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Contagion During the 2008 Financial Crisis: The Case of BRIC Group Financial Markets and Five Developed Markets

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Abstract
In this paper, we are interested in contagion during the 2008 financial crisis, through the stock markets of the United States, United Kingdom, France, Germany, Japan, Brazil, Russia, India and China between 04 January 2006 and 30 December 2009. We took, as variable, daily index returns of these countries. We tried to test, through a correlations study, the existence of contagion and, through a causality study, the presence of causality links, in Granger's sense, among the nine studied countries. Our results showed a "pure contagion" phenomenon between some markets during the 2008 financial crisis. We also found a significant change in causality (short and long term) between the quiet period and that of the crisis.

Keywords: *Financial crisis, contagion, correlation, causality.*

1. Introduction

The financial crisis of 2008 was considered the most severe crisis since the Great Depression. Its magnitude and the speed of its spread across the world come to put forward concerns about the contagion. The latter refers to the spread of financial turmoil from one country to the financial markets of other countries. Although contagion does not have one definition the authors have agreed on, two main forms of contagion can be distinguished: a "contagion by fundamentals," according to Kaminsky and Reinhart (1999) and "pure contagion" for Masson (1999) or "shift contagion" for Forbes and Rigobon (2000). Contagion by fundamentals can be identified by the presence of economic and financial linkages between countries and pure contagion is rather related to the investors' behavior than to the evolution of macroeconomic fundamentals.
The objective of our work is, first of all, to test the existence of contagion during the financial crisis of 2008, through a study of correlations, then identify the presence of causal links, as defined by Granger, among the countries that make up our sample. To measure the contribution of the different stock indexes in the variability of the other indices, the study of causality is complemented by an impulse analysis calculating the shock reaction functions and the decomposition of the variance of the prediction error.
In order to analyze the existence of contagion during the crisis and identify whether it is a pure contagion, we refer to the definition of contagion given by Forbes and Rigobon (2000). Our

study was conducted on a sample of nine countries: the United States, the United Kingdom, France, Germany, Japan, Brazil, Russia, India and China. We took, as variable, daily index returns of these countries during the period from early January 2006 to the end of December 2009.

Our paper is organized as follows: The second section is devoted to a review of the theoretical and empirical literature on the main works that have studied the phenomenon of contagion. In the third section, we present the data and methodology. We analyze the results in the fourth section. Section five is the conclusion.

2. Literature review

From a theoretical point of view, two theories of the international spread of crises can be distinguished: non-contingent to crises theories and contingent ones. In the context of non-contingent to crises theories, transmission mechanisms after and before a crisis are not significantly different. Therefore, the excessive co-movements between markets are a continuation of the relationship before the crisis. Forbes and Rigobon (2000) distinguished the following main channels: trade, learning, coordination of economic policies, as well as aggregate shocks.

Trade plays an important role in the spread of crises, especially for countries that are strongly related by real, economic and international trade ties. Devaluation is the most important mechanism by which the crisis spreads from one country to another. Following the devaluation of the country in crisis, it has a competitive devaluation exports at the expense of competing products from other countries. Following its devaluation, the country in a crisis has a competitive devaluation exports at the expense of competing products from other countries. The latter undergo speculative pressure on their currencies (Kaminsky, Reinhart and Vegh (2003). The learning means reassessing the situation, or the risk, of a country as a result of crises occurring in other countries. According to Calvo and Mendoza (2000), investors try to apply the lessons learned from previous crises in countries that have a similar structure or following similar macroeconomic policies. In addition, the response of a country to a possible crisis may force other countries, members of the same economic or financial agreement, to adopt similar policies (Forbes and Rigobon (2000)). According to Dorunbush et al. (2000), the aggregate or random shocks simultaneously affect the fundamentals of many economies and a strong correlation between different markets can be observed immediately after a shock.

Unlike the non-contingent to crisis theories, contingent ones support the idea that the spread of crises is specific and related to these crises. In other words, crises spread through channels fundamentally different from those before crisis or even nonexistent during periods of financial stability (Forbes and Rigobon (2000), Pritsker (2000) and Edwards (2000)). These theories are based primarily on: multiple equilibria, endogenous liquidity shocks and contagion policy.

Regarding multiple equilibria, Masson (1998) argues that a crisis in one country can be used as a “sunspot” for other countries. According to Marais (2003), the transmission of a crisis from one country to another is caused by the change of the investors’ expectations rather than by the existence of real links between these countries. Liquidity shocks may force the investors to adjust (Schinasi and Smith (2000)) or recompose (Valdes (1998)) their portfolios. In the presence of an information asymmetry between investors, rebalancing their portfolios causes greater price changes than those occurring with full knowledge of the state of fundamentals (Kordes and Pritsker (2002)). Political contagion was identified by Drazen (1999) after a study he carried out on the crisis of the European Monetary System, which took place in the early 1990s. He was able to develop a model in which he showed that the Presidents of the European central banks have undergone pressure to maintain their policy of fixed exchange rates.

The distinction between non-contingent to crises theories and contingent ones reveals the important role of the investors' behaviors and expectations in the spread of financial crises especially when the integration of the financial markets continues to increase (Pritsker (2000) and Dornbusch et al (2000)). According to Dornbusch et al. (2000), the investors' decisions, although they may be individually rational, can cause an excessive co-movement. Contagious behavior may be due to: return and liquidity problems, problems of asymmetric information and coordination of markets or a change in the rules of the game.

Regarding the problems of liquidity and return, institutional investors who support capital losses (Aglietta (2002)) and the commercial banks that depend on a common lender with a strong regional exposure (Rijckeghem and Weder (2000)) are among the market players who are most vulnerable to liquidity problems. The most vulnerable countries to financial contagion are those whose domestic financial markets are more liquid and whose financial assets are distributed on the markets (Kordes and Pritsker (2002)). Concerning the problems of the information asymmetry, Dorunbush et al. (2000) consider that contagion may be due to the information asymmetry, that is to say, the differences in the investors' expectations. Information asymmetries that occur between the informed and uninformed investors can cause a liquidity shock. The uninformed agents observing the liquidity shocks cannot identify the causes and in the case of a misinterpretation of the actions of other agents, a phenomenon of mimicry may occur resulting in amplification of capital outflows from emerging countries (Calvo (1999)). In addition, a change in the investors' assessments of the rules governing the international financial transactions can cause contagion. How investors perceive the rules of the game and the weight of official guarantees has changed significantly after the Asian crisis and especially the Russian one (Calvo (1999)).

On the empirical side, several studies have attempted to prove the existence of contagion and identify its nature, by using several approaches including: studies of correlations between financial markets, Probit / Logit models and ARCH/GARCH models.

King and Wadhwani (1990) examined the changes in the correlation coefficients between different financial markets occurring after the stock market crash of October 1987. Their empirical estimates show that volatility of correlation coefficients in financial markets in London, New York and Tokyo significantly increased after the 1987 crash. In their study of the Mexican crisis, Calvo and Reinhart (1996) suggested that the co-movement of the weekly returns of stock in emerging markets in Asia and Latin America was higher after the Mexican crisis than before it. Meanwhile, Valdes (1998) showed that the Mexican crisis was contagious in Latin America. Goldfajn and Baig (1998), after analyzing the return of the stock markets, interest rates, sovereign debt and currencies of five Asian countries, found that, for each variable, the correlation across countries was significantly higher during the period spanning between July 1997 and May 1998, than during the period from January 1995 to December 1996.

Empirical estimates using Probit / Logit models help to test the significance of the different channels of shock transmission such as the commercial links, financial interdependence and macroeconomic similarities (Marais (2003)). In their estimates based on a sample of 20 industrialized countries over the period 1959 to 1993, Eichengreen et al. (1996) show that a crisis in one country increases, by 8%, the probability that speculative attack is carried out in another country. This model is, henceforth, widely used. Kumar et al. (1998), who refine this model by adding omitted financial and macroeconomic variables, claim that their model has a high explanatory power. In fact, major crashes (Mexico in 1994 and Thailand and Korea in 1997) are

correctly anticipated. In their study on a large dataset of 61 industrial and emerging countries, Caramazza et al. (2000), through their Probit model, show that the trade and financial linkages play a significant role in explaining the contagion of currency crises.
Empirical studies of shock transmission across the financial markets using GARCH models have been proposed by Hamao et al. (1990), who analyzed volatility transmission after the stock market crash of October 1987. They assert the existence of an effect of volatility transmission "volatility spillover" of the U.S. and English financial markets to the Japanese markets. Edwards (1998) was interested in the volatility spread of bond markets in Latin America after the Mexican crisis in 1995 and estimates a univariate GARCH model showing that the increase in volatility in Mexico had an impact on the volatility of the bond market in Argentina, but not in Chile. He was interested in the volatility spread of bond markets in Latin America after the Mexican crisis in 1995 and estimates a univariate GARCH model showing that the increase in volatility in Mexico had an impact on the volatility of the bond market in Argentina, but not in Chile.

3. Data and methodology

The definition of contagion we referred to is that of Forbes and Rigobon (2000), because it is very useful in the empirical context since it can be easily turned into a test of the existence of contagion by testing the statistical significance of changes in market linkages after the shock.
Indeed, these two authors define contagion as *"a significant increase in the market linkages after a shock in one country or a group of countries"*. According to this definition, there's contagion only if the co-movements between markets recorded a significant increase after a shock. However, if the increase in the co-movement is not significant, it may simply reflect the continuation of strong ties that existed during the quiet periods.
The aim of our study is to measure the co-movement and see if they change behavior or not between the quiet period and that of the crisis. To do this, we will proceed through several tests. The first is to test the significant increase in the correlation coefficient adjusted through heteroskedasticity between the period of stability and that of a crisis. While the second aims at testing causality, in Granger's sense, between the nine countries. The study of causality is complemented by an impulse analysis.
To test the existence of contagion, some authors, especially Baig & Goldfajn (1998) and Sander & Kleimeier (2003), used the foreign exchange markets, interest rates and sovereign debt. Many other empirical studies have used the stock market as an indicator of the turbulence in the financial market (Masih and Masih (1999) and Forbes and Rigobon (2002)). Therefore, in our work we study the behavior of the co-movements between the stock markets of nine countries: five developed countries; the United States, the United Kingdom, France, Germany and Japan, and four emerging countries forming the BRIC group which are Brazil, Russia, India and China.
The database of our study focuses on the daily index returns of the nine countries mentioned above. These data are extracted from the database published on the website (www.yahoo.finance.com).
Index returns are considered on the period from 04 January 2006 to 30 December 2009, i.e. 981 observations for each country. This period is divided into two sub-periods: a quiet period from 04 January 2006 to 29 June 2007, i.e. 363 observations, for each country, and a crisis period which began on July 2, 2007, the triggering date of the subprime crisis in the United States, until December 30, 2009, i.e. 618 observations for each country. We therefore consider that the date of onset of the crisis is July 2, 2007, by referring to Iuliana Matei (2010). In the table below, we present the stock index for each country in our sample.

Table 1: Presentation of the stock index

Country	Stock market	Stock index
▪ The United States	▪ the New York Stock Exchange	▪ S&P 500
▪ Great Britain	▪ the London Stock Exchange	▪ FTSE100
▪ The Franc	▪ the Paris Bourse	▪ CAC 40
▪ Germany	▪ the Frankfurt Stock Exchange	▪ DAX
▪ Japan	▪ the Tokyo Stock Exchange	▪ Nikkei 225
▪ China	▪ the Shanghai Stock Exchange	▪ SSECI
▪ India	▪ the Bombay Stock Exchange	▪ BSE30
▪ Brazil	▪ the Sao Paulo Stock Exchange	▪ IBovespa
▪ Russia	▪ the Moscow Stock Exchange	▪ RTSI

3.1. Correlations Study

The relationship between equity indices returns are measured by their correlation coefficient. When the correlation increases significantly during the crisis, contagion is obvious, to the extent that this increase suggests that there is strengthening link or transmission mechanism between the two markets. However, if the increase is not statistically significant, it is only a phenomenon of interdependence rather than contagion.
Several studies, such as of Corsetti et al (2001) and Forbes & Rigobon (2002), have shown that the increase of the correlation coefficient between two financial series may be biased by the effect of the change in the market volatility originating from a shock, which causes heteroscedasticity. To correct this bias, an adjustment is required. Therefore, we use the one proposed by Forbes and Rigobon (2001).

X_t and Y_t are two financial series identifying the index returns in two different markets. To examine the relationship between the returns in different markets, we make use of the simple linear model as follows: $y_t = \alpha + \beta x_t + \varepsilon_t$ with, $E(\varepsilon_t)=0$, $E(\varepsilon_t^2) < \infty$ $E(x_t \varepsilon_t)=0$,
The correlation coefficient between the two series can be measured by:

$$\rho_{(x^t, y^t)} = \frac{\operatorname{cov}(x_t, y_t)}{\sigma_{x_t}\sigma_{y_t}}.$$

The adjusted correlation coefficient proposed by Forbes and Rigobon (2002) is then ρ^*, such as:

$$\rho^* = \frac{\rho}{\sqrt{1+\delta\left[1-(\rho)^2\right]}}$$

. With $\delta = \frac{V^c(x_t)}{V^t(x_t)} - 1$. Where "c" and "t" indicate the periods of crisis and tranquility.
Indeed, δ represents the relative increase in the variance of x between the two periods of crisis and tranquility.
After calculating the adjusted correlation coefficient for each pair of countries in the sample, we will statistically test its increase during the crisis period, to make sure that there is a pure

contagion or not. Thus, to statistically test the rise of an adjusted correlation coefficient, we will use the following two alternative hypotheses:

H_0: $\rho_1^* \leq \rho^*{}_2$

H_1: $\rho_1^* > \rho_2^*$

With, ρ_1^* : The correlation coefficient of the crisis period.

ρ_2^* : The correlation coefficient of the period of tranquility.

To test these hypotheses, we use a Student's test used by Collins and Biekpe (2002) whose statistics is:

$t = \left(\rho_1^* - \rho_2^*\right)\sqrt{\frac{n_1 + n_2 - 4}{1 - \left(\rho_1^* - \rho_2^*\right)^2}}$, with, t follows a Student to (n_1 + n_2- 4) degrees of freedom.

Therefore, accepting H_1, means that the correlation coefficient between the two markets has significantly increased between the quiet period and that of the crisis, which proves the pure contagion. However, the null hypothesis H_0 implies that the increase of the correlation coefficient reflects only the interdependence between the two markets. The test results of the adjusted correlation coefficient are presented in Table 3 in annexes.

3.2. Causality Study

To conduct a causality study, we must make the first step in testing stationarity. If we find that the series are non-stationary at the same level, we proceed to test for co-integration. Two cases can be distinguished depending on whether the series are cointegrated or not. In the absence of co-integration, we must estimate a VAR in first difference because the variables are integrated of order 1 and causality tests are applied to the series in first difference. Besides, in case of existence of cointegration relationships, an error correction term must be introduced into the VAR model of order K which becomes a VECM of order K-1, and in the latter case there are two types of causation tests: a short-term causality and a long-term causality.

In what follows, we will test the stationarity of the series of the index returns via the ADF test and that of Phillips Perron for two sub-periods of stability and crisis. Then, we will identify the number of cointegrating relationships for each of the two sub-periods, before studying the evolution of the causal links between the quiet period and that of the crisis.

3.2.1. Stationarity tests

To test the presence of unit root in the series, we will apply the Augmented Dickey-Fuller test (ADF test) and Phillips Perron’s test.

The ADF test considers three basic models for a single series (X_t where t = 1,… T):

- a model without constant or deterministic trend
- a model with constant and without deterministic trend
- a model with constant and deterministic trend.

The ADF tests the null hypothesis of the presence of unit root (the series X_t is non-stationary ie X_t Integrated of order 1) against the alternative hypothesis of no unit root (the series X_t is stationary ie integrated of order 0). Regression refers to the ADF test can be written as follows:
$\Delta X_t = \alpha + \gamma X_{t-1} + \Sigma^{k}_{i=1} \rho i\, \Delta X_{t-i} + \varepsilon_t$ (1)

- The null hypothesis $\gamma = 0$ implies that the series *Xt* is non-stationary in level.
- The alternative hypothesis $\gamma<0$ implies the absence of a unit root.

It should be noted that if the series is non-stationary under the null hypothesis, the test statistic will have a non-standard distribution and the lag order k is determined, for each series, by the method of criteria information. The latter consists in selecting among a number of models estimated for a number of lag from 0 to h (h is the maximum lag) one whose lag (p) minimizes the Akaike criteria (AIC) and Schwarz (SC) defined as follows: $AIC= \log \det \hat{\sum}_{\varepsilon} + (2N^2P/T)$

$SC= \log \det \hat{\sum}_{\varepsilon} + N^2 p\, (\log T/T)$

Where N is the number of variables, T is the number of observations and Σ_ε is an estimator of the variance-covariance matrix of residuals.
The test is applied first on the level series following a sequential strategy to identify an appropriate model. In the case where the series is non-stationary in level, we will apply the test on first difference series. The application of the Phillips-Perron test is identical to that of Dickey-Fuller, except that it requires the choice beforehand of parameter truncation (*l*) intervened in the calculation of the long term variance of the residuals. We will than present, for each variable, the results obtained with the value suggested by Newey and West (1987): l = int [4 (T/100) 2/9]. Note that the software (Eviews) allows to determine this parameter automatically. The results of the application of the ADF test and those of the Phillips Perron test, respectively, for the quiet period and that of the crisis, are summarized in Tables 4 and 5 in the appendices.

3.2.2. Johansen co-integration tests

Cointegration refers to the presence of long-term stable relationships between the variables X_t and Y_t. To determine the number of cointegration relationships, Johansen developed two statistics: the trace statistics and the maximum eigenvalue statistics. These two statistics coincide in their null hypotheses, but differ in their alternative hypotheses:
The trace statistics tests on a co-integrated VAR:

- The null hypothesis: there are at most *r* co-integrating relationships between X and Y
- The alternative hypothesis: there are at least *r + 1* co-integrating relations between X and Y.

The maximum eigenvalue test Statistics:

- The null hypothesis: there are at most r co-integrating relationships between the variables X and Y.
- The alternative hypothesis: there are exactly r + 1 co-integrating relations between X and Y.

Proceeding with tests of ADF and PP, we demonstrated that all series are integrated of order 1. We therefore have the right to pass the tests of cointegration. To determine the number of cointegrated vectors, we use the trace test which is more powerful than that of the maximum eigenvalue (Matei 2010). Table 6 in the appendix summarizes the cointegration tests carried out separately on the pre-crisis period and that of the crisis.

3.2.3. Granger causality Tests

According to Lardic and Mignon (2002), variable X causes variable Y in the Granger sense if and only if knowledge of the past of X improves the prediction of Y. Non-Granger causality means that the past of variable X_t provides no additional information to variable Y_t. Non-causality is showed using a test of significance of the X_t coefficient delays in a regression of Y_t on X_t and Y_t delays. We can say that X causes Y in the Granger sense if the estimated coefficients of X_t delays are significantly different from zero. In our work, both variables X_t and Y_t represent the series of the index returns of two countries. We follow the methodology of Kleimeier and Sander (2003) and consider the bivariate VAR model in levels as follows:

$X_t = \alpha_x + \sum \beta_{x,i} X_{t-i} + \sum \delta_{x,i} Y_{t-i} + \varepsilon_{x,t}$ (2) (causality of Y to X)

$Y_t = \alpha_y + \sum \beta_{y,i} Y_{t-i} + \sum \delta_{y,i} X_{t-i} + \varepsilon_{y,t}$ (3) (causality de X to Y)

The Granger causality therefore tests if all the coefficients δi are zero with a standard test (F). Three possibilities can be identified at this level:

- If we reject H_0 ($\delta_x = 0$) in equation (2), we can say that Y causes X in the Granger sense.
- If we reject H_0 ($\delta_y = 0$) in equation (3), we can say that X causes Y in the Granger sense.
- If we reject the null hypothesis of no causality in the two previous cases, variables X and Y are therefore interdependent.

The aim of this section is to test the presence of Granger causality in a bivariate VAR model between the nine studied countries, in twos, on the stock market. More precisely, we try to analyze the evolution of the causal links between the quiet period and that of the crisis.

Before performing the tests of Granger causality, we have to first estimate VECM and VAR models through which we will test causality. Two cases can be distinguished depending on whether the series are cointegrated or not: In the absence of co-integration relationships, we estimate a VAR in first differences because the variables are integrated of order 1 and the tests of Granger causality will be applied to the series in first difference. If there is a cointegration relationship between variables X and Y, an error correction term must be introduced into the VAR model in difference. The VAR model of order k becomes a VECM of order k-1 as follows:

$\Delta X_t = \alpha_x + \sum \beta_{x,i} \Delta X_{t-i} + \sum \delta_{x,i} \Delta Y_{t-i} + \gamma_x ECT_{x,t-1} + \varepsilon_{x,t}$ (4)

$\Delta Y_t = \alpha_y + \sum \beta_{y,i} Y_{t-i} + \sum \delta_{y,i} \Delta X_{t-i} + \gamma_y ECT_{y,t-1} + \varepsilon_{y,t}$ (5), ECT: the term error correction

In the case of a VECM, there are two types of causality to be tested: a non-causality of short term of Y on X and a non-causality of long-term of Y on X. The order of the VAR or VECM is determined by the information criteria method and based primarily on criteria of Akaike (AIC) and Schawrtz (SIC). When these two criteria diverge, we will opt for the first test since it is considered an efficient estimator of p (Lardic and Mignon (2002)).

The results of causality tests between the nine countries are summarized in Table 7 in the appendices. The results are distinguished not only according to the periods (the quiet period and the crisis period), but also according to the type of causality adopted in our estimates (the causality of short-term and the causality of long-term). The decision rule is then: we accept the null hypothesis of no causality if the probability is greater than 0.05.

4. Results and Interpretation

4.1. Descriptive analysis

4.1.1. Graphical analysis

A first description of the evolution of the index returns of each country in the sample is given by the graphs in Figure 1 in the appendices. The graphs show a significant simultaneous collapse of indices especially from July 2007, the triggering date of the crisis of the subprime mortgages in the United States. This collapse became even more serious as soon as the beginning of 2008. In September and October 2008, it reached an unbearable magnitude, as the global stock markets experienced the most dangerous decline in their history. From early 2009, the indices began to have an upward trend again, but they were far from their levels before the crash in the fall of 2008. This graphical analysis is supported further by descriptive statistics forming the subject of the next section.

4.1.2. Descriptive Statistics

A statistical description allows us to highlight the evolution of the stock index returns and changes in volatility of these indices between the quiet period and that of the crisis. Descriptive statistics is summarized in Table 2 in appendices.

From this table, we note that, for most countries, the index returns fell, on average, during the crisis period compared to the period before the crisis. However, the standard deviations increased for all countries, except China, during the crisis period compared to the period of tranquility. The statistics describes a sharp depreciation generalized of the index returns, associated with a more intense volatility. We also note that the coefficients of variation representing the ratio between the mean and the standard deviation increased during the crisis period compared to the period of tranquility for all countries except for China. This represents an increase in volatility. The similarity that shows the evolution of the index returns raises the need for a correlations study.

4.2. The results of the adjusted correlation coefficient tests

The correlations study during the two sub-periods gives us a preliminary description of relationships between the different series of the index returns and gives an idea about their evolution. Estimates of adjusted correlation coefficients, for the index returns in the quiet period (04 January 2006-29 June 2007) and that of the crisis (02 July 2007-30 December 2009), as well as results of Student tests, are presented in Table 3 in the appendices.

From Table 3, we can see a significant increase of the adjusted correlation coefficient between the following stock markets: American, English, French, German, Japanese, Russian, except for the Chinese market, India and Brazil. In addition, most of the t-student of adjusted correlation coefficients are significant at the threshold of 1% and 5%. Referring to the approach of Forbes and Rigobon (2000), we interpret this significant increase in correlation coefficients as evidence of pure contagion.

In fact, the adjusted correlation coefficients of the United States, where the crisis occurred and then spread to the United Kingdom, France, Germany, Japan and Russia, are significant. The values of t-Student of the increase of correlation coefficients are respectively equal to 4.6373, 2.0831, 3.2805, 6.9972 and 12.8911.

However, the increase in the adjusted correlation coefficients of the stock markets of the United States, the United Kingdom, France, Germany and Russia, as a source of contagion to the stock

markets of china, India and Brazil, is not statistically significant. This means that the spread of the crisis in these countries to the markets of China, India and Brazil is not the subject of a pure contagion but a simple interdependence through permanent financial linkages that existed both during the period of tranquility and during the crisis period.
The increase in the adjusted correlation coefficients of the Japanese stock market, as a source of contagion of the Indian and Brazilian markets, is not significant but significant at the threshold of 1% for the Chinese market. Therefore, there is a feedback effect between these two markets (Japan, China) to the order of (2.9122, 3.6665). The values of t-Student also indicate that there is a feedback effect of contagion between the U.S. market, on the one hand, and those of the United Kingdom, France, Germany, Japan and Russia, on the other hand. The increase in the adjusted correlation coefficients between the (USA, UK), (USA, France) (USA, Germany) (USA, Japan), and (U.S., Russia) are respectively equal to (4.6373, 4.8014), (2.0831, 1.9508), (3.2805, 1.3507) (12.8911, 12.2669), and (6.9972, 6.9340). Similarly, there is a feedback effect between India and Brazil in the order of (4.4680, 4.1478).

4.3. Results of the stationarity tests

The application of the ADF test shows that all the series of the index returns are integrated of order one during the tranquil period and that of the crisis, except RTSI series, which is found integrated of order 0, I (0), during the pre-crisis period with a probability close to the significance threshold of 0.05, it is weakly stationary in level. Due to the critics associated with this test for its lack of precision in the case of series with tendency change, we concluded that this series has a unit root level. This choice was verified using the (KPSS and ERS) tests. The test results of PP confirm those found through the application of ADF test: all the series are non-stationary.

4.4. Results of Johansen cointegration tests

The decision rule for the Trace test is to reject the null hypothesis of no (r) cointegration relationship when TR statistics is greater than the critical value (i.e. whether the probability of the associated significance is less than 0.05). Under the second hypothesis, the critical values at the threshold of 5% are equal to 25.87211 for $r = 0$ and 12.51798 for $r = 1$ for the quiet period and 15.49471 for $r = 0$ and 3.841466 for $r = 1$ for the crisis period.
The results in Table 6 in the appendices show that, during the quiet time, all the series of the index returns are not cointegrated, in twos, except for two cases: the couples of the index returns of the (United Kingdom, Russia) and (Japan, Russia). It can be noted, as well, that there is a close long-term relationship between Russia and the United Kingdom and Japan on the financial plan. Russia and Japan are two financial and economic important centers in the Asian region. Both of them have experienced a period of crisis in the past, Japan during the 1990s and Russia in 1999. Regarding the UK, we have seen some sensitivity to the movement of capital in Russia. The crisis period is also marked by the absence of long-term relationships between the series of the stock index returns, but not between the series of United States and Germany, on the one hand, and the United States and China, on the other hand.

4.5. Results of causality tests

The results of the causality tests show that the quiet period is characterized by the presence of short-term causal links between 24 pairs of countries and the lack of causality in the long term. During the crisis period, we witnessed the emergence of new causal links between the studied countries. We can identify 57 cases of short-term causality and 2 cases of long-term. We can therefore conclude that the causal links between the nine countries vary between the quiet period and that of the crisis. This significant increase of the links between countries, especially, between the United States, the United Kingdom, France and Germany, on the one hand, and the other countries, on the other hand, suggests the presence of a psychological contagion in the manner of Masson (1999) or of Goldfajn and Valdez (1997), which has affected the investor’s perceptions on the situation of the developed and emerging countries considered.

According to Masson (1999), a crisis in one country can coordinate the investors' expectations in other countries by encouraging them to change their expectations from good to poor balance and can, therefore, cause a crisis in the second country. The transition from good to poor balance and the transmission of the initial shock are generated not by real economic ties, but rather by a change in the investors' beliefs. We can also mention the assumption which states that there is a strong liquidity shock in the U.S. market. The latter may push the investors to reward their portfolio by selling assets in the market of another country unaffected by the crisis if they want to continue operating in this market. A powerful liquidity shock caused by a crisis in the country affects the investors' capital and greatly reduces their liquidity. Being constrained by regulatory requirements or by rationing in credit, these investors are forced to sell their holdings of assets in all the countries not affected by the crisis causing then bad equilibria (Matei (2010)).

The emergence of new causal links during the crisis period compared to the quiet period was explained by Dorunbush et al. (2000) by the fact that a crisis in one country may change the investors' expectations on the vulnerabilities in other countries. Calvo (1999) emphasizes the important role that can be played by problems of the asymmetric information and of coordination in contagion and essentially in the "pure contagion" to the extent that the transmission mechanisms during the crisis are different from those of the quiet period. This is what we were able to validate in the stock markets of nine countries of our sample during the 2008 financial crisis.

4.6. Impulse analysis

The response functions to shocks highlight the nature of the effects of the various shocks on each index. The decomposition of the forecasting error variance seeks the degree of contribution of the different indexes in the variability of other indices. This approach can be viewed as an extension of the causality study already presented in the previous paragraph. Figures 2 and 3 in the appendices illustrate the response functions respectively during the quiet period and that of the crisis for different indexes. The results of the forecasting error decomposition variance, respectively, for the quiet period and that of the crisis are summarized in Tables 9 and 10 and illustrated in Figures 4 and 5 in the appendices.

4.6.1. Analysis of response functions to shocks

When comparing the response functions during the quiet period with those of the crisis period, we can see that the S & P500 is almost totally self explained during the two sub-periods and the other indices have no effect. However, this index has a significant effect on all the other indices except the Chinese index which also admits a strong self explanation. We also noticed that, during the crisis period, the indexes take a little more time, in terms of number of days of the shock, before returning to their equilibrium in a definitive way.

4.6.2. Decomposition of the prediction error variance

During the crisis, the S & P 500 has maintained a strong self-explanation in the order of 91% (Table 10 in appendix), which is slightly lower than the self-explanation during the pre-crisis period which was about 97% (Table 9). However, its contribution to the volatility of the other indices increased during the crisis period compared with the quiet period.
Indeed, the contribution of the S & P500 in the volatility of the FTSE 100 Index rose to 55% during the crisis period instead of 32% during the quiet period and to 59% for the CAC 40 and DAX instead of 34% and 36% during the period before the crisis.
However, the contribution of the FTSE 100 in the volatility of the DAX and CAC 40 during the crisis period compared to the quiet period dropped from 44% and 41% to 24% and 20% (Table 9 and 10 annexes). The volatility of the Nikkei 225 index during the crisis period is attributed within a range of 34%, 10%, 7% to the S & P 500, FTSE 100 and CAC 40. Its self-explanation decreased from 67% to 44% between the quiet period and that of the crisis. The Chinese index kept a very high self-explanation, although it declined from 92% to 82% between the pre-crisis period and the crisis one. While its sensitivity to the S & P 500 rose 4% to 11% between the two periods under quiet and crisis. On BSE 30 index, its self-explanation which was about 69% during the period of stability has become the order of 43% during the crisis. However the contribution of the S & P 500 and FTSE 100 in its volatility between pre-crisis period and that of the crisis period increased from 18% and 6% to 36% and 13%. The contribution of the S & P 500 index in the volatility of the Ibovespa index reached 71% during the crisis, while the self-explanation of the latter dropped to about 22%. Similarly, the sensitivity of the RTSI index to the S & P 500 reached 27% instead of 17%, while the contribution of the FTSE 100 fell from 17% to 13%. The BSE 30 and Ibovespa indexes in turn contribute to its volatility with about 3%.
We conclude that the S & P500 is almost entirely self-explained. However it has a significant effect on all the other indices both during the quiet period and the crisis one, except for the Chinese index which is, in turn, characterized by a strong self-explanation. The decomposition analysis of the variance confirmed the results of the analysis of response functions; since we found that the contribution of the S & P500 in the volatility of the other indices is still strong and becomes even stronger during the crisis. By contrast, the contribution of other indices in the volatility of the S & P500 index is negligible.

5. Conclusions and future research paths

In our work, we tried to explore the contagion phenomenon during the 2008 financial crisis. To do this, we conducted a correlations study supplemented by a causality study. This causality study was extended to an impulse analysis.
Our results proved the existence of pure contagion between the stock markets of the United States, the United Kingdom, France, Germany, Japan and Russia. Concerning China, India and Brazil it is not a pure contagion, but rather interdependence. We also noted that the causal links between the nine studied countries vary between the pre-crisis period and that of the crisis and that the latter brings up new causality in the short term as well as in the long term. This confirms

the results of the correlations study about the presence of a form of " pure" contagion in the stock market during the crisis.

The impulse analysis, by calculating the response functions to shocks and the variance decomposition of the forecast error for the different indexes, revealed that the index of the New York Stock Exchange is almost entirely self explained and contributes to the volatility of all the other indices in both the quiet period and that of the crisis and that this contribution becomes stronger during the crisis. This reflects the influence of the United States on others countries and the importance of its Stock market as a leader market that follows the other financial markets.

It should be noted that the causality study allows showing the existence of causality relationships and identifying their directions, but it does not specify the channels through which the crisis was transmitted from one country to another. It is also noteworthy that in our study we analyzed only one type of market, the stock market, of nine countries. It is much more relevant to consider a more diverse and wide sample of countries and focus on an analysis of several markets (sovereign debt market, stock market, money market, foreign exchange market) to explore the importance of interactions between these markets.

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Appendices:

Figure 1: Evolution of stock index returns (2006-2009)

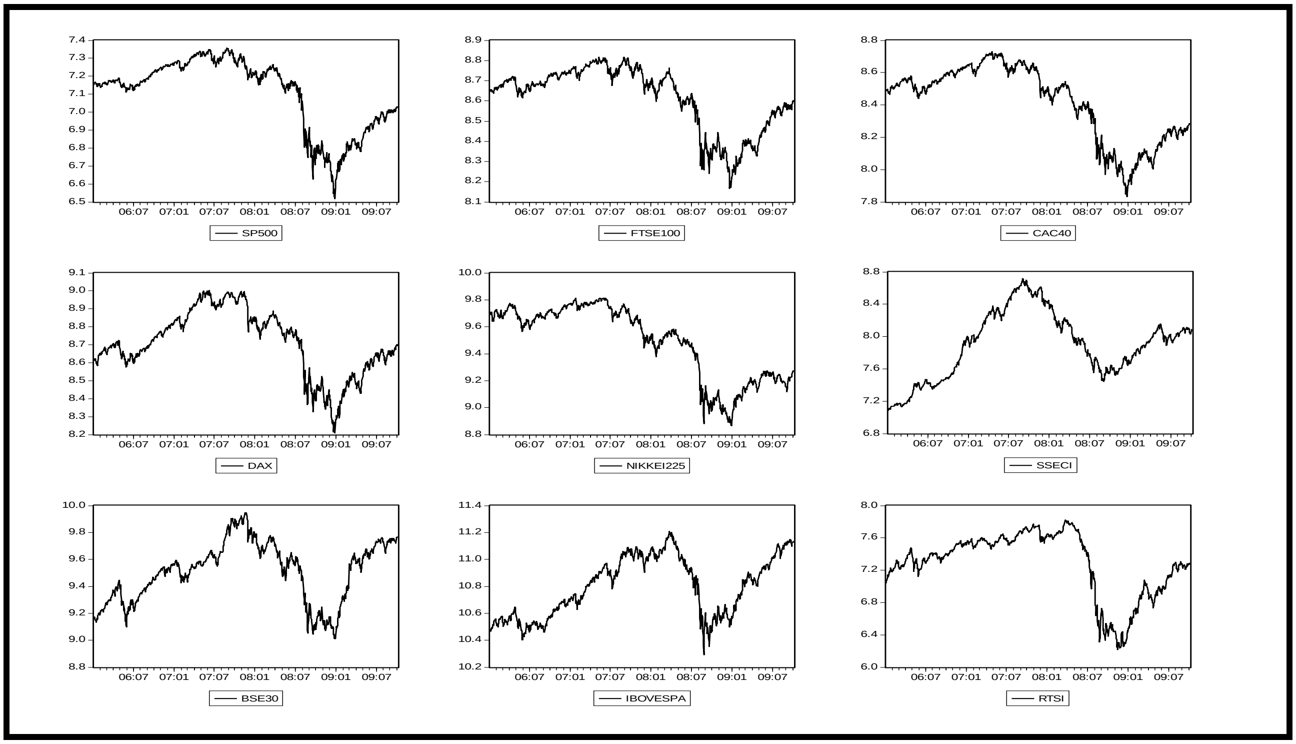

Figure 2: Response functions to shocks during quiet period

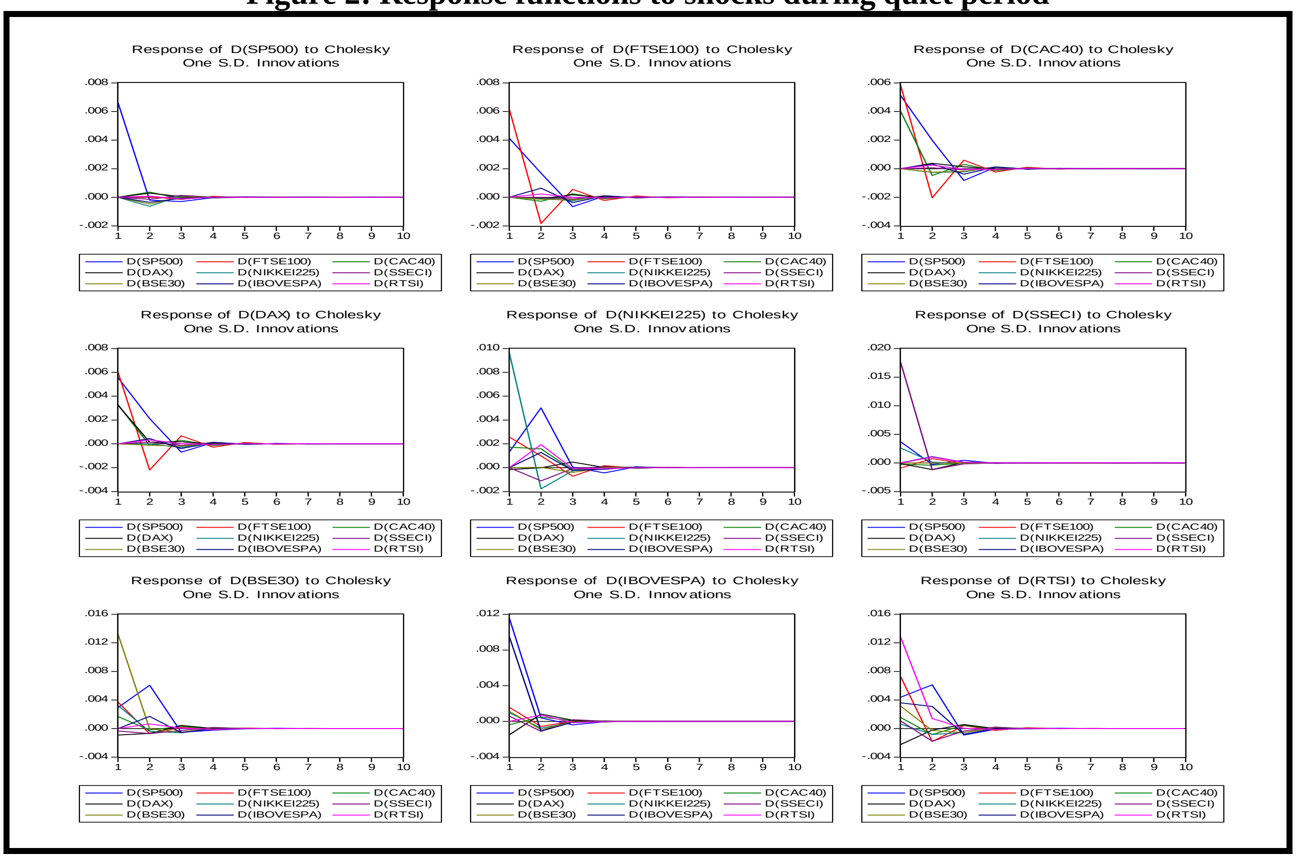

Figure 3: Response functions to shocks during crisis period

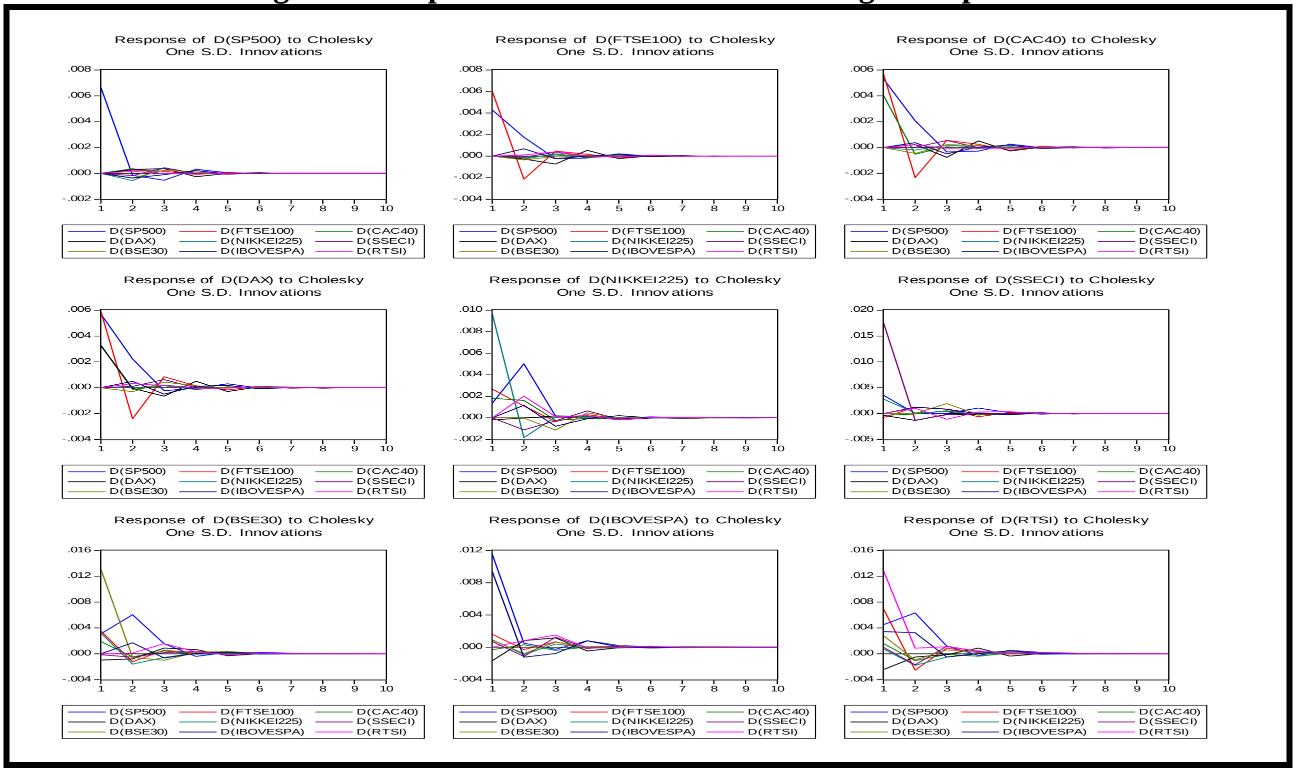

Figure 4: Decomposition of the forecast error variance during quiet period

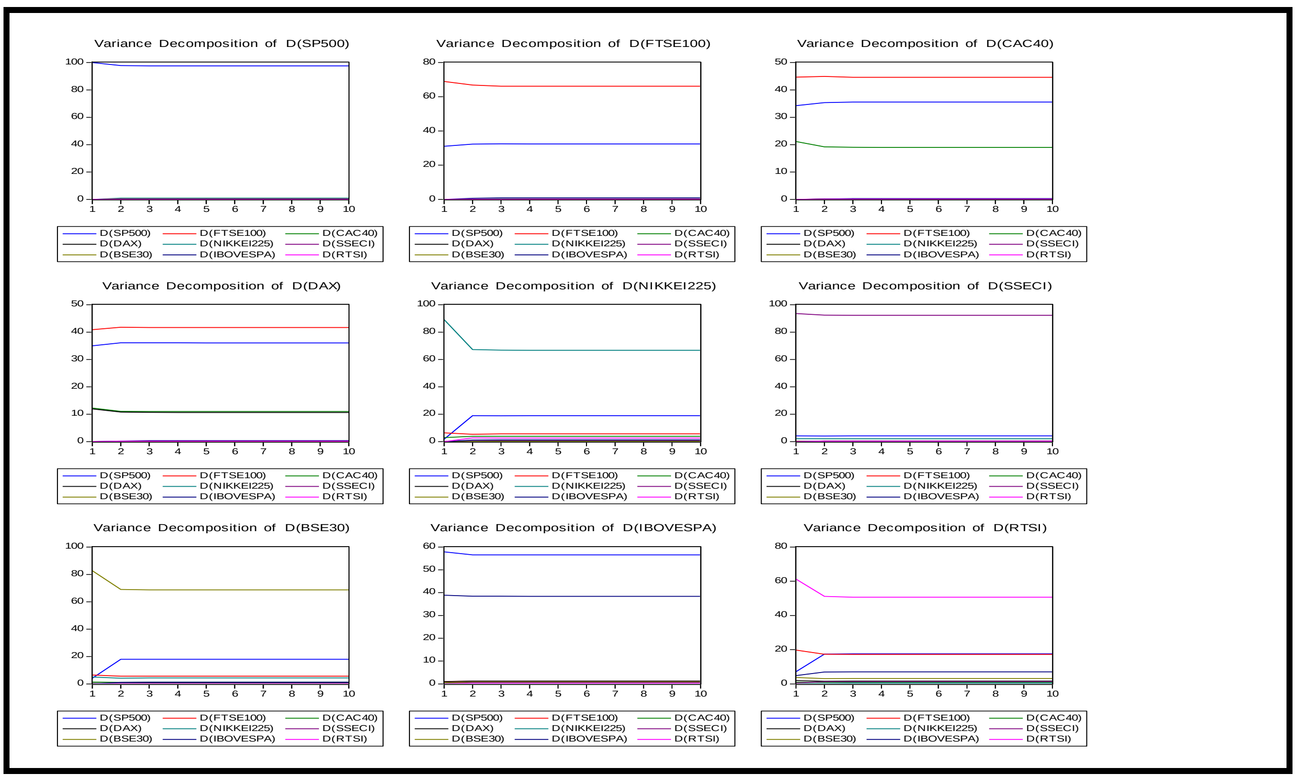

Figure 5: Decomposition of the forecast error variance during crisis period

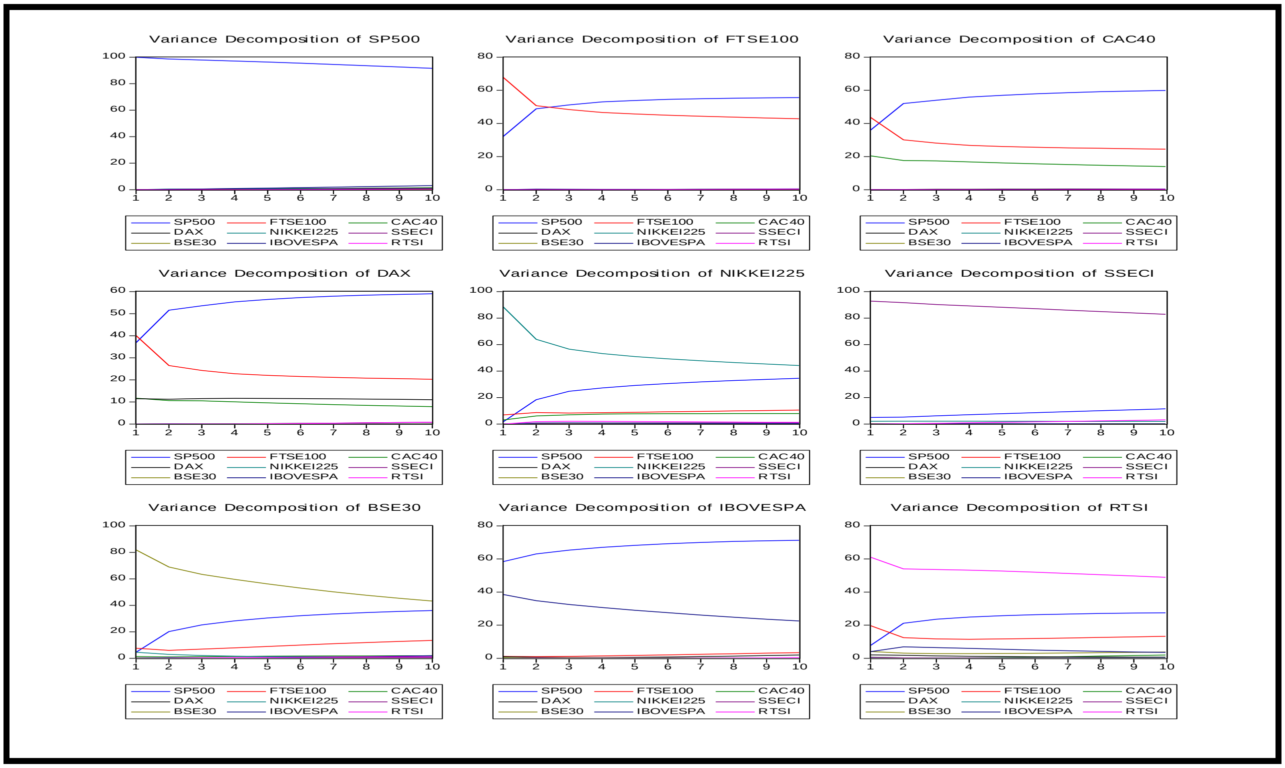

Table 2: Descriptive Statistics

Indices	**S&P 500**	**FTSE 100**	**CAC 40**	**DAX**	**Nikkei 225**	**SSECI**	**BSE 30**	**Ibovespa**	**RTSI**
					Quiet period				
Average	7.213546	8.711435	8.578587	8.744745	9.713969	7.619540	9.402067	10.61897	7.397973
Standard Deviation	0.063228	0.047111	0.071827	0.109424	0.055283	0.390656	0.133598	0.126613	0.131287
Coef. of variation	0.008765	0.005407	0.008372	0.012513	0.005691	0.051270	0.014209	0.011923	0.017746
					Crisis period				
Average	7.037284	8.551987	8.316890	8.684663	9.351832	8.053182	9.565814	10.89592	7.205916
Standard Deviation	0.220713	0.171909	0.236899	0.208700	0.253981	0.333919	0.240750	0.201501	0.481230
Coef. of variation	0.031363	0.020101	0.028484	0.024030	0.027158	0.041464	0.025167	0.018493	0.066782

Table 3: Matrix of correlation coefficients adjusted

Tranquil period (04 January 2006 - 29 June 2007)									
	USA	**UK**	**France**	**Germany**	**Japan**	**China**	**India**	**Brazil**	**Russia**
USA	1	0,6834	0,8221	0,9246	0,2918	0,9411	0,7795	0,8848	0,4029
UK	0,6994	1	0,8653	0,9068	0,3281	0,9031	0,7538	0,8734	0,4171
France	0,8065	0,8419	1	0,9510	0,3322	0,9254	0,7874	0,8841	0,4233
Germany	0,7984	0,7471	0,8716	1	0,3217	0,9484	0,7229	0,9395	0,3924
Japan	0,3725	0,4006	0,4405	0,6333	1	0,7371	0,5378	0,6914	0,2550
China	0,5632	0,4419	0,5349	0,8015	0,1989	1	0,6379	0,8037	0,4130
India	0,5405	0,4929	0,5722	0,7030	0,2428	0,8678	1	0,6809	0,5209
Brazil	0,6544	0,6160	0,6743	0,9163	0,3147	0,9292	0,6346	1	0,3651
Russia	0,4196	0,4186	0,4608	0,6341	0,2059	0,8893	0,7787	0,6703	1
Crisis period (02 July 2007 - 30 December 2009)									
	USA	**UK**	**France**	**Germany**	**Japan**	**China**	**India**	**Brazil**	**Russia**
USA	1	0,8353	0,8844	0,9677	0,6571	0,8407	0,5768	0,5584	0,6195
UK	0,8462	1	0,8375	0,9598	0,5501	0,8629	0,6238	0,6117	0,5945
France	0,8730	0,8108	1	0,9682	0,6923	0,8588	0,5347	0,4902	0,5150
Germany	0,9027	0,8726	0,9129	1	0,6624	0,8683	0,6153	0,5641	0,5925
Japan	0,7538	0,6384	0,8007	0,9052	1	0,8536	0,5186	0,4857	0,5191
China	0,3554	0,3714	0,3984	0,6172	0,2917	1	0,6132	0,5123	0,3279
India	0,3424	0,3667	0,3267	0,5935	0,2315	0,8533	1	0,8124	0,4119
Brazil	0,2934	0,3196	0,2619	0,4952	0,1890	0,7432	0,7761	1	0,4188
Russia	0,6380	0,5963	0,5553	0,8164	0,4360	0,8301	0,6768	0,7281	1
t-Student									
	USA	**UK**	**France**	**Germany**	**Japan**	**China**	**India**	**Brazil**	**Russia**
USA	0	**4,8014 *****	**1,9508 ****	**1,3507***	**12,2669 *****	-3,1545	-6,4709	-10,7914	**6,9340 *****
UK	**4,6373** ***	0	-0,8686	**1,6594****	**7,1185 *****	-1,2574	-4,0975	-8,4732	**5,6367 *****
France	**2,0831 ****	-0,9721	0	0,5380	**12,0641 *****	-2,0886	-8,1617	-13,3971	**2,8796 *****
Germany	**3,2805 *****	**3,9542 *****	**1,2932***	0	**11,3290 *****	-2,5110	-3,3816	-12,6593	**6,3829 *****
Japan	**12,8911 *****	**7,6515 *****	**12,0679 *****	**8,8308***	0	**3,6665 *****	-0,6002	-6,5684	**8,5586 *****
China	-6,6427	-2,2105	-4,3049	-5,8591	**2,9122 *****	0	-0,7726	-9,5185	-2,6680
India	-6,3151	-3,9768	-7,9157	-3,4413	-0,3526	-0,4527	0	**4,1478** ***	-3,4297
Brazil	-12,1013	-9,7023	-14,1496	-14,5110	-3,9582	-5,9176	**4,4680 *****	0	**1,6798 ****
Russia	**6,9972 *****	**5,6425 *****	**2,9673 *****	**5,7954 *****	**7,3925 *****	-1,8541	-3,2033	**1,8089** **	0

(*), (**) And (***) denote that the t-statistics are significant at the 10%, 5% and 1% respectively. Values in bold represent the acceptance of the hypothesis H1: the coefficient has significantly increased between quiet and crisis period.

Table 4: Stationarity tests of ADF

Indices	Tranquil period					Crisis period				
	Calculated ADF		**Critical Value 5%**		**I(d)**	**Calculated ADF**		**Critical Value 5%**		**I(d)**
	In level	**Sig. Prob.**	**In Difference**	**Sig. Prob.**		**In level**	**Sig. Prob.**	**In Difference**	**Sig. Prob.**	
S&P 500	-2.584365	0.2878	-19.54957	0.0000	I(1)	-0.867475	0.9575	-29.36592	0.0000	I(1)
FTSE 100	-3.159282	0.0945	-21.19880	0.0000	I(1)	-0.722810	0.9703	-12.75796	0.0000	I(1)
CAC 40	-2.658385	0.2548	-20.52226	0.0000	I(1)	-0.978769	0.9447	-27.84358	0.0000	I(1)
DAX	-1.750590	0.7266	-19.89045	0.0000	I(1)	-1.225206	0.9037	-26.70463	0.0000	I(1)
Nikkei 225	-2.674340	0.2480	-19.75864	0.0000	I(1)	-1.470382	0.8388	-26.40765	0.0000	I(1)
SSECI	-1.895480	0.6548	-20.17217	0.0000	I(1)	-0.702367	0.9718	-25.49727	0.0000	I(1)
BSE 30	-2.383334	0.3876	-18.23262	0.0000	I(1)	-0.953029	0.9479	-23.87856	0.0000	I(1)
Ibovespa	-1.896795	0.6541	-19.82677	0.0000	I(1)	-1.270870	0.8937	-26.33768	0.0000	I(1)
RTSI	-3.444977	0.0472	-17.29177	0.0000	I(0)	-0.818372	0.9623	-21.74746	0.0000	I(1)

Table 5: Stationarity tests of PP

Indices	Tranquil period					Crisis period				
	calculated PP		**Critical Value 5%**		**I(d)**	**Calculed PP**		**Critical Value 5%**		**I(d)**
	In level	**Sig. Prob.**	**In Difference**	**Sig. Prob.**		**En niveau**	**Sig. Prob.**	**In Difference**	**Sig. Prob.**	
S&P 500	-2.294401	0.4355	-20.18977	0.0000	I(1)	-0.840442	0.9602	-29.74241	0.0000	I(1)
FTSE 100	-3.029731	0.1255	-21.19123	0.0000	I(1)	-0.999614	0.9419	-28.24673	0.0000	I(1)
CAC 40	-2.578897	0.2903	-20.50047	0.0000	I(1)	-0.819893	0.9621	-28.25593	0.0000	I(1)
DAX	-1.706554	0.7467	-19.87395	0.0000	I(1)	-1.043970	0.9357	-26.75325	0.0000	I(1)
Nikkei 225	-2.624861	0.2695	-19.75864	0.0000	I(1)	-1.309336	0.8846	-26.49094	0.0000	I(1)
SSECI	-1.914841	0.6447	-20.13999	0.0000	I(1)	-0.683039	0.9731	-25.49720	0.0000	I(1)
BSE 30	-2.444167	0.3561	-18.21801	0.0000	I(1)	-0.932408	0.9504	-23.86073	0.0000	I(1)
Ibovespa	-1.734847	0.7339	-20.01917	0.0000	I(1)	-0.985803	0.9438	-26.72694	0.0000	I(1)
RTSI	-3.805204	0.0173	-17.35191	0.0000	I(0)	-0.604628	0.9781	-21.74627	0.0000	I(1)

Table 6: Cointegration tests

		Tranquil period				Crisis period			
Country	**r relation -ship**	**Eigen-value**	**Stat. Trace**	**Sig. Prob.**	**Cointegra -tion**	**Eigenvalue**	**Stat. Trace**	**Sig. Prob.**	**Cointegra-tion**
USA –UK	r =0 r =1	0.037777 0.020912	21.35191 7.565851	0.1650 0.2892	No	0.014085 0.003483	10.92289 2.156364	0.2163 0.1420	No
USA – France	r =0 r =1	0.035493 0.018848	19.74945 6.811956	0.2389 0.3645	No	0.014082 0.003002	10.62288 1.858228	0.2358 0.1728	No
USA-Germany	r =0 r =1	0.022679 0.008797	11.40756 3.171999	0.8509 0.8555	No	0.024561 0.002614	**16.98585** 1.617678	**0.0296** 0.2034	**Yes**
USA –Japan	r =0 r =1	0.034539 0.019312	19.67404 7.020378	0.2429 0.3424	No	0.012739 0.004465	10.68841 2.765251	0.2314 0.0963	No
USA – China	r =0 r =1	0.024168 0.014078	13.95029 5.118356	0.6617 0.5795	No	0.022520 0.002686	**15.73861** 1.662096	**0.0459** 0.1973	**Yes**
USA – India	r =0 r =1	0.027517 0.013873	15.03222 5.015181	0.5719 0.5942	No	0.009096 0.002438	7.155290 1.508461	0.5597 0.2194	No
USA – Brazil	r =0 r =1	0.028567 0.014705	15.81095 5.347973	0.5078 0.5472	No	0.008070 0.003379	7.099176 2.091500	0.5661 0.1481	No
USA – Russia	r =0 r =1	0.046182 0.022648	25.19815 8.223940	0.0605 0.2339	No	0.015159 0.002161	10.77668 1.336831	0.2256 0.2476	No
UK –France	r =0 r =1	0.047205 0.017388	23.78862 6.332309	0.0889 0.4193	No	0.007219 0.003307	6.524863 2.047394	0.6335 0.1525	No
UK – Germany	r =0 r =1	0.048358 0.010794	21.81144 3.917981	0.1475 0.7540	No	0.010339 0.003888	8.830701 2.407736	0.3813 0.1207	No
UK –Japan	r =0 r =1	0.047260 0.019877	24.65660 7.227661	0.0703 0.3214	No	0.005581 0.003988	5.928389 2.469503	0.7040 0.1161	No
UK –China	r =0 r =1	0.027083 0.011203	13.97864 4.066982	0.6594 0.7324	No	0.020326 0.001954	13.89976 1.209053	0.0857 0.2715	No
UK –India	r =0 r =1	0.030078 0.018026	17.54277 6.548582	0.3755 0.3940	No	0.010099 0.002250	7.665508 1.392328	0.5018 0.2380	No
UK –Brazil	r =0 r =1	0.043601 0.012106	20.43362 4.384759	0.2048 0.6860	No	0.007534 0.001699	5.724238 1.050602	0.7278 0.3054	No
UK –Russia	r =0 r =1	0.044475 0.029383	**27.11458** 10.73656	**0.0349** 0.0975	**Yes**	0.011528 0.002083	8.454644 1.288877	0.4181 0.2563	No
France - Germany	r =0 r =1	0.035942 0.010992	17.20395 3.989993	0.3999 0.7436	No	0.011371 0.004527	9.871712 2.804319	0.2907 0.0940	No
France –Japan	r =0 r =1	0.040927 0.017457	21.38356 6.339901	0.1637 0.4184	No	0.012230 0.005057	10.73830 3.133371	0.2281 0.0767	No
France –China	r =0 r =1	0.022312 0.011462	12.30761 4.161610	0.7903 0.7186	No	0.022489 0.001888	15.22466 1.167969	0.0549 0.2798	No
France –India	r =0 r =1	0.022003 0.016838	14.12295 6.113421	0.6475 0.4460	No	0.011168 0.002329	8.381671 1.441195	0.4255 0.2299	No
France – Brazil	r =0 r =1	0.028906 0.012058	14.92685 4.367443	0.5806 0.6885	No	0.008857 0.002099	6.796242 1.298422	0.6015 0.2545	No

France - Russia	r =0 r =1	0.042687 0.018246	22.33423 6.629191	0.1296 0.3848	No	0.011166 0.001835	8.074695 1.135377	0.4575 0.2866	No

		Tranquil period				**Crisis period**			
Country	**r relation -ship**	**Eigen-value**	**Stat. Trace**	**Sig. Prob.**	**Cointegra-tion**	**Eigen-value**	**Stat. Trace**	**Sig. Prob.**	**Cointegra-tion**
Germany – Japan	r =0 r =1	0.034478 0.011006	16.61495 3.983968	0.4442 0.7444	No	0.013386 0.005366	11.65331 3.325165	0.1743 0.0682	No
Germany – China	r =0 r =1	0.014978 0.010780	9.360552 3.912593	0.9493 0.7547	No	0.021416 0.002157	14.71336 1.334305	0.0653 0.2480	No
Germany – India	r =0 r =1	0.018806 0.016155	12.52139 5.781768	0.7746 0.4885	No	0.008719 0.001872	6.569781 1.157966	0.6281 0.2819	No
Germany – Brazil	r =0 r =1	0.045336 0.011180	20.75004 4.047616	0.1903 0.7352	No	0.007188 0.002550	6.036011 1.577893	0.6913 0.2091	No
Allemagne – Russia	r =0 r =1	0.042217 0.017750	21.97573 6.447317	0.1417 0.4057	No	0.011837 0.001717	8.420867 1.061898	0.4215 0.3028	No
Japan –China	r =0 r =1	0.024724 0.013373	13.89788 4.860402	0.6660 0.6165	No	0.013193 0.001483	9.124606 0.917120	0.3540 0.3382	No
Japan –India	r =0 r =1	0.024659 0.016803	15.13093 6.117552	0.5637 0.4455	No	0.008152 0.002002	6.297211 1.238487	0.6604 0.2658	No
Japan –Brazil	r =0 r =1	0.031421 0.011380	15.61315 4.120242	0.5239 0.7246	No	0.008369 0.002604	6.805602 1.611639	0.6004 0.2043	No
Japan –Russia	r =0 r =1	0.048822 0.023939	**26.74236** 8.722760	**0.0389** 0.1981	**Yes**	0.013137 0.001974	9.393925 1.221225	0.3302 0.2691	No
China –India	r =0 r =1	0.029882 0.013150	15.73062 4.778784	0.5143 0.6284	No	0.014490 0.003371	11.10725 2.086965	0.2050 0.1486	No
China –Brazil	r =0 r =1	0.020773 0.009092	10.87520 3.297160	0.8822 0.8395	No	0.007932 0.002377	6.391947 1.470472	0.6492 0.2253	No
China –Russia	r =0 r =1	0.055211 0.010298	24.23926 3.736931	0.0788 0.7798	No	0.017141 0.003103	12.60594 1.920899	0.1301 0.1658	No
India –Brazil	r =0 r =1	0.018469 0.009481	10.14053 3.429356	0.9189 0.8221	No	0.011469 0.001546	8.084840 0.956104	0.4564 0.3282	No
India –Russia	r =0 r =1	0.045602 0.016787	22.96097 6.111540	0.1104 0.4463	No	0.006570 0.001841	5.212514 1.138952	0.7859 0.2859	No
Brazil –Russia	r =0 r =1	0.044586 0.020396	23.77195 7.397794	0.0893 0.3048	No	0.010570 0.002662	8.214386 1.647599	0.4428 0.1993	No

Table 7: Short-term causality tests

	Tranquil period				Crisis period			
Country	**Chi-square**	**specification**	**Prob.**	**Causality**	**Chi-square**	**specification**	**Prob.**	**Causality**
USA => UK UK => USA	46.00576 1.680046	VAR (4) VAR (4)	0.0000 0.7943	Yes No	152.1111 25.84376	VAR (5) VAR (5)	0.0000 0.0001	Yes Yes
USA => France France => USA	42.77150 4.005574	VAR (3) VAR (3)	0.0000 0.2609	Yes No	176.7497 29.77268	VAR (5) VAR (5)	0.0000 0.0000	Yes Yes
USA => Germany Germany => USA	36.44264 3.890120	VAR (3) VAR (3)	0.0000 0.2736	Yes No	27.75107 40.39985	VECM (7) VECM (7)	0.0002 0.0000	Yes Yes
USA => Japan Japan => USA	80.64307 3.707243	VAR (1) VAR (1)	0.0000 0.0542	Yes No	372.0091 23.95752	VAR (8) VAR (8)	0.0000 0.0023	Yes Yes
USA => China China => USA	0.000734 0.575000	VAR (1) VAR (1)	0.9784 0.4483	No No	16.04187 63.97693	VECM (6) VECM (6)	0.0135 0.0000	Yes Yes
USA => India India => USA	70.21447 3.031314	VAR (2) VAR (2)	0.0000 0.2197	Yes No	52.73331 4.964085	VAR (6) VAR (6)	0.0000 0.5484	Yes No
USA => Brazil Brazil => USA	3.317035 2.223769	VAR (1) VAR (1)	0.0686 0.1359	No No	10.19603 12.48684	VAR (3) VAR (3)	0.0170 0.0059	Yes Yes
USA => Russia Russia => USA	48.75095 0.462296	VAR (2) VAR (2)	0.0000 0.7936	Yes No	67.53335 24.36960	VAR (8) VAR (8)	0.0000 0.0020	Yes Yes
UK => France France => UK	1.525849 0.614522	VAR (1) VAR (1)	0.2167 0.4331	No No	8.177809 9.838816	VAR (5) VAR (5)	0.1467 0.0799	No No
UK =>Germany Germany => UK	4.832336 0.794995	VAR (1) VAR (1)	0.0279 0.3726	Yes No	24.48738 24.21277	VAR (6) VAR (6)	0.0004 0.0005	Yes Yes
UK => Japan Japan => UK	43.29967 0.248828	VAR (1) VAR (1)	0.0000 0.6179	Yes No	170.6740 3.192004	VAR (7) VAR (7)	0.0000 0.8667	Yes No
UK => China China => UK	0.470060 1.214615	VAR (1) VAR (1)	0.4930 0.2704	No No	26.07291 7.731946	VAR (5) VAR (5)	0.0001 0.1716	Yes No
UK => India Inde => UK	7.935393 0.436760	VAR (1) VAR (1)	0.0048 0.5087	Yes No	34.01250 13.82291	VAR (7) VAR (7)	0.0000 0.0544	Yes No
UK => Brazil Brazil => UK	0.000329 30.78319	VAR (1) VAR (1)	0.9855 0.0000	No Yes	30.61607 52.94627	VAR (8) VAR (8)	0.0002 0.0000	Yes Yes
UK => Russia Russia => UK	7.237056 18.93605	VECM (2) VECM (2)	0.0268 0.0001	Yes Yes	24.34117 31.61886	VAR (8) VAR (8)	0.0020 0.0001	Yes Yes
France => Germany Germany => France	0.686319 1.249299	VAR (1) VAR (1)	0.4074 0.2637	No No	36.49420 50.84516	VAR (6) VAR (6)	0.0000 0.0000	Yes Yes
France => Japan Japan => France	66.99819 1.136961	VAR (1) VAR (1)	0.0000 0.2863	Yes No	181.1763 9.829136	VAR (7) VAR (7)	0.0000 0.1985	Yes No
France => China China => France	0.145815 1.351214	VAR (1) VAR (1)	0.7026 0.2451	No No	19.51238 7.864088	VAR (5) VAR (5)	0.0015 0.1639	Yes No
France => India India => France	17.81594 2.586689	VAR (4) VAR (4)	0.0013 0.6292	Yes No	34.85698 16.78538	VAR (7) VAR (7)	0.0000 0.0188	Yes Yes

France => Brazil	0.195163	VAR (1)	0.6587	No	22.33514	VAR (5)	0.0005	Yes
Brazil => France	18.78402	VAR (1)	0.0000	Yes	67.10547	VAR (5)	0.0000	Yes
France => Russia	0.669017	VAR (1)	0.4134	No	25.79731	VAR (8)	0.0011	Yes
Russia => France	0.393040	VAR (1)	0.5307	No	31.79930	VAR (8)	0.0001	Yes

	Tranquil period				Crisis period			
Country	**Chi-square**	**specification**	**Prob.**	**Causality**	**Chi-square**	**specification**	**Prob.**	**Causality**
Germany => Japan	58.85292	VAR (1)	0.0000	Yes	196.6825	VAR (5)	0.0000	Yes
Japan => Germany	0.296181	VAR (1)	0.5863	No	5.763045	VAR (5)	0.3300	No
Germany => China	5.63E-05	VAR (1)	0.9940	No	19.14596	VAR (5)	0.0018	Yes
China => Germany	1.801484	VAR (1)	0.1795	No	6.601046	VAR (5)	0.2520	No
Germany => India	18.05987	VAR (6)	0.0061	Yes	31.20149	VAR (5)	0.0000	Yes
India => Germany	4.956615	VAR (6)	0.5494	No	12.85717	VAR (5)	0.0248	Yes
Germany => Brazil	0.521155	VAR (1)	0.4703	No	32.83317	VAR (5)	0.0000	Yes
Brazil => Germany	17.05776	VAR (1)	0.0000	Yes	32.56035	VAR (5)	0.0000	Yes
Germany => Russia	0.974860	VAR (1)	0.3235	No	28.63016	VAR (8)	0.0004	Yes
Russia => Germany	0.265680	VAR (1)	0.6062	No	23.00985	VAR (8)	0.0034	Yes
Japan => China	0.395209	VAR (1)	0.5296	No	0.891410	VAR (1)	0.3451	No
China => Japan	0.369865	VAR (1)	0.5431	No	2.949492	VAR (1)	0.0859	No
Japan => India	0.055310	VAR (1)	0.8141	No	8.111142	VAR (3)	0.0438	Yes
India => Japan	4.928184	VAR (1)	0.0264	Yes	55.42504	VAR (3)	0.0000	Yes
Japan => Brazil	0.750895	VAR (1)	0.3862	No	25.53071	VAR (8)	0.0013	Yes
Brazil => Japan	66.87590	VAR (1)	0.0000	Yes	205.9449	VAR (8)	0.0000	Yes
Japan => Russia	7.210378	VECM (2)	0.0272	Yes	4.314562	VAR (1)	0.0378	Yes
Russia => Japan	1.535842	VECM (2)	0.4640	No	42.30044	VAR (1)	0.0000	Yes
China => India	0.300857	VAR (1)	0.5833	No	20.93410	VAR (5)	0.0008	Yes
India => China	0.215041	VAR (1)	0.6428	No	12.60881	VAR (5)	0.0273	Yes
China => Brazil	1.520909	VAR (1)	0.2175	No	0.009934	VAR (1)	0.9206	No
Brazil => China	0.891938	VAR (1)	0.3450	No	20.09788	VAR (1)	0.0000	Yes
China => Russia	0.548862	VAR (1)	0.4588	No	12.23238	VAR (8)	0.1411	No
Russia => China	2.625809	VAR (1)	0.1051	No	24.09823	VAR (8)	0.0022	Yes
India => Brazil	1.508245	VAR (1)	0.2194	No	11.28903	VAR (7)	0.1265	No
Brazil => India	52.75058	VAR (1)	0.0000	Yes	32.64307	VAR (7)	0.0000	Yes
India => Russia	1.352124	VAR (1)	0.2449	No	26.04551	VAR (8)	0.0010	Yes
Russia => India	3.778541	VAR (1)	0.0519	No	21.40114	VAR (8)	0.0062	Yes
Brazil => Russia	51.24851	VAR (2)	0.0000	Yes	46.35081	VAR (8)	0.0000	Yes
Russia => Brazil	6.222481	VAR (2)	0.0445	Yes	21.96029	VAR (8)	0.0050	Yes

Table 8: Long term causality tests

	Country	specification	t-Student	P-value	Causality
Tranquil Period	UK => Russia	VECM (2)	- 0.37429	0.64890	No
	Russia => UK	VECM (2)	-3.87539	1.06245	No
	Japan => Russia	VECM (2)	2.33508	0.30533	No
	Russia => Japan	VECM (2)	4.45610	0.31475	No
Crisis period	USA => Germany	VECM (7)	31.4889	0.02935	Yes
	Germany => USA	VECM (7)	32.2189	0.03358	Yes
	USA => China	VECM (6)	6.27037	0.25667	No
	China => USA	VECM (6)	5.90916	0.10515	No

Table 9: Decomposition of the forecast error variance during quiet period

Decomposition of the S & P500 variance

Horizon	S.E.	D(SP500)	D (FTSE 100)	D(CAC40)	D(DAX)	D(NIKKEI 225)	D(SSECI)	D(BSE30)	D(IBOVESPA)	D(RTSI)
1	0.006617	**100.0000**	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.006696	**97.76210**	0.002146	0.295260	0.180852	0.916650	0.047337	0.510417	0.271485	0.013749
3	0.006709	**97.57635**	0.053220	0.320561	0.184373	0.938740	0.087484	0.509192	0.281465	0.048613
4	0.006709	**97.56047**	0.063858	0.321339	0.186835	0.939404	0.087473	0.510431	0.281530	0.048659
5	0.006710	**97.55919**	0.064535	0.321503	0.186838	0.939363	0.087491	0.510421	0.281942	0.048718
6	0.006710	**97.55894**	0.064614	0.321540	0.186848	0.939405	0.087508	0.510445	0.281980	0.048720
7	0.006710	**97.55891**	0.064632	0.321544	0.186848	0.939408	0.087512	0.510445	0.281981	0.048721
8	0.006710	**97.55890**	0.064635	0.321545	0.186848	0.939408	0.087512	0.510445	0.281981	0.048721
9	0.006710	**97.55890**	0.064635	0.321545	0.186848	0.939408	0.087512	0.510445	0.281981	0.048721
10	0.006710	**97.55890**	0.064635	0.321545	0.186848	0.939408	0.087512	0.510445	0.281981	0.048721

Decomposition of the FTSE 100 variance

Horizon	S.E.	D(SP500)	D (FTSE 100)	D(CAC40)	D(DAX)	D(NIKKEI 225)	D(SSECI)	D(BSE30)	D(IBOVESPA)	D(RTSI)
1	0.007397	31.06555	**68.93445**	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.007843	32.28864	**66.79341**	0.122567	0.015064	0.006024	0.000646	0.032773	0.656733	0.084145
3	0.007911	32.42106	**66.14251**	0.217451	0.061197	0.100058	0.025131	0.084141	0.865695	0.082764
4	0.007918	32.37542	**66.10825**	0.237996	0.062641	0.121107	0.040442	0.091004	0.876434	0.086712
5	0.007919	32.37004	**66.10718**	0.240699	0.062655	0.122171	0.041798	0.091151	0.877128	0.087177
6	0.007919	32.36984	**66.10656**	0.241084	0.062653	0.122266	0.041884	0.091173	0.877346	0.087189
7	0.007919	32.36981	**66.10643**	0.241146	0.062654	0.122292	0.041901	0.091183	0.877388	0.087191
8	0.007919	32.36980	**66.10642**	0.241154	0.062654	0.122296	0.041904	0.091184	0.877393	0.087191
9	0.007919	32.36980	**66.10642**	0.241156	0.062654	0.122297	0.041905	0.091184	0.877393	0.087191
10	0.007919	32.36980	**66.10642**	0.241156	0.062654	0.122297	0.041905	0.091184	0.877393	0.087191

Decomposition of the CAC 40 variance

Horizon	S.E.	D(SP500)	D (FTSE 100)	D(CAC40)	D(DAX)	D(NIKKEI 225)	D(SSECI)	D(BSE30)	D(IBOVESPA)	D(RTSI)
1	0.008750	34.24830	44.63938	**21.11232**	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.009239	35.35270	44.92552	**19.20769**	0.166078	0.075859	0.004537	0.072355	0.121693	0.073569
3	0.009312	35.57597	44.61794	**19.00622**	0.183721	0.131543	0.012016	0.109035	0.288854	0.074702
4	0.009319	35.53427	44.61548	**18.99794**	0.184925	0.150796	0.024099	0.115896	0.299094	0.077499
5	0.009320	35.52874	44.61878	**18.99677**	0.184925	0.151793	0.025362	0.116027	0.299640	0.077962
6	0.009320	35.52845	44.61900	**18.99650**	0.184921	0.151862	0.025431	0.116039	0.299818	0.077973
7	0.009320	35.52842	44.61900	**18.99646**	0.184921	0.151882	0.025444	0.116046	0.299856	0.077974
8	0.009320	35.52841	44.61900	**18.99646**	0.184921	0.151886	0.025447	0.116048	0.299860	0.077975
9	0.009320	35.52840	44.61900	**18.99646**	0.184921	0.151886	0.025447	0.116048	0.299861	0.077975

10	0.009320	35.52840	44.61900	**18.99646**	0.184921	0.151886	0.025447	0.116048	0.299861	0.077975

Decomposition of the DAX variance

Horizon	S.E.	D(SP500)	D (FTSE 100)	D(CAC40)	D(DAX)	D(NIKKEI 225)	D(SSECI)	D(BSE30)	D(IBOVESPA)	D(RTSI)
1	0.009399	34.98674	40.88809	12.21457	**11.91061**	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.009901	36.10447	41.77209	11.02573	**10.75224**	0.000184	0.021465	0.013347	0.202217	0.108259
3	0.009970	36.10265	41.64397	10.96828	**10.63725**	0.092565	0.039804	0.055666	0.353004	0.106816
4	0.009977	36.05650	41.65571	10.97089	**10.62186**	0.110198	0.052050	0.060747	0.361884	0.110158
5	0.009978	36.05113	41.65979	10.97112	**10.61964**	0.111123	0.053152	0.060876	0.362647	0.110519
6	0.009978	36.05082	41.66006	10.97110	**10.61926**	0.111218	0.053232	0.060900	0.362869	0.110529
7	0.009978	36.05077	41.66008	10.97110	**10.61921**	0.111243	0.053248	0.060909	0.362909	0.110530
8	0.009978	36.05076	41.66008	10.97110	**10.61920**	0.111247	0.053251	0.060910	0.362913	0.110531
9	0.009978	36.05076	41.66008	10.97110	**10.61920**	0.111247	0.053252	0.060910	0.362914	0.110531
10	0.009978	36.05075	41.66009	10.97110	**10.61920**	0.111247	0.053252	0.060910	0.362914	0.110531

Decomposition of the Nikkei 225 variance

Horizon	S.E.	D(SP500)	D(FTSE 100)	D(CAC40)	D(DAX)	D(NIKKEI 225)	D(SSECI)	D(BSE30)	D(IBOVESPA)	D(RTSI)
1	0.010188	1.707102	6.330882	2.868235	0.026236	**89.06755**	0.000000	0.000000	0.000000	0.000000
2	0.011923	18.91717	5.305065	3.845875	0.019345	**67.26294**	0.859046	0.000512	1.147445	2.642606
3	0.011968	18.77491	5.629797	3.845418	0.172405	**66.80214**	0.856728	0.110295	1.180300	2.628001
4	0.011979	18.87567	5.640114	3.843736	0.172183	**66.68036**	0.858692	0.110095	1.191789	2.627360
5	0.011980	18.87642	5.641444	3.844577	0.172758	**66.67423**	0.859058	0.111137	1.193308	2.627066
6	0.011980	18.87622	5.641916	3.844681	0.172757	**66.67364**	0.859206	0.111166	1.193308	2.627104
7	0.011980	18.87621	5.642000	3.844690	0.172758	**66.67355**	0.859209	0.111166	1.193310	2.627103
8	0.011980	18.87622	5.642009	3.844692	0.172758	**66.67353**	0.859209	0.111166	1.193311	2.627102
9	0.011980	18.87622	5.642010	3.844692	0.172758	**66.67353**	0.859209	0.111166	1.193312	2.627102
10	0.011980	18.87622	5.642011	3.844692	0.172758	**66.67353**	0.859209	0.111166	1.193312	2.627102

Decomposition of the SSECI variance

Horizon	S.E.	D(SP500)	D(FTSE 100)	D(CAC40)	D(DAX)	D(NIKKEI 225)	D(SSECI)	D(BSE30)	D(IBOVESPA)	D(RTSI)
1	0.018220	4.127899	0.244651	0.019388	0.004311	2.051320	**93.55243**	0.000000	0.000000	0.000000
2	0.018378	4.077546	0.402043	0.068987	0.405978	2.021342	**92.37162**	5.38E-05	0.350741	0.301692
3	0.018386	4.135391	0.405720	0.069648	0.408504	2.023826	**92.29647**	0.000666	0.355479	0.304299
4	0.018387	4.137237	0.405741	0.070031	0.408880	2.024012	**92.29227**	0.001055	0.356449	0.304325
5	0.018387	4.137269	0.405781	0.070054	0.408880	2.024055	**92.29209**	0.001073	0.356449	0.304346
6	0.018387	4.137268	0.405792	0.070055	0.408882	2.024055	**92.29208**	0.001073	0.356449	0.304347
7	0.018387	4.137270	0.405793	0.070055	0.408882	2.024055	**92.29207**	0.001073	0.356449	0.304347
8	0.018387	4.137270	0.405793	0.070055	0.408882	2.024055	**92.29207**	0.001073	0.356450	0.304347
9	0.018387	4.137270	0.405794	0.070055	0.408882	2.024055	**92.29207**	0.001073	0.356450	0.304347
10	0.018387	4.137270	0.405794	0.070055	0.408882	2.024055	**92.29207**	0.001073	0.356450	0.304347

Decomposition of the BSE 30 variance

Horizon	S.E.	D(SP500)	D (FTSE 100)	D(CAC40)	D(DAX)	D(NIKKEI 225)	D(SSECI)	D(BSE30)	D(IBOVESPA)	D(RTSI)
1	0.014552	4.115895	6.497828	1.331827	0.402277	4.958196	0.055062	**82.63891**	0.000000	0.000000
2	0.015925	17.96220	5.632693	1.130952	0.517696	4.207788	0.236622	**69.00532**	1.143880	0.162850
3	0.015975	17.94985	5.608368	1.161755	0.590935	4.320726	0.263824	**68.67912**	1.262587	0.162830
4	0.015980	17.95938	5.617488	1.164952	0.590616	4.324809	0.274429	**68.63733**	1.261939	0.169064
5	0.015980	17.95898	5.619836	1.165118	0.590920	4.324692	0.274456	**68.63500**	1.261894	0.169109
6	0.015980	17.95938	5.619987	1.165150	0.590915	4.324654	0.274454	**68.63438**	1.261966	0.169114
7	0.015980	17.95938	5.620005	1.165158	0.590917	4.324659	0.274457	**68.63433**	1.261975	0.169114
8	0.015980	17.95938	5.620009	1.165159	0.590917	4.324659	0.274458	**68.63433**	1.261975	0.169114
9	0.015980	17.95938	5.620010	1.165159	0.590917	4.324659	0.274458	**68.63433**	1.261975	0.169114
10	0.015980	17.95938	5.620010	1.165159	0.590917	4.324659	0.274458	**68.63433**	1.261975	0.169114

Decomposition of the Ibovespa variance

Horizon	S.E.	D(SP500)	D(FTSE 100)	D(CAC40)	D(DAX)	D(NIKKEI 225)	D(SSECI)	D(BSE30)	D(IBOVESPA)	D(RTSI)
1	0.015191	57.91175	1.069933	0.058859	0.964057	0.404239	0.150232	0.560736	**38.88020**	0.000000
2	0.015380	56.55946	1.179857	0.159546	1.225564	0.634481	0.673443	0.910605	**38.43759**	0.219457

3	0.015389	56.56345	1.179258	0.161367	1.231503	0.636078	0.688179	0.909997	**38.40101**	0.229161
4	0.015389	56.56051	1.179892	0.162119	1.231835	0.638555	0.688742	0.910552	**38.39842**	0.229379
5	0.015389	56.56021	1.180267	0.162178	1.231855	0.638579	0.688794	0.910547	**38.39814**	0.229434
6	0.015389	56.56019	1.180317	0.162185	1.231856	0.638578	0.688793	0.910547	**38.39810**	0.229434
7	0.015389	56.56019	1.180322	0.162186	1.231856	0.638579	0.688793	0.910547	**38.39809**	0.229433
8	0.015389	56.56019	1.180323	0.162187	1.231855	0.638579	0.688793	0.910547	**38.39809**	0.229434
9	0.015389	56.56019	1.180323	0.162187	1.231855	0.638579	0.688793	0.910547	**38.39809**	0.229434
10	0.015389	56.56019	1.180323	0.162187	1.231855	0.638579	0.688793	0.910547	**38.39809**	0.229434
Decomposition of the RTCI variance										
Horizon	**S.E.**	**D(SP500)**	**D(FTSE 100)**	**D(CAC40)**	**D(DAX)**	**D(NIKKEI 225)**	**D(SSECI)**	**D(BSE30)**	**D(IBOVESPA)**	**D(RTSI)**
1	0.016385	7.149162	19.72474	0.896798	1.855248	0.141614	0.429867	3.723527	4.815825	**61.26322**
2	0.018043	17.42695	17.29070	0.957995	1.545342	0.331736	1.313653	3.093435	6.917079	**51.12311**
3	0.018126	17.52329	17.18601	1.019653	1.626551	0.431711	1.339820	3.161684	7.051806	**50.65947**
4	0.018131	17.51696	17.19622	1.024471	1.625583	0.440354	1.352167	3.162396	7.048043	**50.63380**
5	0.018132	17.51638	17.19922	1.024888	1.625701	0.440342	1.352299	3.162245	7.047706	**50.63122**
6	0.018132	17.51675	17.19941	1.024955	1.625682	0.440344	1.352286	3.162212	7.047723	**50.63063**
7	0.018132	17.51677	17.19943	1.024968	1.625681	0.440353	1.352289	3.162213	7.047728	**50.63057**
8	0.018132	17.51677	17.19944	1.024970	1.625681	0.440354	1.352290	3.162213	7.047728	**50.63056**
9	0.018132	17.51677	17.19944	1.024971	1.625681	0.440354	1.352290	3.162213	7.047728	**50.63056**
10	0.018132	17.51677	17.19944	1.024971	1.625681	0.440354	1.352290	3.162213	7.047728	**50.63056**

Table10: Decomposition of the forecast error variance during crisis period

Decomposition of the S&P500 variance										
Horizon	**S.E.**	**D(SP500)**	**D (FTSE 100)**	**D(CAC40)**	**D(DAX)**	**D(NIKKEI 225)**	**D(SSECI)**	**D(BSE30)**	**D(IBOVESPA)**	**D(RTSI)**
1	0.006592	**100.0000**	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.009090	**98.65608**	0.032359	0.271415	0.157335	0.482730	0.000138	0.189625	0.190474	0.019845
3	0.010754	**97.87356**	0.044469	0.383506	0.354721	0.568320	0.024728	0.191037	0.533635	0.026019
4	0.012081	**97.12528**	0.106493	0.505034	0.500105	0.599389	0.065647	0.159254	0.879205	0.059597
5	0.013213	**96.35250**	0.181704	0.629778	0.629163	0.615466	0.119488	0.133153	1.222667	0.116079
6	0.014199	**95.49297**	0.277081	0.771043	0.749446	0.631078	0.185677	0.119698	1.583161	0.189847
7	0.015079	**94.56851**	0.385429	0.925881	0.860410	0.647101	0.264484	0.119518	1.952114	0.276556
8	0.015876	**93.59258**	0.505128	1.094592	0.961045	0.665680	0.354687	0.131228	2.324165	0.370891
9	0.016609	**92.58242**	0.632758	1.275566	1.050870	0.687530	0.455388	0.152904	2.693966	0.468601
10	0.017289	**91.55245**	0.765991	1.467192	1.129609	0.713120	0.565614	0.182503	3.057475	0.566047
Decomposition of the FTSE 100 variance										
Horizon	**S.E.**	**D(SP500)**	**D (FTSE 100)**	**D(CAC40)**	**D(DAX)**	**D(NIKKEI 225)**	**D(SSECI)**	**D(BSE30)**	**D(IBOVESPA)**	**D(RTSI)**
1	0.007370	32.18766	**67.81234**	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.010177	48.82463	**50.75488**	0.044236	0.000262	0.001122	0.006498	0.000794	0.330375	0.037201
3	0.012090	51.20791	**48.38454**	0.033782	0.029009	0.034381	0.005677	0.031318	0.238864	0.034527
4	0.013545	52.98672	**46.60993**	0.027315	0.068097	0.031341	0.022364	0.030842	0.191291	0.032102
5	0.014745	53.86799	**45.67442**	0.023386	0.107379	0.029893	0.044892	0.028245	0.178413	0.045385
6	0.015756	54.51367	**44.91086**	0.021482	0.150831	0.027955	0.077450	0.025073	0.193783	0.078899
7	0.016623	54.93649	**44.31050**	0.022685	0.196431	0.026643	0.118645	0.022523	0.236131	0.129951
8	0.017379	55.23848	**43.77807**	0.027536	0.243008	0.025759	0.168985	0.020870	0.300307	0.196980
9	0.018046	55.45000	**43.29008**	0.037252	0.289289	0.025440	0.227953	0.020160	0.382913	0.276909
10	0.018641	55.59886	**42.82539**	0.052729	0.334345	0.025728	0.295334	0.020345	0.480263	0.366998
Decomposition of the CAC 40 variance										
Horizon	**S.E.**	**D(SP500)**	**D (FTSE 100)**	**D(CAC40)**	**D(DAX)**	**D(NIKKEI 225)**	**D(SSECI)**	**D(BSE30)**	**D(IBOVESPA)**	**D(RTSI)**
1	0.008756	35.95803	43.64085	**20.40111**	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.012324	52.00915	30.14071	**17.61885**	0.127553	0.019631	0.011019	0.016806	0.042677	0.013614
3	0.014773	54.01635	28.13339	**17.38691**	0.234046	0.097659	0.019354	0.051833	0.049427	0.011031

4	0.016677	55.88779	26.77216	**16.76608**	0.296553	0.104146	0.052039	0.046362	0.059643	0.015217
5	0.018281	57.00569	26.10650	**16.20469**	0.333573	0.111618	0.088347	0.039515	0.082559	0.027512
6	0.019661	57.91555	25.61021	**15.66292**	0.363391	0.116056	0.133851	0.034225	0.113468	0.050327
7	0.020871	58.60155	25.25800	**15.17616**	0.388844	0.121025	0.186916	0.031485	0.154867	0.081153
8	0.021949	59.15148	24.97097	**14.73589**	0.411747	0.126375	0.247985	0.031411	0.205246	0.118900
9	0.022919	59.59005	24.72667	**14.34142**	0.432778	0.132730	0.316494	0.033692	0.264437	0.161733
10	0.023801	59.94305	24.50600	**13.98821**	0.452330	0.140229	0.392243	0.037993	0.331719	0.208225

Decomposition of the DAX variance

Horizon	S.E.	D(SP500)	D (FTSE 100)	D(CAC40)	D(DAX)	D(NIKKEI 225)	D(SSECI)	D(BSE30)	D(IBOVESPA)	D(RTSI)
1	0.009409	36.81307	40.08236	11.66025	**11.44432**	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.013445	51.54967	26.49068	10.57158	**11.25088**	0.004100	0.029917	0.000235	0.083806	0.019133
3	0.016305	53.58612	24.23860	10.50981	**11.52468**	0.016282	0.050598	0.003598	0.056996	0.013316
4	0.018562	55.36020	22.75058	10.02626	**11.63510**	0.012632	0.116028	0.006506	0.044043	0.048652
5	0.020485	56.42162	22.02858	9.581991	**11.59441**	0.010686	0.192701	0.016184	0.036500	0.117333
6	0.022173	57.26855	21.49158	9.148857	**11.50818**	0.010260	0.286717	0.032621	0.032307	0.220929
7	0.023684	57.88997	21.10673	8.764536	**11.39959**	0.010201	0.394441	0.052632	0.031515	0.350381
8	0.025058	58.36996	20.79123	8.423388	**11.28035**	0.010219	0.515624	0.074888	0.033969	0.500371
9	0.026322	58.73671	20.52164	8.125059	**11.15563**	0.010010	0.648687	0.097791	0.039887	0.664597
10	0.027495	59.01802	20.27816	7.865257	**11.02847**	0.009552	0.792702	0.120379	0.049310	0.838150

Decomposition of the Nikkei 225 variance

Horizon	S.E.	D(SP500)	D(FTSE 100)	D(CAC40)	D(DAX)	D(NIKKEI 225)	D(SSECI)	D(BSE30)	D(IBOVESPA)	D(RTSI)
1	0.010113	1.706546	6.807710	2.988399	0.029248	**88.46810**	0.000000	0.000000	0.000000	0.000000
2	0.014964	18.37668	8.648610	6.025557	0.031324	**63.95958**	0.457682	0.003844	0.755115	1.741616
3	0.018119	24.69183	8.231543	6.932166	0.063061	**56.56688**	0.656568	0.046915	0.781114	2.029921
4	0.020472	27.23495	8.544225	7.453949	0.119024	**53.16880**	0.733976	0.053944	0.691515	1.999621
5	0.022415	29.09599	8.828704	7.648900	0.172383	**50.95037**	0.766730	0.046773	0.621236	1.868907
6	0.024059	30.54137	9.168573	7.751200	0.228681	**49.20463**	0.785935	0.040622	0.559086	1.719904
7	0.025479	31.74408	9.508232	7.804181	0.290183	**47.74154**	0.794369	0.037940	0.505548	1.573929
8	0.026722	32.77156	9.851350	7.838253	0.355916	**46.44443**	0.795665	0.039191	0.460796	1.442837
9	0.027825	33.67473	10.18804	7.864742	0.425094	**45.25483**	0.791603	0.044125	0.425030	1.331795
10	0.028814	34.48028	10.51565	7.890928	0.496828	**44.13953**	0.783520	0.052137	0.398127	1.242994

Decomposition of the SSECI variance

Horizon	S.E.	D(SP500)	D(FTSE 100)	D(CAC40)	D(DAX)	D(NIKKEI 225)	D(SSECI)	D(BSE30)	D(IBOVESPA)	D(RTSI)
1	0.018203	4.887822	0.205959	0.057207	0.002772	2.061470	**92.78477**	0.000000	0.000000	0.000000
2	0.024699	5.192909	0.113067	0.176076	0.266902	2.181251	**91.62798**	0.003753	0.176699	0.261362
3	0.029754	6.141378	0.090841	0.206347	0.316100	2.153583	**90.27959**	0.008918	0.243947	0.559300
4	0.034000	6.957241	0.081955	0.208993	0.314592	2.098448	**89.18166**	0.015560	0.250239	0.891311
5	0.037745	7.743616	0.080445	0.209084	0.298171	2.052715	**88.11437**	0.019700	0.239050	1.242846
6	0.041130	8.514457	0.080970	0.208791	0.277235	2.013526	**87.05140**	0.021573	0.220860	1.611189
7	0.044248	9.275090	0.082323	0.209644	0.255235	1.980942	**85.98628**	0.021525	0.200355	1.988607
8	0.047155	10.02383	0.083400	0.211867	0.233844	1.954044	**84.92360**	0.020174	0.180019	2.369219
9	0.049891	10.76050	0.083757	0.215501	0.213847	1.932014	**83.86664**	0.018247	0.161496	2.748005
10	0.052485	11.48434	0.083158	0.220385	0.195615	1.913924	**82.81899**	0.016517	0.145951	3.121114

Decomposition of the BSE 30 variance

Horizon	S.E.	D(SP500)	D (FTSE 100)	D(CAC40)	D(DAX)	D(NIKKEI 225)	D(SSECI)	D(BSE30)	D(IBOVESPA)	D(RTSI)
1	0.014264	4.527688	7.555420	1.272320	0.207518	4.523166	0.074464	**81.83942**	0.000000	0.000000
2	0.021127	20.14865	5.995862	0.958610	0.325835	2.894707	0.244946	**68.86539**	0.439905	0.126096
3	0.025567	25.17472	6.915691	1.209674	0.224428	2.033500	0.398959	**63.40687**	0.302037	0.334115
4	0.029142	28.22189	7.856738	1.380423	0.194607	1.566725	0.460310	**59.54289**	0.281694	0.494721
5	0.032255	30.39555	8.939104	1.530945	0.217882	1.294066	0.496752	**56.09707**	0.379461	0.649168
6	0.035050	32.10160	9.974829	1.647327	0.278599	1.149455	0.513998	**52.97774**	0.571543	0.784907
7	0.037607	33.43367	10.96357	1.738667	0.361352	1.093995	0.517192	**50.15210**	0.840300	0.899157
8	0.039973	34.49304	11.87990	1.807100	0.454237	1.099478	0.509572	**47.60112**	1.164784	0.990758
9	0.042180	35.33990	12.72046	1.857545	0.548861	1.147025	0.494298	**45.30138**	1.529104	1.061428

10	0.044249	36.02103	13.48326	1.893924	0.639799	1.223012	0.473878	**43.23105**	1.920497	1.113552

Decomposition of the Ibovespa variance

Horizon	S.E.	D(SP500)	D(FTSE 100)	D(CAC40)	D(DAX)	D(NIKKEI 225)	D(SSECI)	D(BSE30)	D(IBOVESPA)	D(RTSI)
1	0.015023	58.36561	1.076493	0.083692	0.935797	0.492419	0.150451	0.393100	**38.50244**	0.000000
2	0.020382	63.04846	0.929191	0.051186	0.540819	0.287547	0.098331	0.214644	**34.74583**	0.083997
3	0.023960	65.35876	1.140962	0.040355	0.422804	0.216606	0.071482	0.162339	**32.51246**	0.074233
4	0.026763	67.00283	1.397814	0.032343	0.444988	0.190165	0.058964	0.133778	**30.67962**	0.059494
5	0.029091	68.26131	1.713544	0.027697	0.562897	0.178442	0.055830	0.115989	**29.02731**	0.056980
6	0.031083	69.24920	2.045490	0.025070	0.755279	0.175191	0.061522	0.103532	**27.51081**	0.073911
7	0.032825	70.01094	2.389372	0.023282	1.003664	0.176730	0.076199	0.094081	**26.11142**	0.114318
8	0.034379	70.58623	2.733847	0.021722	1.292846	0.181202	0.100390	0.086469	**24.81684**	0.180455
9	0.035784	71.00305	3.073029	0.020169	1.610162	0.187192	0.134527	0.080139	**23.61883**	0.272909
10	0.037072	71.28528	3.401592	0.018808	1.944987	0.193754	0.179002	0.074781	**22.51061**	0.391178

Decomposition of the RTCI variance

Horizon	S.E.	D(SP500)	D(FTSE 100)	D(CAC40)	D(DAX)	D(NIKKEI 225)	D(SSECI)	D(BSE30)	D(IBOVESPA)	D(RTSI)
1	0.016147	7.707967	19.71458	0.631492	2.025346	0.266624	0.573058	4.038586	4.002605	**61.03974**
2	0.024832	21.11688	12.44026	0.270115	1.763779	0.128626	0.266592	3.104320	6.912153	**53.99728**
3	0.030286	23.60432	11.67208	0.185634	1.413444	0.086508	0.205052	2.745398	6.472964	**53.61460**
4	0.034398	24.90218	11.50151	0.246774	1.185641	0.083152	0.163107	2.747099	5.957651	**53.21289**
5	0.037786	25.70323	11.67763	0.413420	1.021935	0.101443	0.136056	2.851380	5.437337	**52.65757**
6	0.040659	26.29739	11.93907	0.664135	0.895334	0.135774	0.117507	3.004343	4.952181	**51.99427**
7	0.043143	26.72757	12.25737	0.965765	0.797134	0.180099	0.105076	3.182248	4.513377	**51.27136**
8	0.045325	27.04951	12.59264	1.296837	0.722383	0.231361	0.097707	3.375465	4.130060	**50.50404**
9	0.047263	27.29056	12.93088	1.637711	0.667622	0.286182	0.094854	3.576982	3.805610	**49.70960**
10	0.049000	27.47140	13.26154	1.974013	0.630038	0.342067	0.096253	3.782574	3.540747	**48.90136**