) and of the return rate (right), in the sample period between November 30, 2007 and December 5, 2013.

Figure 1: Index evolution.



The graphical analysis of the indexes shows that they have very similar behaviour patterns over the sample period, especially the Large and Mid Caps indexes. The behaviour patterns were strongly marked by the emergence of the global financial crisis, in particular after the fourth quarter of 2008, which started a bear market phase, coupled with a sharp increase in the volatility of European markets. The values of the indexes suffered significant variations over the studied period. However, despite variations, yields have average stationary features, giving a first indication that these may be stationary.

The main yield descriptive statistics of the four indexes are shown in Table 1. The analysis of descriptive statistics supports the conclusion that all indexes showed a negative daily average profitability.

Table 1: Yield descriptive statistics

	Large	*Mid*	*Small*	*Micro*
Average	-0.00022	-0.00022	-0.00004	-0.00013
Median	-0.00011	0.00028	0.00079	0.00094
Maximum	0.10083	0.08973	0.08757	0.06501
Minimum	-0.08113	-0.08621	-0.07424	-0.05817
Standard Deviation	0.01617	0.01471	0.01371	0.00818
Asymmetry	0.04194	-0.23670	-0.30629	-1.07280
Kurtosis	7.71691	6.85468	6.31291	12.54646
Jarque-Bera	1430.89400	969.69150	729.75260	6155.19200
Probability	(0.00000)	(0.00000)	(0.00000)	(0.00000)
ADF (levels)	(0.14511)	(0.20771)	(0.33961)	(0.32594)
ADF (returns)	(0.00000)	(0.00000)	(0.00000)	(0.00000)

All yield series showed signs of deviation due to the normality hypothesis, given the skewness and kurtosis coefficients, different from zero and three, respectively. The analysed series are leptokurtic and feature asymmetric tails.

In order to know the adjustment of the normal distribution to the empirical distributions of the four series, the Jarque-Bera test was also applied, and its statistical values can be seen in Table 1. Taking into account the test values and their respective probabilities (equal to zero), we concluded that all series are statistically significant at 1%, so the hypothesis of their normality is clearly rejected.

In order to determine the series stationarity (levels and yields), the traditional Augmented Dickey-Fuller tests (ADF; see Dickey and Fuller, 1979) were applied. The null hypothesis (H_0) of this test stipulates that the series has a unit root, that is, that the series is integrated of order 1, I (1), given the alternative hypothesis (H_a) that the series does not have a unit root or is I (0). The results of the series stationary tests are shown in Table 1. The yield series evidenced immobility, I (0), at the significance level of 1%, whereas the series in levels were shown to be non-stationary, or R (1), for the same level of significance.

In order to further study stock market behaviour, one starts by calculating the coefficients of Contemporary Correlations between European index yields (see Table 2).

Table 2: Contemporary Correlations between yields

	Large	***Mid***	***Small***	***Micro***
Large	1.000			
Mid	0.946	1.000		
	(0.000)			
Small	0.910	0.967	1.000	
	(0.000)	(0.000)		
Micro	0.782	0.842	0.890	1.000
	(0.000)	(0.000)	(0.000)	

All the correlation coefficients recorded positive values and were statistically significant at a significance level of 1%, according to the values of the respective p-values. The values of correlation coefficients were quite high. The coefficients for the smaller caps produced, in either case, strong correlations. The remaining pairs have resulted in very strong correlations exceeding 90%, which possibly means the European stock markets described, in the short term, very similar movements.

In order to analyze the existence of a causal relationship between the four indexes, we applied the VAR Granger Causality/Block Exogeneity Wald Tests procedure, whose null hypothesis states that there is no causal relationship between the indexes. This procedure assesses the significance of each joint lagged endogenous variable in each equation of the VAR, through the statistic χ^2, and simultaneously the significance of the joint contribution of all offset endogenous variables, present in the equation using F-statistic. For each of the equations of the estimated VAR models, we present the Wald test statistics, about the joint significance of each of the other endogenous variables, based on the selected offsets, defined by the Akaike-Schwarz information criteria.

Table 3 is a summary of the results for Granger causality tests. These results revealed some statistically significant unidirectional relations. However, we did not identify any two-way relationships, with statistical significance, and this differentiates these results from other recent research, including Tudor (2011) and Mandigma (2014), favoring the idea that yield generating mechanism in the segment indexes can differentiate the mechanism of conventional indexes that take into consideration the largest market capitalizations.

The Small Cap and Micro Cap indexes proved to be the most endogenous, as they were caused, in the Granger sense, by the Mid Cap and Large Cap indexes, also being caused by the combined effect of the remaining offset indexes at the significance level of 1%. The Large Cap index was the less endogenous, which, in the Granger sense, was not caused individually by any other indexes, or by the combined effect of the other indexes. In terms of exogeneity, this index clearly stood out from its peers, as it contained information on the movements of other indexes. These results led us to conclude that the Large Cap describes an autonomous behavior, but also that this index plays the role of the driver of the other stock indexes, as it helps to explain their movements.

Table 3: Granger Causality/Block Exogeneity Wald Tests

		Dependent Variable			
		Large	***Mid***	***Small***	***Micro***
Excluded variables	***Large***		6.1652	9.5698	10.7161
			(0.0458)	(0.0084)	(0.0047)
	Mid	1.0862		9.2792	8.6212
		(0.5809)		(0.0097)	(0.0134)
	Small	0.0377	0.5156		0.3774
		(0.9813)	(0.7727)		(0.8280)
	Micro	1.0518	2.7613	4.1728	
		(0.5910)	(0.2514)	(0.1241)	
	All	4.7200	9.9412	17.3152	26.5036
		(0.5802)	(0.1272)	(0.0082)	(0.0002)

The statistical significance of various causal relationships allows us to question the assumptions of the efficient market hypothesis, since the movements in a particular index are partly preceded by past movements in other indexes, which shows certain predictability in these movements and enables the development of arbitration operations.

Granger causality test helps to understand the links between markets, but does not show if the indexes have a negative or a positive effect on their peers, or lets you know if some links are stronger than others. To get these answers, we use generalized impulse response functions, amplitude corresponding to a standard deviation, in order to obtain further evidence about the short-term movements of the transmission mechanisms. The results of the impulse response functions are summarized in Table 4.

Response functions to impulses, calculated from the autoregression vector model, lets us to realize that the four European indexes showed statistically significant reactions as a result of shocks from abroad (see Table 4). A significant part of these shocks statistically significant effects for only a period, fading afterwards. All reactions displayed the expected signal; i.e., they accompanied the direction of index variation originated where the shock occurred and there were no correction reactions to the initial shock.

Table 4: Summary of the results of the impulse-response functions

	Large	***Mid***	***Small***	***Micro***
Large		1 1 +	1 1 +	1 1 +
Mid	1 1 +		2 1,2 +,+	1 1 +
Small	2 1,2 +,+	2 1,2 +,+		2 1,2 +,+
Micro	6 1,2,3,4,5,6 +,+,+,+,+,+	6 1,2,3,4,5,6 +,+,+,+,+,+	6 1,2,3,4,5,6 +,+,+,+,+,+	

Notes: Online market responses to impulses from the column in markets; each cell has three rows: the first row indicates the number of periods during which the online market response was statistically significant, according to the criterion of one standard deviation; the second row indicates the order number of these periods; while the third row indicates the signal of the impulse response.

With regard to the persistence of the reactions, we concluded that, in general, the indexes for the larger cap segments (Mid and Large) were the ones which triggered the less persistent responses, in most cases for a period only. Conversely, the Micro Cap index recorded the most persistent reactions to impulses by its peers (six days). This high persistence may be interpreted as evidence that information on this index has not been incorporated instantly, contradicting the efficient market hypothesis.

In order to study the possibility of long-term relationships between European indexes, bivariate Johansen cointegration tests were applied.

A necessary condition for the application of the cointegration test is that the variables have the same integration order. Taking the results shown in Table 1 into account, it is concluded that, in any case, the ADF unit root tests showed that the indexes are at levels I (1), satisfying the prerequisite for the application of cointegration tests. If the series are cointegrated, there is statistical evidence of long-term relationship between the indexes.

Notably, the Johansen method presupposes prior estimation of a vector model. A key element in the specification of the Vector models is the lag size. In each of the bivariate analyses, the choice of the optimum number of VAR lags took into account the usual Akaike-Schwarz information criteria.

After estimating the VAR model, the Johansen cointegration test was applied, whose statistics are summarized in Table 5, namely in the two columns on the right side. The first column presents results for the trace test, while the second column shows the test results for the maximum eigenvalue. In both cases, in the above-mentioned columns, there are values for test statistics and for the probability of rejecting the null hypothesis (p-value); e.g., that there is no cointegrating vector. Taking into account that, in some cases, there was some discrepancy in the results produced by the two statistics, the trace test was preferred, in accordance with the recommendation of Johansen (1991), Kasa (1992), Serletis and King (1997) and Hubrich *et al.* (2001).

Table 5: Johansen cointegration tests

		Trace test (λ_{trace})	**Maximum Eigenvalue Test** $(\lambda_{\max})$
Large	***Mid***	24.3267 (0.013)	15.7673 (0.0523)
	Small	16.2118 (0.1647)	13.9076 (0.0999)
	Micro	17.1430 (0.1273)	13.9371 (0.0989)
Mid	***Small***	14.8163 (0.0631)	14.4033 (0.0475)
	Micro	15.1520 (0.0563)	11.4471 (0.1319)
Small	***Micro***	39.7495 (0.0005)	31.7660 (0.0005)

The null hypothesis of non-cointegration between the Large Cap and the Mid Cap, but also between the Small Cap and the Micro Cap, was rejected by the trace test, a cointegrating vector being identified for the significance levels of 5% and 1%, respectively. In any case, the results revealed the existence of a balance between long-term pairs formed by these indexes.

In summary, the Johansen bivariate cointegration analysis identified some balanced relationships in the long run between pairs of European indexes. The occurrence of common movements suggests the existence of common factors that limit the independent variation between the indexes and allow a certain degree of market behaviour predictability. Verifying balanced relationships conditions investment alternatives, in the light of a possible international diversification strategy. However, the results also show that it is possible for investors, in a long-term perspective, to adopt an investment strategy which combines assets from large/ small businesses or large /micro, because these pairs do not reveal balanced relationships in the long run and can, therefore, be viewed as alternatives for investment diversification.

According to Granger (1986) and Baillie and Bollerslev (1989), and similarly to the conclusion drawn as to the short-term connections between the indexes, the long-term connections, measured from the Johansen methodology, also contradict the assumptions of the efficiency hypothesis of the markets, as it contributes to a predictability degree in market behaviour.

4. SUMMARY, CONCLUSIONS AND LIMITATIONS

The study of links and interdependencies between stock markets has been a very popular study topic in finance. The absence of links between markets translates into an advantage in terms of diversification of investment portfolios in the global context. Several studies have reported a reduction in benefits associated with diversification, especially after the occurrence of extreme events, as are the stock market crashes.

In the present study, we considered a number of Eurozone stock market indexes, representing different cap segments, namely Micro Cap, Small Cap, Mid Cap and Large Cap. In order to ascertain the existence of short-term co-movements, coefficients of contemporary correlation were calculated, an autoregression vector was estimated, from which causality tests were applied and impulse-response functions estimated. The study of possible long-run balanced relationships between the indexes involved the application of bivariate cointegration tests.

The coefficients of contemporary correlation recorded very high values, particularly among indexes for the three largest capitalizations. The results of Granger causality tests revealed several statistically significant unidirectional links. The Large Cap index stood out, emerging as the least endogenous, but also as the most exogenous. This reflects, on the one hand, an autonomous behaviour of this index compared to others and, on the other hand, the high capacity of this index to help explain peer movements. In turn, the impulse response functions show that, in general, index reactions are not persistent, fading fast some days after the stimulus. The only exception was the Micro Cap Index, which reported statistically significant answers six days after the impulse originated in their peers.

The analysis of Johansen bivariate cointegration identified a number of balanced relationships in the long run between European index pairs. The occurrence of common movement may be the result of the existence of common factors, which limits the independent variation between the indexes and enables a certain degree of predictability. The verification of these relationships ultimately conditions the investment alternatives in an international diversification perspective. The results suggest that it is possible for investors, in a long-term perspective, to adopt an investment strategy which combines assets from large/ small businesses or large /micro, because these pairs do not reveal balanced relationships in the long run and can, therefore, be viewed as alternatives for investment diversification. The short-term and long-term results obtained question the validity of the market efficiency hypothesis assumptions, since the prediction of the movement of some indexes can be improved if we consider the offset of the remaining movements, giving rise to arbitrage transactions, which contradicts the genesis of this theory.

In future research, we plan to further study the links between European stock markets, giving again emphasis to the use of cap segments, so that we follow two research lines. In the first, we will analyse the transmission of information between the indexes, using multivariate models of conditional heteroskedasticity, in order to accommodate the volatility clusters and the asymmetric effect. In the second, we will study alternative allocation of international investment, based on size diversification and optimization models.

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