The Contagion Effect of the Terrorist Attacks of the 11th of September

João Leitão[1]

Cristóvão Oliveira[2]

Abstract: In the context of interdependence of the financial markets, it becomes interesting to analyze the implications associated with the Terrorist Attacks of the 11th of September of 2001, in the USA, in terms of the development of contagion mechanisms between the main international stock exchanges. The sample is subdivided in two periods, in order to capture two different conjectures, that is, the pre-attack period, and the one that is concerned with the post-attack period.

The results obtained through the estimation of a vector autoregressive model, incorporating an error correction mechanism, are presented. These results provide the detection of cointegrating relations among the economic variables, in study. A dynamic analysis is done, using exogeneity block tests, in order to check the existence of causality relations, which are defined in a Grangerian sense. For a forecasting purpose, the techniques of the variance decomposition of Cholesky, and of the impulse response functions are used. The occurrence of contagion is ratified by the results, starting from the terrorist attacks in the USA, which yielded a bigger volatility, with positive sign, in the Portuguese, and in the English Stock Exchanges.

Key Words: Contagion, Stock Exchange, Vector Autoregressive Model.

JEL: C30, C32, G10, G15.

[1] Assistant Professor at Universidade da Beira Interior (UBI), Ph.D. in Economics.
Postal address: Universidade da Beira Interior, Departamento de Gestão e Economia, Estrada do Sineiro, 6200 209 Covilhã, Portugal. Phone: + 351 275 319 653; Fax: + 351 275 319 601; E-mail: jleitao@ubi.pt
[2] Graduated in Economics at Universidade da Beira Interior (UBI).

The Contagion Effect of the Terrorist Attacks of the 11th of September

1. Introduction

The process of globalization of the financial markets has implicated deep transformations in the international stock exchanges. The transformations of the relationships among the different stock exchanges have been analyzed, making use of the analysis of the correlation coefficients, of simultaneous equations models, and more recently, using vector autoregressive models (VAR).

The article aims to analyse the interrelations or the contagion relationships among the main stock exchanges, taking as reference point the terrorist attacks of the 11th of September of 2001, in the USA. For this purpose, a previously selected specification of a vectorial autoregressive model is used, in order to evaluate the relationships among the main stock exchanges, firstly, in a period pre-attack and, later, in a period post-attack.

The present work is structured in two parts. In the first part, a revision of the relevant economic theory is made, in order to develop, subsequently, the econometric approach, which is related with the analysis of contagion. In the second part, an econometric approach is developed, by making a brief review about some empirical studies that use the VAR models, in the contagion analysis.

Afterwards, an evaluation of the contagion relationships among the stock exchanges indexes is made, by considering two different reference periods, that is, the pre-attack period, and the post-attack period. For this purpose, the existence of causality relationships between the variables included in the study, is tested, in a Grangerian sense. Besides, a forecasting analysis is presented, using two different techniques, that is, the variance decomposition of the forecasting error of Cholesky, and the impulse response functions, in order to evaluate the contagion propagation mechanism among the international stock exchanges located in the USA, in Japan, in England, in Germany, in Spain, and in Portugal.

2. Literature Review

2.1 Interdependence of the Stock Exchanges

According to Pretorius (2002) three are two main categories concerning to the existence of co-movements among the international stock exchanges. The first category corresponds to the contagion effect, which is intended to be the part of the stock exchanges co-movement that is not possible to explain, by applying the economic theory. The second category concerns to the characteristics of the stock exchange, which influence the extension of the interdependence that is revealed by the stock exchange, that is, the degree of industrial substitution, the volatility, and the dimension.

2.1.1. Contagion

According to Dornbusch et al. (2000), we can consider three different contagion definitions. First, in a generic sense, the contagion corresponds to a process of transmission of shocks, from a country to other country, or several countries. This phenomenon is related with negative schocks, and also with expansion effects.

Second, in a restrictive sense, the contagion is expressed by the propagation of shocks between countries (or several countries), considering the co-movements that are activated through the common shocks, and that result in unexpected values for the main economic indicators. In case of adoption of this definition, the process of construction of the referred indicators should be taken in consideration. Otherwise, the occurrence of excessive co-movements could not be correctly evaluated, and for this reason, the existence of contagion cannot be tested, in an accurate way.

Third, in a very restrictive sense, this definition corresponds to the view advocated by Forbes and Rigobon (2001)[3], which state that the contagion should be interpreted as being the change in the transmission mechanisms that are observed during the crisis.

According to Wolf (1998), the contagion is not measurable by itself, although it can be estimated trough the residuals of the co-movement, which is not explained by the main economic indicators. Two perspectives exist in this research field, the first is based on the informational determinants, and the second is supported by the analysis of the institutional determinants.

[3] The authors used this definition in several studies related with the mechanism of transmission of shocks, or the contagion effect between the stock exchanges.

In relation to the first perspective, when we consider a scenario of perfect information, each investor acts in the way that he thinks the others act. This way, the investors sell their investments in a certain period if they believe that the other investors will also sell the investments, which were made in the same period. This just explains a part of the investors' behaviour in the stock exchange. This fact drives to a situation of excessive put options, in case that the high number of investors believes that other investors are disappointed with the performance. The investors' behaviour will lead to a movement in the market, which will be characterized by a decline, or by an ascension, depending of the shock effect. If that movement is not originated through the action of the economic indicators, then it can be considered, as a contagion effect.

Bourguinat (1992) distinguishes two types of contagion: the horizontal one, and the vertical one. The first is related with the interconnection of the financial markets. The linkage between the prices that is insured through the application of the procedures of automatic rating of the NASDAQ type, allows the automatic quotation of thousands of shares in London, and in New York. In addition to this, there are multiple forms of electronic transmission, in the world scale. During the crash of October of 1987, the measuring of the contagion coefficients between the stock exchanges has showed that in the stocks exchanges of Tokyo, of London, and of New York, the value of the cited coefficients increased, as the titles volatility grows up. This means that, if in an important financial market, an abrupt movement takes place, then the shock wave will be propagated more quickly. The vertical contagion is explained through the interrelation between the markets.

In fact, the vertical integration of this kind of markets has moved forward, more and more. Beyond of those classic channels of transmission, we have also to consider the linkages between the stock markets and the currency market, and between the stock markets, and the options markets, etc. This vertical integration of the markets also favours the propagation mechanism in the global market.

2.1.2. The Stock Exchanges: Basic Characteristics

In terms of the basic characteristics that can influence the functioning and the trajectory of the stock exchanges, we are going to describe, in a brief way, the main effects associated with the dimension, the volatility, and the degree of industrial substitution.

2.1.2.1. The Dimension

The effect originated through the presence of a small company, in terms of the evolution of the stock exchange is a well documented phenomenon[4]. The small companies have, usually, higher profits, due to smallest liquidity of their titles quoted in the stock exchange, and also due to the associated high transaction cost. The dimension of the market can determine the degree of development, the grade of liquidity, and the transaction costs that are associated with the exchange of financial instruments. In this perspective, a great disparity in the dimension of the market can indicate great differences, in terms of liquidity, of transaction costs associated with two stock exchanges, which for its turn can result in a co-movement of smaller extent. In simple terms, if an increase in the differential between two markets occurs, then an increase, or a decrease, in terms of the extension of the co-movements, will take place, in both.

2.1.2.2. The Volatility

In the vision of Pretorius (2002), the underlying presupposition to the great part of the models of investment is that the investors should be compensated by the risk they assume. In this sense, how bigger is the risk associated to a certain financial instrument, the greater will be the financial return. This means that the financial return should be a positive function of the associated risk, which is measured through the volatility. Considering the rate of return of the stock exchanges as a function of the volatility, two markets that present a similar volatility, should yield the same profits. So, if the volatility of a market increases, relative to the other market, then the profits of the first market should increase in relation to the profits obtained in the second market. Therefore, if there is a convergence, or a divergence, in terms of the volatility of the two markets, then their indexes will also converge, or diverge.

[4] For detailed information, please see Asness et al. (1996), and Berk (1996).

2.1.2.3. The Degree of Industrial Substitution

The correlation between the two stock exchanges is also affected by the effect associated with the degree of industrial substitution, which is observable in several industries. This way, the performance of an index is, partially, determined by the industries (Wolf, 1998; Serra, 2000).

Considering two indexes of markets dominated by ordinary shares in a single industry, for example, the oil industry, if there is a decrease, in terms of the world demand, then this can contribute for a substantial decrease, in terms of the price of the shares of the oil companies, in both markets. In this sense, when two markets are dominated by the same kind of industry, then we expect that the correspondent stock indexes come to reveal a co-movement, to the extent that the general performance of the stock exchange is based on that kind of industry.

2.2. The Contagion Analysis

In the analysis of the propagation mechanism of crisis, and of the associated volatility, two different types of tests are usually used. The first kind of tests is related with the evaluation of the coefficients of the correlation between the stock indexes. In this specific field, the test proposed by Forbes and Rigobon (2002), which takes in consideration the volatility (that is, the heterocedasticity); and also the test proposed by Corsetti et al. (2002), are instruments, commonly, used to test the volatility, previously referred, although the endogeneity problem of the variables.

Rigobon (2002) introduced a second kind of tests, by considering the matrix of variance and of covariance of the stock exchange indexes, as well as allowing the presence of heterocedasticity, and including omitted values in a simultaneous equation model.

2.2.1. The Test of Forbes and Rigobon

Considering r_i, and r_j, as stochastic variables, and that they identify the returns of the stock exchanges that are generated in two different markets *i*, and *j*, the following equation is derived:

$$r_{it} = \alpha + \beta r_{jt} + \varepsilon_{it}, \qquad E(\varepsilon_{it}) = 0, \qquad E(\varepsilon_{it}^2) < \infty, \qquad E\left(r_{jt}\varepsilon_{it}\right) = 0. \tag{1}$$

The authors demonstrate that when two stochastic variables: r_i, and r_j; are considered, and if the variance of one of the variables increase, then the correlation among them, will also increase. Besides, in order to find out if the correlation coefficient observed in the previous period to the crisis, and the one that is observed during the crisis, are the same, starting from the coefficient obtained in a regular period (p_t), we calculate the correlation coefficient, taking into consideration the increase in the variance (p_t^{tc}). This coefficient of correlation corresponds to the one which is observed during the period of crisis. This way, the test allows to verify if the theoretical coefficient introduced by the authors (p_t^{tc}), and the one which is observed during the crisis (p_t^{c}), are the same.

Taking δ_t, as the relative increase in the variance of *j*, we can evaluate if the market is facing a crisis. The relationship which provides the calculus of the coefficient of the correlation for the crisis period, given the correlation coefficient (p_t) observed during the regular periods is expressed by the following:

$$p_t^{tc} = p_t \sqrt{\frac{1+\delta_t}{1+\delta_t p_t^2}} \qquad (2)$$

Considering the correlation coefficient during the periods of crisis (p_t^{c}), and the theoretical correlation coefficient (p_t^{tc}), the null hypothesis which is going to be considered is expressed by:

$$H_0:\ p_t^{c} = p_t^{tc} \qquad (3)$$

The increase of the variance in the market *j*, can also be originated by the idiosyncratic component, and by the non observed variables. In the simulation accomplished by these authors, it was ascertained that, whenever it happens a significant increase of the volatility, this is originated, partially, through the heterocedasticity of the referred non observed variables. Furthermore, the theoretical coefficient is always smaller than the one observed in the periods of high volatility. This fact is justified by the fact that the coefficient proposed by the authors does not capture the increase, in terms of the volatility of the variables, constituting a very little significant test for ratifying the existence of a contagion effect.

For its turn, a part of the significant increase of the volatility is due to the idiosyncratic component of the generating market (r_{it}). In this case, the theoretical coefficient is too high, compared to the coefficient observed in the periods of great volatility. Consequently, the test will, erroneously, conduct to a result characterized by a lack of interdependence, in periods of high volatility.

The parameter β reduces the distortion originated by the non observed shocks. Independently of the variable that causes the increase of the variance in r_j, if β reaches a high value (that is, if the dependence of r_i, in terms of r_j, is high) then the theoretical coefficient will be similar to the observed coefficient, by keeping constant the parameters.

2.2.2. The Test of Corsetti, Pericoli, and Sbrasia

These authors presuppose that the return rates of the stock exchange of the country *i*, can be estimated, using the following model specifications:

$$r_{it} = \alpha_i + \gamma_i f_t + \varepsilon_{it}, \tag{4}$$

$$r_{jt} = \alpha_j + \gamma_j f_t + \varepsilon_{tj}, \tag{5}$$

where f is a common factor that is, usually, adjusted with a world index. The variable f, and the idiosyncratic shocks correspond to the random independent variables, with finite and strictly positive variance.

Starting from this model, the authors present a theoretical coefficient to be observed during the periods of crisis, which is expressed in the following way:

$$\phi = \rho\left[\left(\frac{1+\lambda_j}{1+\lambda_j^c}\right)^2 \frac{1+\delta}{1+\rho^2\left[(1+\delta)\left(1+\lambda_j/1+\lambda_j^c\right)-1\right](1+\lambda_j)}\right] \tag{6}$$

Where: $\lambda_j = \mathrm{var}(\varepsilon_j)/\gamma_j^2\ \mathrm{var}(f)$, $\lambda_j^c = \mathrm{var}(\varepsilon_j/C)/\gamma_j^2\ \mathrm{var}(f/C)$, and C corresponds to the event: "Crisis in the country *j*". For simplifying the coefficient, we consider that $\lambda_j^c = \lambda_j$. One constant relation of λ_j, means that the variance of the global factor, and the variance of the risk of a specific country increases in the same proportion during the periods of crisis in the country *j*, which is expressed by the following:

$$\frac{\mathrm{var}(r_j/C)}{\mathrm{var}(r_j)} = \frac{\mathrm{var}(f/C)}{\mathrm{var}(f)} = \frac{\mathrm{var}(\varepsilon_j/C)}{\mathrm{var}(\varepsilon_j)} = 1+\delta \tag{7}$$

This way, the correlation coefficient to be observed in the period of crisis can be expressed in the following way:

$$\phi(\lambda_j) = \rho\left[\frac{1+\delta}{1+\delta\rho^2+(1+\lambda_j)}\right]^{1/2} \tag{8}$$

Considering $\lambda_j = 0$, we find out that the coefficient is identical to the one which is proposed by Forbes and Rigobon (2002). When λ_j equals to zero, the country *j* does not suffer from idiosyncratic shocks $(\mathrm{var}(\varepsilon_j) = 0)$ and, in this case, *j* represents the global factor, and each shock in *j* corresponds to the global, or the regional effects[5].

The modification introduced in the coefficient by these authors, comparing to the coefficient proposed by Forbes and Rigobon (2002), aims to reduce the distortion effect, when the idiosyncratic component of the generating market is the main source of heterocedasticity.

2.2.3. The Test of Rigobon

The two previous tests are partial, if the data suffer from the endogeneity problems, or from problems originated by omitted variables. Rigobon (2002) proposed a test, using a model of simultaneous equations, and also considering the omitted variables, and by allowing the presence of heterocedasticity in the data, that is, the Test of the Determinant of the Change in the Covariance Matrix (DCC).

For this effect, the following model describes the correspondent index of a stock exchange with *N* countries:

$$\underset{N\times N}{A}\,\underset{N\times 1}{R_t} = \underset{N\times K}{\Gamma}\,\underset{K\times 1}{Z_t} + \underset{N\times 1}{\varepsilon_t}, \tag{9}$$

where *Z* and *K* are non observed shocks, Γ is the matrix which contains the coefficients of the common shocks; ε_t is the vector correspondent to the idiosyncratic shocks; $E(\varepsilon_t Z_t) = 0$, that is, the idiosyncratic risks, and the common shocks that are non correlationated, presenting $E(Z_t) = 0$. The author also states that $E(R_t) = 0$, and that R_t is a series non correlationated. If R_t is a stationary series, then the results are independent from the previous presuppositions.

---

[5] The theoretical coefficient proposed by Forbes and Rigobon (2002) is, always, equal or bigger, than the one that was proposed by Corsetti *et al*. (2002), excepting the case when: $\rho < 0$.

Given the increase of the volatility during the period of crisis, the creation of two subsets of data, can be proceeded. The first containing the stock exchange index concerned to the period of low volatility (that is, a regular period) and, the second one embracing the stock exchange index relative to the period of high volatility (that is, a crisis, or a irregular period). Afterwards, for each period, two matrixes of variances and of covariances can be computed:

Ω_t^l = The matrix of variances, and of covariances, in periods of low volatility;

Ω_t^h = The matrix of variances, and of covariances, in periods of high volatility;

This way, the DCC statistic is obtained through the following:

$$DCC = \det(\Omega_t^h - \Omega_t^l) = \det(\Delta\Omega_t) \qquad (10)$$

The test allows to observe if the statistic of DCC is equal to zero. If the parameters are stable along the subsets, then the statistic of DCC will be equal to zero. When the statistic of DCC is different from zero, the parameters are not stable, and the presupposition relative to the existence of heterocedasticity is not satisfied. One of the usual problems relative to the use of the DCC test is because the rejections are based on the instability of the parameters, which constitutes a violation of the heterocedasticity rule.

2.3. The Empirical Studies: A Brief Review

After the crash of 1987, in the USA, the interest for analyzing the relationships between the international stock exchanges has grown. In what concerns to the studies about the relationships between the international stock exchanges, we have to stress out the work of Malliaris and Urrutia (1992), where the influence of the crash of 1987 in six of the main stock exchanges, is analysed, using the causality defined in a Grangerian sense. The main results revealed the existence of causality in the month (that is, October) where the crash took place, although in the pre-crash period, and in the post-crash period, this kind of evidence was not detected.

Masih and Masih (1997) analyzed the relationships between five stock exchanges, that is, the DOW JONES, the NIKKEI, the CAC, the DAX, and the FTSE, in the period before the crash of 1987, and in the period after this occurrence, using a VAR model with an error correction mechanism. Furthermore, an analysis of the causality relations defined, in a Grangerian sense, an analysis of the variance decomposition of Cholesky, and also an analysis of the impulse-response functions, are presented.

The main results revealed that the crash did not affect the leadership role assumed by the DOW JONES, the English and the German markets became more dependent in relation to the other markets. Additionally, the crash provoked a bigger interdependence between the stock exchanges indexes.

In the study of Gabriel (1999), by making use of a VAR model, it was detected the existence of several causality relationships, in the case of the western industrialized countries, although it has not been detected any standard of leadership between the fourteen markets, in study.

Manso (2002) developed a study covering the Portuguese, the Spanish, the French, and the Italian Stock Exchanges, making use of a VAR model. The main results have reavealed the existence of a bilateral causality relation between the Portuguese, and the Spanish markets, and also the existence of independence relations between the French, and the Italian Markets.

Later, Miralles and Miralles (2003) have analyzed, in the short term, and in the long term, the dynamic relationships established between the Portuguese stock exchange index: the PSI 20, and other international stock exchanges indexes, namely, the DOW JONES, the NIKKEI, the NASDAQ, the FTSE, the DAX, the CAC, the HANG SENG, and the IBEX, using a VAR model too. The main results showed the existence of cointegrating relationships between the variables, as well as the existence of bidirectional relationships, defined in a Grangerian sense. The analysis presented by the authors was complemented with the presentation of the results of the variance decomposition of Cholesky, and of the impulse-response functions. Moreover, it was revealed that as the Portuguese index has become more integrated in the set of the more developed markets, it became more influenced by the remaining indexes included in the study, especially, the DOW JONES.

3. Econometric Approach

3.1. Data Description

The present study aims to ratify the existence of a contagion effect between the most important international stock exchanges, by contrasting two different periods, that is, the pre-attack period, and the post-attack period, which as occurred in the 11th of September of 2001, in the USA.

The data[6] was collected, taking into consideration the criteria of the higher capitalization in the stock exchange, according to the International Federation of Stock Exchanges (IFSE).

The six indexes that were selected for the present work, cover the four reference indexes of the international stock markets, namely, the DOW JONES (DJI), the NIKKEI 225 (NIKKEI), the FTSE 100 (FTSE), the DAX XETRA (DAX), as well as the two indexes relative to the Iberian market, that is, the PSI 20 (PSI), and the IBEX 35 (IBEX).

Kohers and Kohers (1995) consider that when we use more aggregated data, it should be collected in a diary basis, because this procedure is more adequate to detect and to analyze the linkages which are established, in the long term.

In this sense, for the data included in our sample, we have considered the data in the weekly close[7], since the 28th of September of 1999, until the 30th of August of 2004, resulting in a sample of 310 observations.

It should be stressed that the sample was divided in two periods, comprising two different conjectures. As in the study of Masih and Masih (1997), the first period corresponds to the pre-attack period, and the second one to the post-attack period.

By presenting the correlation coefficients, a first evaluation of the relationships between the indexes, is made, taking the two different periods of analysis (Table 1).

Table 1 – Matrix of the Correlations between the Stock Exchanges

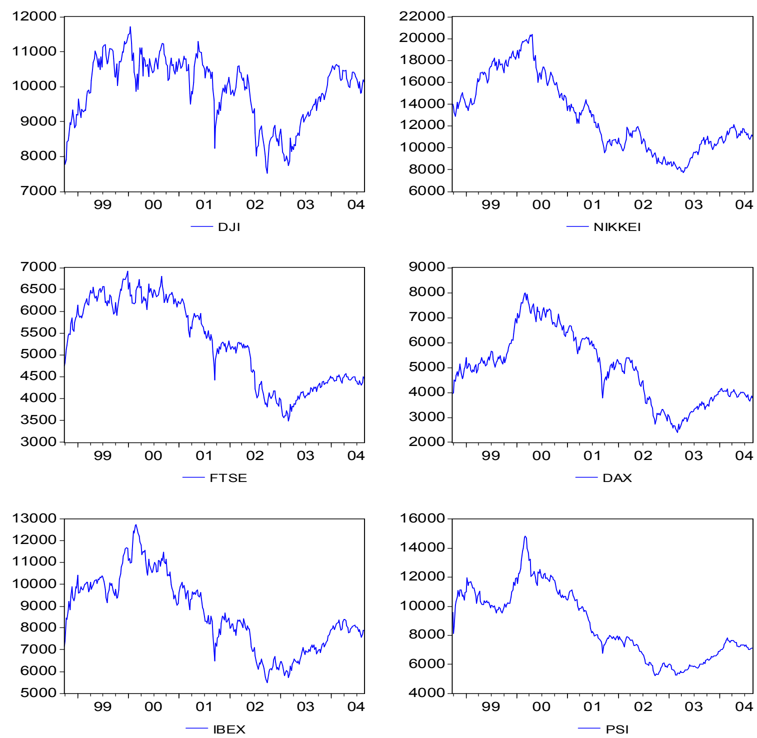
	DJI	NIKKEI	FTSE	DAX	IBEX	PSI
	Total period (9:8:1998 – 8:30:2004)					
DJI	1.00000					
NIKKEI	0.68731	1.00000				
FTSE	0.72355	0.90464	1.00000			
DAX	0.74352	0.83564	0.91204	1.00000		
IBEX	0.75174	0.93193	0.94006	0.91838	1.00000	
PSI	0.61809	0.91277	0.92601	0.90395	0.96166	1.00000
	Pre-Attack (9:8:1998 – 9:10:2001)					
DJI	1.00000					
NIKKEI	0.44963	1.00000				
FTSE	0.61677	0.72277	1.00000			
DAX	0.57164	0.48404	0.58111	1.00000		
IBEX	0.44801	0.79717	0.81664	0.74590	1.00000	
PSI	0.13541	0.65367	0.62522	0.66478	0.86180	1.00000
	Post-Attack (9:17:2001 – 8:30:2004)					
DJI	1.00000					
NIKKEI	0.82199	1.00000				
FTSE	0.68806	0.64773	1.00000			
DAX	0.71634	0.70388	0.97867	1.00000		
IBEX	0.94017	0.80110	0.81408	0.83065	1.00000	
PSI	0.82903	0.79995	0.87606	0.89445	0.93308	1.00000

[6] The source of the data was the following one: http://finance.yahoo.com/.
[7] It corresponds to Friday, or to Tuesday, in case of having a national holiday on Friday.

For the total period, and taking into consideration the results previously presented, the existence of strong correlations between the European indexes, is detected. It must also be stressed that the DJI is the one that presents weaker correlations, in relation to the remaining indexes.

For its turn, when we pass from the pre-attack period, to the post-attack period, a big importance of the DJI, is detected. For example, the correlation coefficient between the DJI, and the PSI increases from 13%, to 83%. In the post-attack period, the higher correlation coefficient between two indexes corresponds to the pair: (FTSE, DAX); with an approximate value of 98%.

Picture 1– The Evolution of the International Stock Exchanges



From the visual inspection of the Picture 1, we retain that the adoption of the Euro, in 1999, was received with some instability observed in the most important European Stock Exchanges, where decreasing tendencies were observed.

For almost of the indexes, specially, the DJI, a break on the decreasing tendency was observed around the end of 2002. This fact has signalled an economic takeoff from the part of the international stock exchanges, which has constituted a relative recover from the recessive movements that were, previously, observed in these markets.

3.2. The Unit Root Tests

The first step in the determination of the kind of relationship between the variables in study, is the prosecution of the unit root tests, in order to detect the integration order of the series. The procedures widely used to detect the existence of unit root make use of the Augmented Dickey-Fuller Augmented (ADF) Test, and of the Philips Perron (PP) Test. In what concerns to the ADF test, this can be expressed in the following way:

$$\Delta \boldsymbol{X}_t = \alpha + \gamma t + \lambda^* \boldsymbol{X}_{t-1} + \delta_1 \Delta \boldsymbol{X}_{t-1} + \delta_2 \Delta \boldsymbol{X}_{t-2} + \ldots + \delta_{p-1} \Delta \boldsymbol{X}_{t-p+1} + \boldsymbol{\mu}_t \qquad (11)$$

The previous expression corresponds to a parametric correction, which consists in adding lagged terms of the variable ΔX_t, in order to correct the correlation of upper order. The prosecution of the $ADF(\gamma)$ test consists in testing the null hypothesis $H_0 : \gamma = 0$, against the alternative hypothesis $H_1 : \gamma < 0$. When γ is non-significant, the null hypothesis cannot be rejected, from this we retain that the series is non-stationary (that is, the series is integrated), or that it presents a unit root (Marques, 1998).

An alternative approaching for the problem of the autocorrelation in μ_t, is the one that was proposed by Philips and Perron (1988). This approach is a non-parametric one, because the proposed tests are non parametric (because they do not require the estimation of additional parameters), following an autoregressive process, which can be enunciated as follows:

$$\Delta \boldsymbol{X}_t = \alpha + \gamma t + \lambda^* \boldsymbol{X}_{t-1} + \boldsymbol{\mu}_t \qquad (12)$$

The asymptotic distribution of the estimators of the regression, as well as, their *t* ratios depend on the parameters σ^2, and σ_u^2. In practice, σ^2, and σ_u^2, are not known, and so it is necessary to proceed with their estimation, in a consistent way[8].

Table 2 – The ADF tests, and the PP tests, including a constant and the tendency

Indexes	First Differences			
	Pre-Attack		Post-Attack	
	ADF	PP	ADF	PP
DJI	-14,45*	-14,42*	-11,46*	-11,45*
NIKKEI	-13,84*	-13,89*	-11,99*	-12,02*
FTSE	-13,13*	-13,15*	-12,00*	-12,18*
DAX	-11,92*	-11,88*	-12,68*	-12,70*
IBEX	-11,51*	-11,48*	-12,82*	-12,85*
PSI	-13,51*	-13,32*	-10,62*	-10,65*

[8] For a consentaneous example of the estimation process, see Newey and West (1987).

Notes:
[#] The number of lags that is considered in the ADF test, it is the one that assures the minimization of the Akaike Informative Criteria (AIC), and of the Schwarz Bayesian Criteria (SBC).
[##] The number of lags included in the PP test, it corresponds to the one that is given by West (1987).
[###] The significance level is 1%, and the critical value is available in the Eviews package (MacKinmon, 1996).
[####] The time series that are used correspond to the natural logarithm of the variables in study.
* It denotes the rejection of the null hypothesis relative to the existence of a unit root.

In the vision of Khalid and Kawai (2003), the appreciation of the results obtained through the prosecution of the ADF test, and the PP test, including a constant and the tendency, is enough to detect the existence of unit roots in the time series, in study.

This way, after having differentiated the series, one time, the null hypothesis is rejected, that is, the time series are stationary, and they are integrated of order one, or *I(1)*.

3.3. Estimation of the VAR Model

After detecting the integration order of the variables, the VAR model is estimated, embracing a system with six equations, and considering all the variables as endogenous one. It must be stressed that in what concerns to the entry order of the variables, and taking into consideration the capitalization values of the stock exchanges, the same criteria as Masih and Masih (1997), and Miralles and Miralles (2003), was implemented. In this line, the system of equations can be enunciated as follows:

$$\begin{bmatrix} DJI_t \\ NIKKEI_t \\ FTSE_t \\ DAX_t \\ IBEX_t \\ PSI_t \end{bmatrix} = \begin{bmatrix} m_1 \\ m_2 \\ m_3 \\ m_4 \\ m_5 \\ m_6 \end{bmatrix} + \begin{bmatrix} a_{1,1} & a_{1,2} & \cdots a_{1,6} \\ a_{2,1} & a_{2,2} & \cdots a_{2,6} \\ \vdots & \vdots & \vdots \\ a_{6,1} & a_{6,2} & \cdots a_{6,6} \end{bmatrix} \times \begin{bmatrix} DJI_{t-p} \\ NIKKEI_{t-p} \\ FTSE_{t-p} \\ DAX_{t-p} \\ IBEX_{t-p} \\ PSI_{t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{bmatrix} \tag{13}$$

where: the DJI_t, the $NIKKEI_t$, the $FTSE_t$, the DAX_t, the $IBEX_t$, and the PSI_t, are the stock exchanges of the USA, of Japan, of United Kingdom, of Germany, and of Portugal, respectively. The number of lags is given by: $p = 1,...,k$, where k corresponds to the optimal number of lags $(p_{\max})$; t is the correspondent week; and ε_{it} are the errors, or the random disturbances.

3.3.1. The Optimal Number of Lags

In this section, we proceed to the selection of the optimal number of lags (p_{max}), considering the results of five different information criteria, namely, the Likelihood Ratio (*LR*), the Final Prediction Error (*FPE*), the Akaike Information Criteria (*AIC*), the Schwarz Bayesian Criteria (*SBC*), and the Hannan and Quinn Criteria (*HQ*).

Table 3– Selection of the optimal number of lags

Lags	*LR*	*FPE*	*AIC*	*SBC*	*HQ*
			Pre-Attack		
0	-	5.06E-15	-15.89110	-15.76904	-15.84150
1	1828.432	1.76E-20	-28.46153	-27.60712*	-28.11438*
2	92.10332*	1.45E-20*	-28.65907*	-27.07231	-28.01436
3	41.16612	1.72E-20	-28.49089	-26.17178	-27.54861
4	46.47963	1.94E-20	-28.38207	-25.33061	-27.14223
			Post-Attack		
0	-	2.25E-16	-19.00407	-18.88202	-18.95448
1	1807.714	9.06E-22*	-31.42652*	-30.57211*	-31.07937*
2	62.57871	9.29E-22	-31.40373	-29.81697	-30.75902
3	37.82412	1.13E-21	-31.20944	-28.89033	-30.26716
4	61.83637*	1.13E-21	-31.22650	-28.17504	-29.98666

* It identifies the optimal number of lags selected by each one of the criteria.

In order to detect the existence of error autocorrelation, the results obtained through the application of the Lagrange Multiplier (LM) tests, with one, and with four lags, respectively, are presented below [9].

Table 4 – The LM tests for detecting error autocorrelation

	LM (1)		**LM (4)**	
	x^2	Prob.	x^2	Prob.
Pre-Attack	44,1200	0,1659	45,4327	0,1347
Post-Attack	47,9147	0,0885	50,0340	0,0601

Through the simulation of distinct VAR models, with one, and with two lags, respectively, and taking into consideration only the AIC criterion for selecting the optimal number of lags, we found that, for the pre-attack period, the model should be estimated using two lags. For its turn, for the post-attack period, the correspondent VAR model should be estimated, using just one lag, since both procedures provide the minimization of the values of the referred criterion.

[9] According to the procedures used in the studies of Ratanapakorn and Sharma (2002), Wongbangpo and Sharma (2002), and Miralles and Miralles (2003).

3.3.2. The Cointegration Tests

After computing the optimal number of lags to be considered in the estimation process, we follow Johansen and Juselius (1990), and we take into consideration the principle of the maximum likelihood, using two different statistics: the Max-Eigenvalue Statistic (λ_{Max}), and the Trace Statistic (λ_{Trace}), in order to obtain the results of the cointegration tests, which are presented below in the Table 5.

Table 5 – The Cointegration Tests

	Hypotheses		λ_{Trace}		Hypotheses		λ_{Max}	
EV	H_0	H_1	Observed	Critical	H_0	H_1	Observed	Critical
				Pre-Attack				
0.292470	r=0	r=1	128,3503*	94.15	r=0	r>0	52,5882*	39.37
0.198114	r=1	r=2	75,7621*	68.52	r≤1	r>1	33,5600*	33.46
0.121848	r=2	r=3	42,2021	47.21	r≤2	r>2	19,7502	27.07
0.074758	r=3	r=4	22,4519	29.68	r≤3	r>3	11,8103	20.97
0.062122	r=4	r=5	10,6416	15.41	r≤4	r>4	9,7485	14.07
0.005858	r=5	r=6	0,8931	3.76	r≤5	r>5	0,8931	3.76
				Post-Attack				
0.318472	r=0	r=1	126,9890*	94.15	r=0	r>0	58,6630*	39.37
0.167307	r=1	r=2	68,3260	68.52	r≤1	r>1	28,0129	33.46
0.149552	r=2	r=3	40,3131	47.21	r≤2	r>2	24,7848	27.07
0.050985	r=3	r=4	15,5284	29.68	r≤3	r>3	8,0067	20.97
0.027707	r=4	r=5	7,5217	15.41	r≤4	r>4	4,2990	14.07
0.020843	r=5	r=6	3,2228	3.76	r≤5	r>5	3,2228	3.76

Notes:
[+] The first column corresponds to the Eigenvalues (EG).
[++] The critical values of the Max-Eigenvalue Statistic, and of the Trace Statistic, at a significance level of 5%, were collected from Osterwald-Lenum (1992).
* It denotes the rejection of the initial hypothesis, at a significance level of 5%.

The results that were presented above in the Table 5, revealed a difference between the two periods in analysis, in terms of the number of cointegrating vectors. In this sense, in the pre-attack period, by observing the second line, we retain that the observed value is bigger than the critical value for both statistics. From this, we consider two cointegrating vectors to estimate the VAR model, using two error correction terms (ECT).

For the post-attack period, through the analysis of the first line, we detect only one cointegrating vector, which it will be considered in the correspondent VAR model estimation, by using only one ECT.

The cointegrating vectors that are going to be incorporated in the estimation of the VAR models, with correction error mechanisms, for the two distinct periods considered in the present analysis, are presented below in the Table 6. The contrasts of the elements that compose the cointegrating vectors, are both made at 5% and 10% significance levels.

Table 6 – The Cointegrating Vectors of the VAR Models for the Pre-Attack, and the Post-Attack Periods

Variables	Pre-Attack		Post-Attack
	Z_1	Z_2	Z_3
ΔDJI	1,00	0,00	1,00
ΔNIKKEI	0,00	1,00	-0,2645*
ΔFTSE	-0,5272*	0,8132*	0,7029**
ΔDAX	-0,1831**	0,5419**	-0,3066*
ΔIBEX	-0,5911*	-4,6235*	-0,6295*
ΔPSI	0,6300*	1,6172*	0,0658*
C	-3,4565	6,1446	-5,0680

Notes:
[*] In the Pre-Attack period the joint hypothesis of the coefficients of each vector is tested, by using an assimptotic distribution with two degrees of freedom. The statistic used for this effect is the χ^2 .
[**] In the Post-Attack period, an asymptotic distribution is also considered, making use of the χ^2 statistic, with one degree of freedom.
[***] For both periods of analysis, the cointegrating vectors were normalized in relation to the DJI (because this index corresponds to the one that presents the bigger stock exchange capitalization).

3.4. The Dynamic Analysis

3.4.1. Contrasts of Granger Causalities

For analysing the dynamic relationships between the variables in study, in the pre-attack period, two error correction terms (ECT1, and ECT2) are incorporated, and in the post-attack period, one error correction term (ECT3) is considered. In order to evaluate the existence of causality relationships between the stock exchanges indexes, the causality concept, originally, proposed by Granger (1969), is used. In the prosecution of the causality tests, for each pair of variables, the Wald statistic is applied[10].

[10] In the Table 7, the line named: Block; corresponds to the value observed for the Wald statistic, which provides the result for the test of joint significance that is relative to all the other endogenous variables that are included in the correspondent equation.

Table 7 – The contrasts of the Granger causalities, in the pre-attack period

	ΔDJI	ΔNIKKEI	ΔFTSE	ΔDAX	ΔIBEX	ΔPSI
ΔDJI	–	2,22265	0,28165	0,19558	0,35134	0,18831
ΔNIKKEI	4,61249**	–	1,57444	1,94229	4,20389	1,79813
ΔFTSE	4,06789	0,69939	–	0,53356	1,20659	11,59697*
ΔDAX	8,80463*	3,06429	2,85912	–	3,81627	2,18958
ΔIBEX	0,58792	0,96910	1,61164	0,48201	–	29,38654*
ΔPSI	7,26506*	6,27185*	1,26667	0,72927	0,25109	–
Block	25,50897*	25,90469*	6,73646	5,19138	12,30122	62,25282*
ECT1	-0,27659*	0,06882	-0,21655*	0,00325	0,20798**	-0,26194*
ECT2	0,04882*	-0,02213	0,04360*	0,03174	0,06241*	0,02673**

Notes:
[+] Consider the variable or the block, which are expressed in each column, as being the independent variable (that is, the origin of the causality), and the variable that is presented in line, as being the dependent variable (that is, the destination of the causality).
[++] The contrasts of the causality of the variables are made by using the χ^2 statistic, with one degree of freedom, while the contrasts of the significance of the error correction term (ECT), are made through the use of the *t* statistic.
* Significance level: 5%.
** Significance level: 10%.

According to the results presented above in Table 7, in what concerns to the pre-attack period, none of the variables can be considered as totally exogenous, since at least one causality relationship is detected for each variable, and given the significance of the coefficient that is associated with the error correction terms. The indexes that accomplish the adjustment mechanism in relation to the deviations that are observed in the equilibrium relationships, in the long term, are the DJI, the FTSE, the IBEX, and the PSI. In what respects to the causality tests, a joint causality of the variables: DJI, NIKKEI and PSI, at a significance level of 5%, is detected. This fact ratifies the importance of the inclusion of this set of variables in the specification of the model that is used here. It must be stressed the existence of feedback relationships between the stock exchange indexes. From this, we only detect the existence of unidirectional causalities. In this ambit, it is of noticing the importance of the PSI, which is the origin of the causality for the DJI, and the NIKKEI, at a significance level of 5%. It is also detected that, for this period, the DJI is not the origin of any causality relationship, nevertheless, it is explained by the past values of the NIKKEI, of the DAX, and of the PSI.

Table 8 – The contrasts of the Granger causalities, in the post-attack period

	ΔDJI	ΔNIKKEI	ΔFTSE	ΔDAX	ΔIBEX	ΔPSI
ΔDJI		0,02740	3,24205*	1,12851	0,55581	4,98731*
ΔNIKKEI	3,37669**		2,08722	0,11727	0,02584	0,94362
ΔFTSE	5,65210*	0,94682		1,35280	1,28246	0,40392
ΔDAX	2,32894	1,33782	3,58086*		1,05661	1,54062
ΔIBEX	3,01021**	0,38250	7,43357*	0,54756		0,38260
ΔPSI	3,42763**	0,06330	8,57981*	5,33206*	1,26480	
Block	15,45189*	1,95924	20,09378*	8,84680	3,62983	6,31080
ECT3	0,03122	0,38657*	-0,04062	0,23327*	0,24334*	0,24504*

Notes:
* Significance level: 5%.
** Significance level: 10%.

From the analysis of the contrasts of the Granger causalities in the post-attack period, we retain that the terrorist attacks of the 11th of September had a strong effect, in terms of the existence of feedback relationships between the DJI, and the PSI, as well as, between the DJI, and the FTSE.

From this, the international dimension of the terrorist attacks of the 11th of September, in terms of the propagation of the effects over the international stock exchanges, specially, the Portuguese, and the English one, is ratified.

Making use of the analysis of the coefficients of the error correction terms, we observe that the NIKKEI, the DAX, the IBEX, and the PSI, correspond to the indexes who accomplish the adjustment mechanism, in relation to the deviations that are observed in the equilibrium relationships, in the long term.

It must also be stressed that, in the post-attack period, the causality relationships that include the Portuguese index, reveal the effects of the economic crisis that has been observed in the European Union (EU), since this index is not the destination of any causality relationships, embracing other European market.

In fact, not even the strong commercial relations with the Spanish neighbour market, have contributed for the existence of a causality relationship. In this line, the terrorist attacks have influenced more the Portuguese financial market, than other European financial markets.

3.4.2. The Variance Decomposition of Cholesky

In the pre-attack period, using the analysis of the variance decomposition of Cholesky, the IBEX presents a very weak degree of exogeneity (only 6%), after 24 weeks, for this reason the correspondent forecasting error is explained through the innovations in the following indexes: DJI, NIKKEI, FTSE, and PSI, with 17, 15, 31 and 22 percentage points, respectively.

Assuming the condition of the bigger capitalization stock exchange index, the DJI ratified the results obtained through the contrasts of the Granger causalities, by revealing a weak degree of exogeneity (7%), and being, especially, influenced by the FTSE, and the PSI indexes. Nevertheless, the DJI has presented a weak degree of exogeneity, it has assumed a great importance, in determining the relationships between the markets, namely, through a strong influence on the FTSE (26%), the IBEX (18%), and the PSI (29%).

After 24 weeks, the indexes that have presented a bigger degree of exogeneity were the NIKKEI, and the FTSE, reaching 80, and 68 percentage points.

The PSI has assumed a singular isolation profile, in relation to the remaining indexes, since it is only detected a strong influence, from the part of the DJI, which has contributed for explaining 29% of the variance of the forecasting error relative to the Portuguese index.

In the post-attack period, a strong influence of the DJI over the remaining indexes is detected. It must be stressed that in the transition from the pre-attack period to the post-attack period, the degree of exogeneity of the DJI has evoluted from a low level of 6%, to a high level of 95%.

This evolution can be related with strong recessive movements, which were observed in the post-attack period, and that have reinforced the isolation relative to the other stock exchanges.

Excluding the DJI, the degrees of exogeneity that were observed in the pre-attack period have, slightly, decreased, for the remaining indexes, which have started to be more influenced by the DJI.

For its turn, the PSI has maintained a considerable degree of exogeneity near the 40 percentage points, and as it was, previously, referred, the PSI was influenced by the DJI, reaching 46 percentage points, after 24 weeks (contrasting with the 29 percentage points, in the pre-attack period).

Table 9 – Dynamic analysis of the causalities directions

Causalities Directions	Dynamic Analysis	8 Weeks	24 Weeks	The percentage weight
Pre-Attack				
$\Delta NIKKEI \rightarrow \Delta DJI$ *	VDC	10.10	8.69	+
	IRF	0.0072	0.0061	
$\Delta DAX \rightarrow \Delta DJI$	VDC	2.10	0.79	-
	IRF	0.0002	-0.0010	
$\Delta FTSE \rightarrow \Delta PSI$ *	VDC	8.80	4.93	+
	IRF	0.0076	0.0068	
$\Delta IBEX \rightarrow \Delta PSI$	VDC	4.51	1.82	+
	IRF	0.0038	0.0036	
$\Delta PSI \rightarrow \Delta DJI$ *	VDC	9.67	18.91	-
	IRF	-0.0084	-0.0105	
$\Delta PSI \rightarrow \Delta NIKKEI$	VDC	1.55	2.12	+
	IRF	0.0060	0.0049	
Post-Attack				
$\Delta DJI \rightarrow \Delta FTSE$ *	VDC	57.56	56.41	+
	IRF	0.0150	0.0149	
$\Delta DJI \rightarrow \Delta PSI$ *	VDC	45.10	46.01	+
	IRF	0.0201	0.0201	
$\Delta NIKKEI \rightarrow \Delta DJI$	VDC	1.30	0.90	-
	IRF	-0.0019	-0.0018	
$\Delta FTSE \rightarrow \Delta DJI$	VDC	0.63	0.55	+
	IRF	0.0016	0.0016	
$\Delta DAX \rightarrow \Delta FTSE$	VDC	1.17	0.65	-
	IRF	-0.0012	-0.0012	
$\Delta IBEX \rightarrow \Delta DJI$	VDC	0.78	0.47	-
	IRF	-0.0013	-0.0012	
$\Delta IBEX \rightarrow \Delta FTSE$	VDC	0.72	0.28	-
	IRF	-0.0004	-0.0003	
$\Delta PSI \rightarrow \Delta DJI$	VDC	2.35	2.40	+
	IRF	0.0036	0.0035	
$\Delta PSI \rightarrow \Delta FTSE$	VDC	4.40	4.43	+
	IRF	0.0390	0.0390	
$\Delta PSI \rightarrow \Delta DAX$	VDC	4.08	4.68	+
	IRF	0.0097	0.0097	

Legend: VDC is the Variance Decomposition of Cholesky; IRF corresponds to the Impulse-Response Functions.

Notes:
[#] The sign of the percentage weight is obtained through the sum of the coefficients of the first 10 weeks, in order to reach the stability of the coefficients (Goux, 1996).
* It denotes a significant impact, that is, when it assumes an impact bigger than 5%, after 8 weeks (Goux, 1996).

Taking into consideration the results of the analysis of the variance decomposition of Cholesky that are presented above in the Table 9, we retain that in the pre-attack period, the causality relationships that present a significant impact, are defined in the following causalities directions: $\Delta NIKKEI \rightarrow \Delta DJI$; $\Delta FTSE \rightarrow \Delta PSI$; and $\Delta PSI \rightarrow \Delta DJI$.

The direct impact of the PSI on the DJI has a significant and negative effect, which is ratified by the percentage of the explained variance of the forecasting error of the DJI that is explained by the Portuguese index, reaching 10 percentage points, after 8 weeks. This impact on the DJI becomes stable, after 14 weeks. In the post-attack period, only two causality relationships, which are defined in following directions: $\Delta DJI \rightarrow \Delta FTSE$, and the $\Delta DJI \rightarrow \Delta PSI$; present a direct and a significant impact.

In this sense, and taking into consideration the generic definition proposed by Dornbush et al. (2000), the existence of a contagion effect, or of a propagation mechanism of the shocks, is detected, which was originated by the terrorist attacks that took place in the 11st of September of 2001, in the USA.

The main explanations for the existence of a contagion effect in the subsequent period to the referred attacks, can be described through three fundamental statements. Firstly, the terrorist attacks have originated a recessive movement in the local stock exchange, at the USA, which for its turn, has produced a direct and significant effect on the English, and the Portuguese stock exchanges.

Secondly, the levels of exogeneity that were detected for the FTSE, and the PSI, in the pre-attack period, were object of a correction, in the post-attack period. This way, these two indexes passed to be preceded by the fluctuations observed in the stock exchange index of the USA.

Thirdly, the fact that the attacks did took place in the international stock exchange with bigger capitalization, has provoked a wave of fear and of uncertainty relative to the hypothetic occurrence of new attacks, which has contributing for redirecting the investments for other international markets. This situation, is revealed through the sign obtained for the percentage weight of the causality (see Table 9), relative to other European financial markets, and it is also ratified by the coefficients obtained through the simulations of the impulse response functions.

4. Conclusions

The existence of interdependences between the international stock exchanges, in study, is ratified through the results obtained for the causality tests, which allow to ascertain the observance of several precedence relationships.

It is also revealed that, the stock exchange with the bigger capitalization index, that is, the DJI, has presented a strong dependence in relation to the remaining indexes, in the pre-attack period. Nevertheless, this dependence is object of a correction during the post-attack period, which confirms the importance of the USA, as the main world potency, in economical and political terms. This situation, is also ratified by the strong influence that is exercised by the DJI over some indexes, as well as, by the big degree of exogeneity, which is presented by the DJI, during the post-attack period.

The Portuguese index is influenced, significantly, by the DJI. This fact, can be explained both by the high degree of opening of the Portuguese economy, and by the small dimension of its financial market.

The high degrees of exogeneity that are observed during the pre-attack period, have decreased, in the Japanese, in the German, in the English, and in the Portuguese Stock exchanges. This situation is related with the existence of a propagation mechanism of positive or negative shocks, starting in the USA stock exchange, and impacting, in a subsequent way, in the other interdependent financial markets.

From the results here obtained, we retain that the referred shocks were initiated in the financial market where the terrorist attacks did took place, and that they have resulted in a bigger interdependence between the international stock exchanges, in study.

Finally, in what concerns to the specific analysis of the contagion relationships established between the international stock exchanges, it must be stressed that, a propagation movement initiated from the USA, in direction to the English, and the Portuguese financial markets, is detected. This situation can be explained by a conversion of the financial transactions, originally, made at the USA, which for its turn, has originated a larger volatility of the shares traded in the two referred European markets. In this sense, the shock wave that was provoked by the abrupt movement observed in the financial market of the USA, was transmitted, quickly, into the English, and into the Portuguese financial markets, which have suffered from a positive effect that was originated by the associated volatility.

References

Asness, C.; Liew, J.; Stevens, R. (1996), "Parallels between the cross-sectional predictability of stock and country returns" Working paper, Goldman Sachs Asset Management, New York.

Berk, J. (1996), "An Empirical Re-examination of the relation between firm size and return", Working paper, University of British Columbia.

Bourguinat, H. (1992), *Finance Internatinal*, Presses Universitaires de France

Corsetti, G.; Pericoli, M.; Sbracia, M. (2002), "Some contagion, some interdependence more pitfalls in tests of financial contagion*",* CEPR Discussion Paper No. 3310, London.

Dickey, D.; Fuller, W. (1979), "Distribution of the estimators for autoregressive time series with a unit root", *Journal of the American Statistical Association*, 74, pp. 427–431.

Dornbusch, R.; Park, Y.; Claessens, S. (2000), "Contagion: Understanding How it Spreads", *The World Bank Research Observer*, Nº15, Vol. 2, pp. 177-197

Forbes, K.; Rigobon, R. (2001), "Contagion in Latin America: Definitions, measurement, and policy implications", *Economia*, Vol. 2, pp. 1–46

Forbes, K.; Rigobon, R. (2002), "No contagion, only interdependence: Measuring stock market co-movements", *Journal of Finance*, Nº 57, Vol. 5, 2223–2261.

Gabriel, V. (1999), *Globalização dos Mercados Financeiros: Interdependências entre O Mercado de Acções Português e Alguns dos Principais Mercados Internacionais*, Dissertação de Mestrado em Gestão, Universidade da Beira Interior, Covilhã, Portugal.

Goux, J-F. (1996), "Le canal étroit du crédit en France ", *Revue D'Économie Politique*, 106(4), Juillet-Août, 1996, pp. 655-681.

Granger, W. (1969), "Investigating causal relations by econometric models and cross-spectral methods", *Econometrica*, 37, pp. 424–438.

Johansen, S.; Juselius, K. (1990), "Maximum Likelihood Estimation and Inference on Cointegration with Applications to Money Demand", *Oxford Bulletin of Economics and Statistics*, 52, pp.169-210.

Khalid, A.; Kawai, M. (2003), "Was financial Market contagion the source of economic crisis in Asia? Evidence using a multivariate VAR model", *Journal of Asian Economics*, 14, pp. 131-156.

Kohers, T.; Kohers G. (1995), "Recent Developments in European Stock Market Linkages", *The Middle-Atlantic Journal of Business*, Nº 31, Vol. 3, December.

Mackinnon, J. (1996), "Numerical Distribution Functions for Unit Root and Cointegration Tests", *Journal of Applied Econometrics*, Vol. 11, Nº 6, John Willey & Sons, Ltd, pp. 601-618.

Malliaris, A.; Urrutia J. (1992), "The International Crash of October 1987: Causality Tests", *Journal of Financial and Quantitative Analyses*, 27, pp. 353-364.

Manso, J. (2002), "Competitiviness and Dynamism of the Luso-Spanish Stock Exchanges in the context of the Latin Countries of Europe", Actas das XII Jornadas Luso-Espanholas de Gestão Científica, Universidade da Beira interior, Covilhã.

Marques, C. (1998), *Modelos Dinâmicos, Raízes Unitárias e Cointegração*, Edições da Universidade Nova de Lisboa (EDINOVA), Lisboa.

Masih, M.; Masih, R. (1997), "Dynamic linkages and the propagation mechanism driving major international stock markets. An analysis of the pre and post-crash eras", *Quarterly Review of Economics and Finance*, nº 37, Vol. 4, pp. 859–885.

Miralles, J.; Miralles, J. (2003), "Relações Dinâmicas entre as principais bolsas de valores. Os efeitos sobre a Euronext Lisboa" Revista de Gestão e Economia, Nº 5/2003, Universidade da Beira Interior, Covilhã, Portugal, pp. 8-20.

Newey, W.; West, K. (1987), "A simple positive semi-definite, heteroscedasticity and autocorrelation consistent covariance matrix", *Econometrica*, 55, pp. 703-708.

Osterwald-Lenun, M. (1992), "A note with quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistics", *Oxford Bulletin of Economics and Statistics*, 54, pp. 461–471.

Phillips, P.; Perron, P. (1988), "Testing for unit root in time series regression", *Biometrika*, 75, pp. 335–346.

Pretrorius, E. (2002), "Economic determinants of emerging stock market interdependence", *Emerging Marketing Review*, Vol. 3, pp. 84-105.

Ratanapakorn, O.; Sharma, S. (2002), "Interrelationships among Regional Stock Indices", *Review of Financial Economics*, 11, pp.91-108.

Rigobon, R. (2002), "On the measurement of the international propagation of shocks: Is the transmission stable?", *Journal of International Economics*, forthcoming.

Serra, A. (2000), "Country and industry factors in returns: evidence from emerging markets stocks", *Emerging Market Review*, Vol. 1, pp. 127-151.

Wolf, H. (1998), "Determinants of emerging market correlations", *Emerging Market Capital Flows,* Kluwer Academic Publishers, Great Britain, pp. 219-235.

Wongbangpo, P.; Sharma S. (2002), "Stock Market and Macroeconomic Fundamental Dynamic Interactions: Asian-5 Countries", *Journal of Asian Economics*, Vol. 13, pp. 27-51.