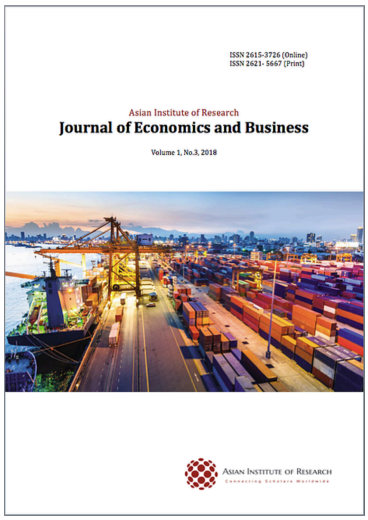

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The Financial Crisis and its Impact on Comovements of Financial Markets: Evidence from Exchange-Traded Funds

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Abstract
The two-fold objective of this paper is, on one hand, to study the comovements of international financial markets before and after the "subprime" financial crisis and, on the other hand, to determine their impact on international diversification, using substitutes for investable country indices, that is, exchange-traded funds. These new instruments are highly prized by investors. Three main categories of comovements are analyzed: short-term comovements as studied by contagion and dynamic conditional correlations; long-term comovements as studied by cointegration; and, finally comovements induced by the transmission of extreme values. In studying these comovements between the American market and 21 other developed and emerging markets, our results suggest that, after the financial crisis, the interdependencies and transmission of extreme values between the American market and the other markets studied increased significantly in the short term and, thus, reduced the advantages of international diversification in the short term. However, our analyses of contagion and cointegration suggest that the benefits of international diversification persist over the long term, even in times of crisis.

Key Words: Short-Term Comovements, Long-Term Comovements, Financial Crisis, Exchange-Traded Funds, International Diversification.

1. Introduction

One striking characteristic of the globalization of financial markets and the rapid transmission of information is the spread of financial crises from one country to another. The experience of recent financial crises has shown that spectacular movements in a particular market may have a major and rapid impact on other markets, even if the underlying economic fundamentals differ. Consequently, in such a context, it is important for investors and regulators to understand the nature of links between financial markets during financial crises. Indeed, investors are interested in the international diversification of risks. Nonetheless, if, for example, the financial markets become more tightly correlated in times of crisis, then the possibilities of international diversification diminish at the very time when they are most needed. For regulators of financial markets, it is also important to understand these links, on the one hand, because of the perceived increase of the spread of contagion among world financial markets and, on the other hand, so that they are able to propose adequate regulatory solutions.

The literature on comovements of financial markets is very rich and encompasses three major branches: the first is interested in short-term comovements and tests their characteristics using correlation coefficients or vector autoregression models (Bae, Karolyi, and Stulz, 2003); the second studies comovements by modelling and

testing long-term relations of cointegration amongst financial asset prices (Ahlgren and Antell, 2002); and, finally, the third is interested in the transmission of volatility amongst financial markets, and studies this through ARCH and GARCH modelization and their various extensions (Baele, 2004).

Nevertheless, the succession of crises, notably the American stock market crash of 1987, the Japanese crash of 1989-1990, the Mexican economic crisis of 1994-1995, the Asian crisis and the Russian political-financial turmoil of 1997-1998, have all led a number of researchers to concentrate more on comovements of financial markets in the short term in the particular context of a financial crisis, as well as on its contagion (Claessens, Dornbusch and Park, 2001; Dungey, Fry, Gonzalez-Hermosillo and Martin, 2007; Forbes and Rigobon, 2002; and Corsetti, Pericoli and Sbracia, 2005). Forbes and Rigobon (2002) defined contagion as a significant increase of inter-market comovements following a shock in a given country.[1]

However, the existence of contagion during financial crises remains an open question on which there is no clear consensus. Indeed, initial studies have demonstrated an increase in correlation coefficients during financial crises and have concluded that, indeed, a contagion effect exists (Bertero and Mayer, 1989; King Sentana and Wadhwani, 1994; and Murshid, 2006). However, other researchers (Forbes and Rigobon, 2002; and Bordo and Murshid, 2006)[2]Note that, in considering heteroscedasticity, the increase in correlations between financial markets is not significant. They conclude that there was no pure contagion but merely the continuation of interdependencies which existed before the shock but at higher levels of correlation. More recently, Corsetti et al. (2005), in an essay on financial contagion based on a single-factor model, conclude that there is "a certain contagion and a certain interdependence." The divergence of these results does not allow us to definitively determine whether or not there is contagion during financial crises in as much as the majority of these studies have based their analyses of comovements on market indices which are not investable, thus, which do not necessarily reflect reality.

This research differs from previous studies because not only do we analyze the short-term comovements of markets stemming from a financial crisis, but we also study the long-term transmission of extreme variations. In addition, we illustrate the impact of these different types of comovements on the international diversification of an American investor's portfolio composed of exchange-traded funds (ETF), notably iShares, as substitutes for foreign financial markets. While the majority of studies rely on market indices which are not investable, we use iShares, organized as exchange-traded funds and conceived to track the performance of certain investable indices constructed by S&P or MSCI, amongst others. Our choice to use ETFs is justified by the fact that they are good proxies for market indices (Phengpis and Swanson, 2004), that they seem to be more appropriate for studying the different interactions amongst global markets (Schwebach, Olienyk, and Zumwalt, 2002) and that they permit us to measure the impact of these comovements on international diversification, since they are readily investable, these funds adequately follow variations in the market (Pennathur, Delcoure, and Anderson, 2002). Furthermore, from a technical perspective, the series of prices of iShares is exempt from a certain number of specific problems of international funds, such as nonsynchronization, fluctuations in exchange rates and transaction restrictions (Olienyk, Schwebach, and Zumwalt, 1999).

To test each category of comovements, we employ different methodologies. Thus, for the short term, we verify the existence of contagion using the methodology of Forbes and Rigobon (2002). Subsequently, to control for the problem of heteroscedasticity raised by Forbes and Rigobon (2002), we use the multivariate GARCH model introduced by Engle (2002). This model is more appropriate to measure dynamic conditional correlations (DCC). Furthermore, and since the American financial crisis lasted longer than others, we take advantage of this opportunity to study long-term comovements, using the cointegration analysis proposed by Engle and Granger (1987). Finally, given the extent of this crisis, we test the transmission of extreme values with the value-at-risk (VaR) methodology, calculated using three distinct approaches.

[1] There are other definitions of contagion in the literature. In this paper, we use that of Forbes and Rigobon (2002).

[2] Forbes and Rigobon (2002) define "pure contagion" as a significant increase of market comovements following a shock. A higher level of correlation merely suggests the continuity of interdependencies through pre-existing real channels (basic contagion).

This study contributes to the existing literature in a number of ways. First and foremost, this paper is the first to utilize exchange-traded funds which replicate investable indices to study stock market comovements during a financial crisis, the “subprime” crisis in the United States. The use of ETFs allows us to avoid problems related to the lack of synchronization between markets in different time zones, the volatility of exchange rates and the lack of liquidity. This study also permits us to examine different categories of comovements in both the short and long-term, as well as the phenomenon of contagion and the transmission of extreme values between the American market and 21 other developing and emerging markets before and after the "subprime" financial crisis.

The rest of the article is organized as follows. The next section provides a review of the literature in two parts. The first examines various studies on comovements of financial markets, financial crises, and international diversification. The second part is devoted to the literature on exchange-traded funds. In the second section, we present the methodology: the test for contagion proposed by Forbes and Rigobon (2002); GARCH dynamic correlations to study short-term interdependencies; an analysis of cointegration to handle long-term relations; and, finally, value-at-risk to bring to light the impact of extreme values during the crisis on internationally diversified portfolios. The analysis of results and the conclusion follow in the final section.

2. Review of the Literature

2.1. Comovements of Markets, Financial Crises, and International Diversification

Grubel (1968) and Levy and Sarnat (1970) were the first to demonstrate that the combination of foreign and domestic shares improves a portfolio’s return/risk ratio. Solnik (1974) confirms that adding international equity to a portfolio composed of American stocks substantially reduces its systematic risk by as much as 40%, without diminishing the portfolio's return (Bergstrom, 1975).

However, the emergence and growth of globalization have raised questions about the potential advantages of international diversification. Indeed, when national markets are segmented, a particular market will be more influenced by national factors than external ones, which will increase the benefits of diversification. Nonetheless, since economies are increasingly integrated, national markets are more affected by common external factors, multivariate and stock markets become more closely correlated, thus lessening the advantages of international diversification.

Some empirical evidence of this phenomenon was brought forward by Solnik, Boucrelle and Le Fur (1996). The authors examined both the correlation and the volatility of stock markets in some large industrialized countries. Their research revealed that, while the correlations between markets fluctuate significantly, they have a tendency to increase over time. They also showed that, even if the volatility is not completely synchronized, it has a tendency to be contagious across markets. Their results also underscore a significant rise in the correlation between markets in a period of strong volatility. Thus, the benefits of international diversification would be greatly reduced at the very point when managers of global funds most need effective international diversification, that is, in a period of considerable volatility such as that which usually characterizes bear markets. This phenomenon was also reported in an earlier study by Erb, Harvey, and Viskanta (1994). These conclusions then suggest that international correlations increase during periods of great volatility.

Consequently, for investors, an understanding of the nature of interdependencies of financial markets during financial crises becomes crucial since the last two decades have witnessed a series of such crises. All these crises have arisen in a given country and then spread to other markets and different regions. The spreading of this shock can only be explained by the evolution of fundamentals or by economic ties between these countries (Kaminsky and Reinhart, 2000; Caramazza et al., 2004; and Haile and Pozo, 2008). These financial crises and other events which create considerable turmoil in the financial markets have very profound consequences. They are generally characterized by major drops in share prices and increased market volatility. In addition, they have serious implications for risk and portfolio managers due to the eventual changes in the structure of dependence amongst the markets during these crisis periods.

Along these same lines, King and Wadhwani (1990) studied the impact of the 1987 collapse of the American stock market on the correlations of stock markets in the United States, the United Kingdom, and Japan. Lee and Kim (1993) examined the effects of this same collapse on twelve developed stock markets. Calvo and Reinhart (1996) analyzed the impact of the Mexican peso crisis of 1994 on its contagious effect in the main financial markets. These studies generally concluded that correlations between markets in a period of crisis increase significantly, thus bearing witness to the contagious effect in financial markets following financial crises. Hamao et al. (1990) and Edwards et al. (2003) arrived at the same conclusion when investigating the spillover effects of volatility.

In one of the most important recent studies, Forbes and Rigobon (2002) researched the question of the interdependence and contagious effect of markets during financial crises. The authors defined contagion as a significant increase in the comovements of markets following a shock in one country or a group of countries. Their study demonstrated that the correlations depend on volatility and, consequently, the estimation of correlations has an upward bias when markets are most volatile. After correcting for this bias, their results suggest that there was no contagion but simply a continuity of interdependence during the Asian crisis, the Mexican crisis and the 1987 crash of the American market.

Simulating a chronological series of returns of financial assets according to stochastic processes commonly used in financial research, Bartram and Wang (2005) replicate the study of Forbes and Rigobon (2002) and, both analytically and empirically, investigate the impact of volatility on the interdependence of markets. Their results reveal that this does not always depend on volatile systems and that the bias in correlation measures requires the respect of certain hypotheses relative to the dynamic of chronological series. Furthermore, data from the real world not always being homoscedastic, the correction of estimations of unconditional correlations during a financial crisis is not always necessary. Consequently, Bartram and Wang (2005) conclude that contagion certainly exists as a real phenomenon during financial crises and that it reduces the advantages of international diversification when this is most needed.

There are other limitations to the main trends of this literature covering the financial crises. First, numerous researchers have considered that a significant increase in correlation coefficients between markets is proof of contagion. However, Forbes and Rigobon (2002) demonstrate that correlation coefficients are conditional on the volatility of markets, which increases during crises, causing an upward bias in the estimation of correlations. The rise in correlation coefficients could be due to heteroscedasticity, the volatility becoming greater during a crisis, in comparison to stable periods, thus biasing the tests for contagion.

Secondly, given that contagion is defined as a significant increase of inter-market comovements, while any correlation which continues at high levels is only considered interdependence (Forbes and Rigobon, 2002), the existence of contagion must entail demonstrating a dynamic increment in the correlations. Thus, the dynamic nature of the correlation needs to be considered.

Thirdly, the identification of the source of the crisis can also greatly influence the conclusions. This choice may seem arbitrary in the study of certain crises. Thus, for example, Chiang et al. (2007), respectively tested Thailand and Hong Kong as countries at the source of the contagion during the Asian crisis. Moreover, the date of the onset of the crisis and the length of the time of the study play a determining role in the results obtained (Billio and Pelizzon, 2003). Consequently, the choice of subsamples characteristic of periods of greater and lesser volatility may be questionable and contribute to a selection bias (Boyer et al., 1999).

Fourthly, most studies interested in financial crises and contagion have focussed on an examination of short-term inter-market links. Essentially, these studies have used correlations or vector autoregression models (Bae, Karolyi and Stulz, 2003). Long-term comovements, however, have often been neglected, apparently due to the short duration of financial crises preceding the American subprime crisis. Long-term inter-market relations are generally validated through the cointegration tests of Engle and Granger (1987) or using Johansen's test in the multivariate case, but the studies have rarely used them in the context of financial crises (Ahlgren and Antell, 2002; and Sheng and Tu, 2000).

Fifthly, previous empirical studies of contagion during financial crises were hampered by the nonexistence of negotiable and "investable" financial instruments as "proxies" for the national stock markets.[3] This is particularly problematic in the case where daily data are used.[4] Above all, to represent the markets, earlier studies used stock market indices such as that of MSCI or the IFC indices[5] for emerging markets. Nevertheless, these indices are not directly negotiable shares. Bekaert and Harvey (1995) stress that the usage of these indices generally ignores important factors, such as the higher cost of transactions, the lack of liquidity and the barriers to foreign investment which especially characterize emerging markets. Consequently, they violate the hypothesis of "investability" underlying the argument for arbitration and, therefore, call into question the conclusions concerning the potential of international diversification.

Sixth and finally, the integration of financial markets has major consequences for the performance of international portfolios and for financial risk management. Investors are interested in international diversification with the goal of reducing their risk. Nonetheless, if financial markets become more tightly correlated in times of crisis, the possibilities of international diversification diminish, at the very time it is most needed. However, increased correlations are not the only source of concern in evaluating the benefits of international diversification. Another current problem is the potential gap with respect to the normal distribution. It is well documented in the literature that most financial returns do not follow a normal distribution[6]And, consequently, we need to examine the impact of the higher points on the advantages of international diversification, especially in the context of a financial crisis distinguished by an excess of volatility and more frequent extreme values.

In a recent study, Kim (2011) examines the effects of cointegration and contagion in the United States and the Asia-Pacific region, using nine ETFs in the period from January 7th, 2004 to September 30th, 2010, with subperiods before and after the 2007 financial crisis. The nine ETFs are: SPDR, TOPIX, KODEX200 (KODEX), Tracker Fund of Hong Kong (TraHK), Polaris Taiwan Top 50 Tracker Fund (TT), SPDR S&P/ASX 200 Fund (STW), StreetTRACKS Straits Times Index Fund (STI), SmartFONZ (FNZ) and China 50 ETF. Analysis of the cointegration shows that there Is a relation of cointegration of SPDR and TraHK, STW, STI, and FNZ before and after the global financial crisis. However, the TOPIX shows little cointegration with the SPDR. In the case of the KODEX and the TT, no relation of cointegration existed before the crisis, but one appeared subsequently. On the other hand, although the SPDR was cointegrated with the China 50 before the crisis, this relationship weakened after the crisis. Granger tests of causality indicate that, while American stock markets led the stock markets of the Asia-Pacific region, the latter did not have the same influence. This study confirms the fact that, generally, since the global financial crisis of 2007-2008, effects of cointegration have not continued to grow.

Similarly, Ji and In (2010) examine the impact of the global financial crisis on the comovements of LIBOR-OIS currency swaps, a measure of the financial stress on interbank markets. Analysis of the response generated was done in a system with a number of variables. The collection of data suggests that the crisis considerably changed the nature of interactions between currencies. Also, according to the authors, the global monetary markets did not succeed in containing the financial stress, with the American dollar and the role of the Japanese yen as a source of liquidity seeming to be significant, while these two currencies were steering the currency system and the stress of liquidity.

The current state of the literature shows that correlations increase during financial crises. However, there is no clear consensus about the nature of interdependencies and their impacts on international diversification. Therefore, this paper is contributing to the literature in proposing a fresh look at the relation between the interdependence of financial markets and volatility regimes under conditions of financial crisis. The utilization of practical instruments of international diversification, notably ETFs, will allow us to broach the subject more realistically.

[3] To our knowledge, Olienyk et al. (1999) and Barari et al. (2008) have produced the only research which used iShares to study the comovements of financial markets.
[4] Olienyk et al. (1999)advance the argument of the non-synchronization of negotiations and the fluctuations of exchange rates.
[5] International Finance Corporation
[6]. The distributions of returns of financial securities often reveal asymmetry and an excess of kurtosis.

2.2. Exchange-Traded Funds and International Diversification

The current literature on international diversification through ETFs has been limited to the study of country iShares. Moreover, all these studies fall into three principal categories. The first essentially bears on factors influencing the returns for iShares and the evolution of their level of correlation with the American market. The results of these studies usually reveal that country iShares are strongly dependent on the American market, which minimizes their contribution to the portfolio's performance with respect to the direct use of stock market indices. The second category of research bears on the capacity of iShares to replicate their underlying indices, sometimes in comparing them to classic index investment funds. Generally, they conclude that the tracking error of country iShares is negligible, often temporary and that the capacity of country iShares to track their indices is better than that of classical index funds. Finally, certain studies have compared the performance of country iShares in the context of portfolio management, to that obtained by classical funds or even that of ADRs. These studies have attempted to find the optimal geographic allocation in the different countries for which iShares are available. In this last category, the authors have also concluded that iShares offer better performance than their rivals, classic investment funds.

One of the earliest studies of ETFs as instruments of international diversification was that of Olienyk, Schwebach, and Zumwalt (1999). The authors determined the cointegration and Granger causality between the SPDR, 17 WEBs[7]And 12 country funds during the period from 1996-1998. The benefits of the diversification of country iShares were also analyzed by Pennathur, Delcoure, and Anderson (2002), Schwebach, Olienyk (2002), Durand and Scott (2003), and Miffre (2004). Pennathur, Delcoure, and Anderson (2002) apply two models, the first to a single factor and the second to two factors, to the price of country iShares during the period 1996-1999. Their two-factor model, which includes the local market returns and those of the American market, indicates that iShares are considerably exposed to the American market. Therefore, the authors conclude that country iShares do not constitute a perfect investment vehicle for international diversification.

This conclusion is confirmed by Durand and Scott (2003) in the case of Australian iShares. The authors employ a VaR model to explain the dynamic of returns and of volumes of Australian iShares due to movements of returns in the American market, volumes and exchange rates. Their results suggest that American investors who invest in the Australian market tend to exaggerate their reaction to public and past information emanating from the American stock market, exchange rates and returns on iShares.

However, despite their strong correlation with the American market, iShares seem to offer greater diversification than that of country fixed capital funds. Miffre (2004) demonstrates that investment in country iShares can produce efficient frontier which is more highly performing than those obtained from country fixed capital funds. Based on the optimization of portfolios and the Sharpe ratio, we conclude that a representative investor would benefit from international variability investment, placing approximately half of his or her wealth in the S&P 500 index and the remainder in iShares representing the developed European markets (Spain, Italy, the U.K. Sweden and France). Miffre (2004) is the only author who considered the correlation between the S&P 500 returns and those of iShares over time. Nonetheless, while recognizing that correlations are not constant over time, the author did not consider this phenomenon in constructing optimal portfolios.

Schwebach, Olienyk, and Zumwalt (2002) draw attention to the impact of volatility on the efficacy of diversification. They evaluate the performance and benefits of the diversification of iShares and country fixed capital funds, before and after the Asian crisis. After having analyzed the correlations, their paper concludes that the performance and scale of the advantages of diversification have changed considerably since the Asian crisis. This was reflected in increased correlations. As suggested by the results of the analysis of correlations, after the Asian crisis, iShares offered better opportunities for diversification than country fixed capital funds.

Similarly, Phengpis and Swanson (2004) discuss the construction of optimal portfolios and, in this context, they employ the results of the analysis of cointegration to determine whether, rather than counting exclusively on short-term information, consideration of information regarding long-term integration could help to improve

[7] World Equity Benchmark Securities; SPDR is the fund negotiated in the market representing the S&P500.

gains from diversification. The authors conclude that the utilization of national indices (as opposed to iShares) to evaluate the benefits of diversification could exaggerate the real advantages. In addition, the inclusion of long-term information as additional data in the construction of portfolios might improve the advantages of diversification.

Zhong and Yang (2005) examine the risk factors which explain the returns of iShares. The iShares studied in this article are those who track the MSCI indices of foreign countries and, therefore, are of interest to American investors seeking international diversification. The main question addressed by the authors is whether or not the price of iShares on the American market faithfully replicates the corresponding MSCI index, or whether significant deviations exist between the performance of the fund and that of the underlying index. The fundamental concern is, thus, to know whether iShares provide American investors complete exposure to the foreign country's index or whether the risk of these funds traded in the market contains a substantial component which is related to the particularities of the American market. Movements in the price of iShares on the American market may differ from those of the MSCI index for two main reasons. First, the underlying capital comprising the iShares funds is limited but not exactly equal to the capital comprising the MSCI index. Pennathur, Delcoure, and Anderson (2002) indicate that approximately 95% of the capital in the iShares fund corresponds to the MSCI index. Secondly, iShares may be traded at prime or at a discount compared to the net value of the fund share.

3. Data

Our database is comprised of daily prices of iShares in 14 developed countries, and 7 emerging countries, and SPDR for the American market. These data are all in American dollars and cover the period between July 1st, 2004 and June 30th, 2010. This period allows us to divide our sample into two subsections, the period between July 2004 and June 2007, before the crisis, and that between July 2007 and June 2010, after the financial crisis. In addition to the United States, the sample includes the following 14 developed countries: Australia, Austria, Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Singapore, Spain, Sweden, Switzerland and the United Kingdom, and the following seven emerging countries: Brazil, Hong Kong, Malaysia, Mexico, South Africa, South Korea and Taiwan. To our knowledge, this paper is the first to employ such a large sample of countries to study comovements in the context of a financial crisis. As these data are daily and cover a period of six years, they are perfectly adapted to the study of the long-term relationship, using the technique of cointegration. The returns are calculated in continuous time.

4. Methodology

4.1. Analysis of Correlations: Contagion or Interdependence?

As the analysis of the correlation was primarily used to measure the degree of financial contagion, we begin our analysis with an examination of correlations between the American market and the other markets under study. Nonetheless, the correlation coefficients between markets are liable to increase during periods characterized by greater volatility. In other words, if a crisis hits Country A with increased volatility in its financial market, it will be transmitted to the financial market of Country B with a rise in its volatility and also in the correlation between returns of both Countries A and B (Longin and Solnik , 1995; and Ang and Bekaert, 2002).

To isolate the effect of contagion on the effect of increased volatility, we calculate the correlation coefficients adjusted for heteroscedasticity, using the method proposed by Forbes and Rigobon (2002). Next, we use the standard Z test for statistical inferences. This methodology requires the identification of the source of contagion which, in our study, is the American market.

Forbes and Rigobon (2002) propose that the calculation of the correlation coefficient be adjusted for heteroscedasticity with the following formula:

$$^{*} = \frac{}{\sqrt{1+ \left(1 \quad ^{2}\right)}}$$

where: $= \left(\text{var}(r_2)_h / \text{var}(r_2)_l\right) \quad 1$

is the unadjusted correlation which varies in periods of increased volatility (*h*) or stable volatility (*l*) and is calculated using the following formula:

$$= Corr(r_1, r_2) = \frac{Cov(r_1, r_2)}{\sqrt{\text{var}(r_1).\text{var}(r_2)}} = \frac{_1 \text{var}(r_2)}{\sqrt{\quad _1^2 \text{var}(r_2) + \text{var}(r_1) \quad .\text{var}(r_2)}} = \quad 1 + \frac{\text{var}(r_1)}{_1^2 \text{var}(r_2)}^{1/2}$$

$r_{1,t}$ and $r_{2,t}$ are respectively the returns for Markets *1* and *2* at time *t* in the following equation:

$$r_{1,t} = \quad _0 + \quad _1 r_{2,t} + \quad _{1,t}$$

Where $_{1,t}$ is the independent random error term of $r_{2,t}$; represents the relative increase of the variance of r_2 ; and $\text{var}(r_2)_h$ $\text{var}(r_2)_l$ represent the variances of r_2 respectively during the periods of higher and stable volatility.

Morrison (1983) suggests a statistical test of the following null hypothesis:
Ho: no increase in the correlation

This test is calculated using the following formula: $T = \left(Z_0 \quad Z_1\right) \Big/ \sqrt{1/\left(N_0 \quad 3\right) + 1/\left(N_1 \quad 3\right)}$ with $Z_0 = 1 \Big/ 2 \ln \left(1 + \quad _0\right) / \left(1 \quad _0\right)$ and $Z_1 = 1/2 \ln \left(1 + \quad _1\right) / \left(1 \quad _1\right)$ as the two Fisher transformations of coefficient correlation before and after the crisis. N_0 And N_1 are, respectively, the number of observations before and after the crisis. This test is basically normally distributed and sufficiently robust for the non-normality of correlation coefficients.[8]

4.2. Analysis Using GARCH Dynamic Correlations (DCC-GARCH)

Initial studies on the correlations between international markets generally employed a constant correlation to study the benefits of international diversification (Panton and Lessig, 1976; and Watson, 1980). This approach ignores the fact that the correlation between two variables fluctuates over time and that, therefore, it often deviates from their constant unconditional correlation. Other simple methods such as historical rolling correlations, correlation coefficients adjusted for different volatility regimes and methods of exponential smoothing are widely used (Forbes and Rigobon, 1999). In this paper, we contribute to this literature by using conditional correlations which vary over time, in order to obtain a different perspective on the use of the correlation in the study of international diversification. More precisely, we examine the model of dynamic conditional correlation (DCC) introduced by Engle (2002).

Indeed, Engle (2002) developed a novel approach (Dynamic Conditional Correlation), in two steps, according to which correlations are dynamic. This new class of multivariate GARCH model is distinguished by its simplicity in the sense that, at the first stage, univariate GARCH specifications are estimated for each series separately and

[8] Basu (2002) and Corsetti et al. (2005) used this test.

then, at the second stage, the dynamic correlations are estimated based on the central residuals from the first stage.

The conditional correlation between two random variables r_i and r_j at time t is conditional on the information available at time (t-1) and is defined as follows:

$$\rho_{ij,t} = q_{ij,t}/\sqrt{q_{ii,t}q_{jj,t}} = E_{t-1}[r_{i,t}r_{j,t}]/\sqrt{E_{t-1}[r_{i,t}^2]E_{t-1}[r_{j,t}^2]} \qquad (1)$$

We can normalize each return using its dynamic standard deviation to obtain the following normalized return:

$$z_{it} = r_{i,t}/\sigma_{i,t} \qquad (2)$$

In separating the returns according to their conditional standard deviations, we create variables z_{it} ; i = 1,2... n, which all have a conditional standard deviation of 1.

The conditional correlation of returns $r_{i,t}$ expressed in the equation (1) is equal to the conditional covariance of standardized variables $z_{it,}$as can be seen in the following demonstration:

For equation 2, we have: $z_{it} = r_{i,t}/\sigma_{i,t}$ in dividing the returns by their conditional standard deviation, we create variables z_{it}; i = 1,2... n, which all have a conditional standard deviation equal to 1.

The conditional correlation of returns $r_{i,t}$ expressed in Equation (1) is equal to the conditional covariance of standardized variables $z_{it,}$as we can see in the following demonstration:

$$E_t[z_{it}z_{jt}] = E_t[(r_{i,t}/\sigma_{i,t})(r_{j,t}/\sigma_{j,t})]$$

$$= E_t(r_{i,t}r_{j,t})/(\sigma_{i,t}\sigma_{j,t})$$

$$= \sigma_{ij,t}/(\sigma_{i,t}\sigma_{j,t})$$

$$= \rho_{ij,t} \quad \text{for all } i \text{ and } j \qquad (3)$$

Thus, the modelization of the dynamic conditional correlation of raw returns is equivalent to the modelization of the conditional covariance of standardized returns. To model the covariance between standardized returns z_{it}, Engle (2002) suggests the GARCH process (1,1) which permits us to model the return in the following manner:

$$q_{ij,t+1} = \overline{\rho_{ij}} + \alpha(z_{it}z_{jt} - \overline{\rho_{ij}}) + \beta(q_{ij,t} - \overline{\rho_{ij}}) \qquad (4)$$

Where $\overline{\rho_{ij}}$ is the unconditional correlation between z_i and z_j with the following GARCH restriction: $\alpha+\beta<1$ in order to guarantee non-negativity and the stability of variances. Thus, the conditional correlations are modeled individually according to the GARCH process.

4.3. The Analysis of Cointegration

Cointegration is a characteristic that a certain stable chronological series may exhibit. Engle and Granger (1987) were the first to develop an estimation technique in two stages to analyze the long-term equilibrium relationships (cointegration) of chronological series. Amongst other things, this technique has been used by a number of other researchers to study the interdependence of financial markets and the efficiency of the foreign exchange market (Hakkio and Rush, 1989, 1991; and Copeland, 1991).

Consistent with the methodology of Engle and Granger, two nonstationary variables, (for example, a and Y_t) are said to be cointegrated when there is a linear economic relationship between them which is stable over time, even if these variables evolve independently from one another, and even if they do not fluctuate around the same constant variable. This null linear combination represents the long-term relationship between the variables, a relationship which may be considered to be in a state of equilibrium (Step 1). In such a case with two variables, the linear combinations form a line which links the values of pairs of two variables in long-term equilibrium. The deviations from this line, which represent short-term movements around the equilibrium, must be stable and statistically and significantly linked to the initial differences for at least one of the original variables (Step 2).

The initial determination of the instability of individual variables (for example, the series of prices of iShares) constitutes a pretest of cointegration analysis (Haley, 2007). It consists of determining whether the variables under study are, indeed, integrated of order 1 (X_t ~ I (1) and Y_t ~ I (1)). A variable I (1) contains a single unit root and should be differentiated only once to become stationary, I (0). The goal of the initial test is to determine whether the individual variables constantly fluctuate around a fixed average. To that end, we conducted a unit-root test, that is, the ADF test (K*) (Augmented Dickey-Fuller by Dickey and Fuller, 1981), on each variable. To determine the optimal order of k delays,* we use the following three information criteria: Akaike (AIC), Schwartz (SC), and Hann-Quin (HC). When the condition of instability is met, we can apply the Engle and Granger two-step procedure as follows:

The first step requires an estimation by least squares regression (OLS) of the relationship between the prices of the SPDR and iShares in another country:

$$Y_t = \alpha + \beta X_t + \varepsilon_t$$

Where:

- Y_t is the price of iShares in a given country at date *t;*
- X_t is the price of the SPDR on date *t;* and
- ε_t is the error term.

The goal here is to extract the error terms $\hat{\varepsilon}_t$ from the regression $\hat{\varepsilon}_t = Y_t - \hat{\alpha} - \hat{\beta} X_t$.

Subsequently, we verify whether the error terms are indeed stable, using the same ADF(K*) test. There again, the order of optimal k* delay will be determined by the three information criteria identified earlier. Consequently, if the error terms are stable, then we can proceed to the next step.

The second step requires a least squares regression (OLS) estimation of two error correction models (ECM), one for each variable studied (1) (series of ETFs). The two error correction models are represented by the following two equations:

$$\Delta Y_t = \mu_1 + \gamma_1 \varepsilon_{t-1} + \sum_{i=1}^{p} \delta_i \Delta X_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta Y_{t-1} + u_t$$

$$\Delta X_t = \mu_2 + \gamma_2 \varepsilon_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta X_{t-1} + u_t'$$

Where p, the number of delays, is chosen arbitrarily (p=1 in the present document), and ΔY_t *and* ΔX_t are the changes in the cointegrated variables. The two coefficients γ_1 and γ_2 reflect the adjustment speed of the long-term equilibrium. For a cointegration relationship to exist, at least one of the two coefficients, $\gamma_1$ou γ_2, must be

significantly different from zero. If at this second stage of the estimation, there is no such statistically significant error correction, the analyst must conclude that this is probably a case of spurious correlation (Haley, 2003).

4.4. Analysis of Value at Risk

The effect of the deviation from the constant correlation is not the only concern in the evaluation of the benefits of international diversification. Another current problem is the potential deviation from the normal distribution. It is well known that most financial returns are not distributed normally (often being asymmetrical with an excess of kurtosis). Consequently, we need to examine the impact of the peak periods on the advantages of international diversification, especially since the context of some of the data is that of a financial crisis characterized by an excess of volatility and more frequent extreme values. More precisely, we use the four moments value-at-risk (VaR) in order to integrate kurtosis and asymmetry into the measurement of risk, and then to compare this two moments VaR measure with the unconditional variances and GARCH variances estimated in the first section. In addition, examination of the potential loss with the VaR is an alternative measure of the degree of a portfolio's diversification.

Value-at-risk (VaR) is a measure which permits us to combine the statistical points of distribution into a single value, allowing us to compare the performance of portfolios across a number of markets in terms of risk in the distribution tails. Consequently, the VaR offers a direct comparison compatible with the interests of portfolio managers in evaluating the downside risk of a portfolio. The two moments VaR, currently a popular measure of downside risk, is given in the following formula:

$$VaR_p = \mu_p - z_\alpha \sigma_p$$

Where μ_p is the portfolio's average return, σ_p its standard deviation and z_α is the number of standard deviations associated with a certain percentile α. The two moments VaR underlies the normal distribution of returns where only the average return and the standard deviation are considered.

The modified VaR, considering only the four first moments of the distribution of returns, offers a measure of the potential risk for a portfolio given a probability characterized by its average return, its standard deviation, its asymmetry and, finally, its kurtosis. This VaR was developed by Favre and Galeano (2002) and is expressed in the following equation:

$$VaR_p = \mu_p - \left[z + \frac{1}{6}(z^2 - 1)S_P + \frac{1}{24}(z^3 - 3z)K_P - \frac{1}{36}(2z^3 - 5z)S_P^2\right]\sigma_P$$

Where μ_p, σ_p, S_P and K_P are the four first points in time for the distribution of the returns of Portfolio P (S_P *and* K_P representing respectively asymmetry and the kurtosis of Portfolio P). The two moments VaR is a particular case of this four moments VaR in the case when the asymmetry and kurtosis are negligible.

5. Empirical Results

Analysis of short term comovements with the use of correlation coefficients, as reported in Table 1, confirms the conclusions of Forbes and Rigobon (2002). We observe that, apart from the correlation with Japan, all the correlations not adjusted for heteroscedasticity increased significantly after the financial crisis. However, in correcting this bias identified by Forbes and Rigobon (2002), the adjusted correlations are not significant, with the exception of Australia. These results clearly demonstrate that the American financial crisis was not transmitted to other countries by a contagion effect, but that the correlations increased with other countries because of interdependence, as stated by Forbes and Rigobon (2002).

Table 1: Test of the Significance of the Increase of the Correlation After the Crisis

	Correlation before the crisis	Correlation after the crisis	Correlation-adjusted after the crisis	Z-statistic (nonadjusted)	Z-statistic (adjusted)
Developed Countries					
U.S.-Australia	0.027	0.287	0.102	-5.199***	-1.460*
U.S.-Austria	0.248	0.496	0.192	-5.650***	1.135
U.S.-Belgium	0.331	0.537	0.213	-4.950***	2.480
U.S.-Canada	0.490	0.726	0.340	-7.465***	3.512
U.S.-France	0.409	0.583	0.239	-4.498***	3.710
U.S.-Germany	0.422	0.623	0.263	-5.402***	3.515
U.S.-Italy	0.390	0.549	0.219	-3.972***	3.660
U.S.-Japan	0.055	0.000	0.000	1.065	1.058
U.S.-Netherlands	0.391	0.584	0.239	-4.961***	3.269
U.S.-Singapore	0.089	0.371	0.136	-5.829***	-0.918
U.S.-Spain	0.399	0.552	0.221	-3.849***	3.837
U.S.-Sweden	0.308	0.548	0.219	-5.780***	1.845
U.S.-Switzerland	0.302	0.512	0.200	-4.913***	2.117
U.S.-U.K.	0.351	0.581	0.237	-5.757***	2.418
Developing Countries					
U.S.-Brazil	0.605	0.760	0.372	-5.729***	6.015
U.S.-Hong Kong	0.096	0.288	0.103	-3.891***	-0.137
U.S.-Malaysia	0.050	0.171	0.059	-2.374***	-0.180
U.S.-Mexico	0.607	0.770	0.383	-6.155***	5.837
U.S.-South Africa	0.205	0.419	0.156	-4.642***	0.967
U.S.-Korea	0.091	0.254	0.090	-3.263***	0.028
U.S.-Taiwan	0.045	0.167	0.058	-2.397***	-0.251

Short term comovements estimated by the dynamic conditional correlations (DCC- GARCH) are represented in Figure 1. As our sample covers 21 developed and emerging countries, we content ourselves with presenting the results of certain representative countries, the other results being similar. On these graphs, we can distinguish two main periods. The period before the crisis is characterized by weak volatility and some relatively weak dynamics. The second period which covers that of the financial crisis and which coincides with considerable instability in the global markets is characterized by a system of extremely heightened conditional volatility, and correlations between the American market and the other countries which increased significantly. These results confirm those of Longin and Solnik (1995) who demonstrate that comovements between stock markets increase in periods of high volatility. These results also confirm those of Schwebach et al. (2002) who found that volatility and correlations amongst 11 markets, 5 of whom are in the G7, increased after the Asian crisis.

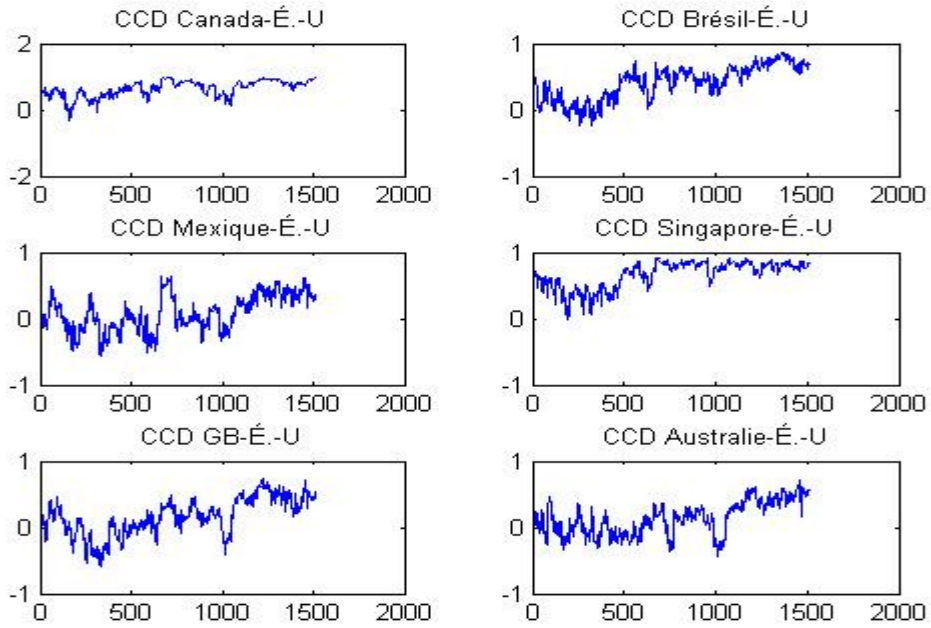


Figure 1: The GARCH Dynamic Correlation Between the American Market and Other Developed and Emerging Markets Before and After the Financial Crisis

Concerning long-term comovements, before and after the financial crisis, we have summarized the conclusions of all the results of the analysis of cointegration, using the method of Engle and Granger (1987) in Table 2 for the developed countries and Table 3 for developing countries. The details of these calculations are presented in the annex. These two tables first show that, for all countries, there is no cointegration with the American market during the period after the financial crisis (2007-2010) or for the entire period before and after the crisis, that is, between 2004 and 2010. However, for the period before the crisis, certain countries were cointegrated with the American market, notably Australia (very strong integration), Belgium, Hong Kong, Mexico and Taiwan (strong integration), Austria, the Netherlands, Spain, and the United Kingdom (weak integration).

Tables 2 and 3 also present the unconditional correlation between the American market and the other countries. We observe that, for all the countries except Japan, the unconditional correlation increased after the financial crisis. Furthermore, we note that, despite increased correlations after the crisis, the integration disappeared for the countries which were integrated with the American market before the crisis. This result is hardly surprising, given that correlation and cointegration are two different measures of interdependence in the short and long terms which are separate and distinct (Carol Alexander, 2001).

Table 2: Summary of the Statistical Intensity of Cointegration and Unconditional Correlation in Developed Countries.

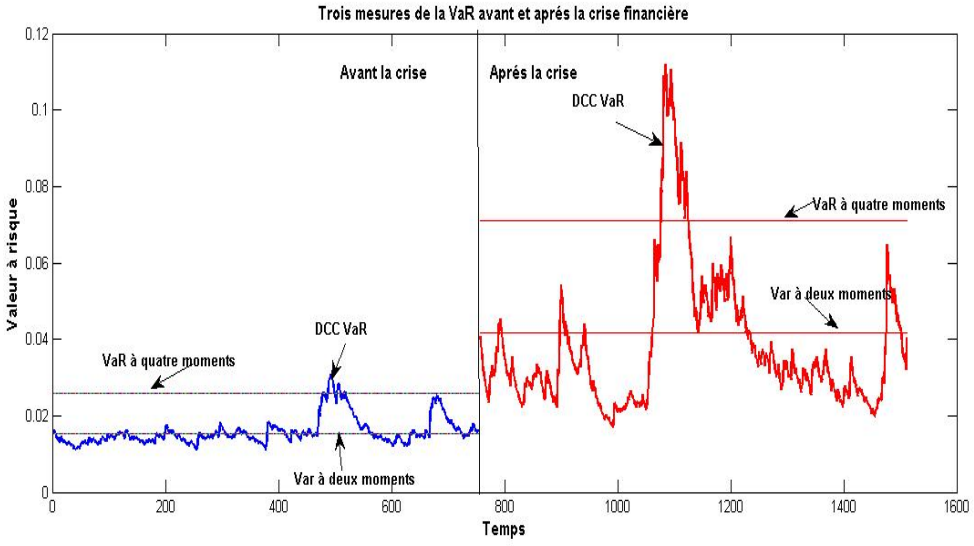
Market Pairs	Before the Crisis (2004-2007)		After the Crisis (2007-2010)		Throughout the Period (2004-2010)	
	Cointegration	Correlation	Cointegration	Correlation	Cointegration	Correlation
U.S.-Australia	Very Strong	0.027	None	0.287	None	0.213
U.S.-Austria	Weak	0.248	None	0.496	None	0.439
U.S.-Belgium	Strong	0.331	None	0.537	None	0.495
U.S.-Canada	None	0.490	None	0.726	None	0.703
U.S.-France	None	0.409	None	0.583	None	0.538
U.S.-Germany	None	0.422	None	0.623	None	0.568
U.S.-Italy	None	0.390	None	0.549	None	0.508
U.S.-Japan	None	0.055	None	0.000	None	-0.009
U.S.-Netherlands	Weak	0.391	None	0.584	None	0.539
U.S.-Singapore	None	0.089	None	0.371	None	0.293
U.S.-Spain	Weak	0.399	None	0.552	None	0.515
U.S.-Sweden	Very Strong	0.308	None	0.548	None	0.494
U.S.-Switzerland	None	0.302	None	0.512	None	0.461
U.S.-U.K.	Weak	0.351	None	0.581	None	0.528

Table 3: Synthesis of the Statistical Intensity of Cointegration and Conditional Correlation in Emerging Countries

Market Pairs	Before the Crisis (2004-2007)		After the Crisis (2007-2010)		Throughout the Period (2004-2010)	
	Cointegration	Correlation	Cointegration	Correlation	Cointegration	Correlation
U.S.-Brazil	None	0.605	None	0.760	None	0.714
U.S.-Hong Kong	Strong	0.096	None	0.288	None	0.220
U.S.- Malaysia	None	0.050	None	0.171	None	0.127
U.S.-Mexico	Strong	0.607	None	0.770	None	0.721
U.S.-South Africa	None	0.205	None	0.419	None	0.354
U.S.-Korea	None	0.091	None	0.254	None	0.205
U.S.-Taiwan	Strong	0.045	None	0.167	None	0.133

Finally, to study the impact of extreme values on international diversification during the financial crisis, we created two portfolios. Each is composed of all the securities in our sample (the 21 iShares plus the American SPDR) and covers each of two subperiods of this study, that is, the periods before and after the crisis. Then, for each portfolio we calculated the VaR using three distinct methods: the two moments VaR with unconditional variance; the two moments VaR GARCH conditional variance and the four moments VaR which takes into consideration asymmetry and kurtosis. The results are summarized in Figure 2. First, they reveal that the returns are not normally distributed. Indeed, for the two subperiods, the four moments VaR is always higher than that at two points. However, after the crisis, we observe that the difference between these two VaRs is greater. This is due to the fact that the volatility and, above all, the extreme values (estimated by the kurtosis), were greater after the crisis. The conditional two moments VaR shows the considerable volatility characterizing the period after the crisis. Finally, we are able to conclude that the potential losses of internationally diversified portfolios, calculated by the VaR, were much greater after the financial crisis. This result can be explained by the high rate of extreme values and by the increased volatility.

Figure 2: The VaR of Portfolios from the American Market and Those of All Other Developed and Emerging Countries Before and After the Financial Crisis



6. Conclusion

A number of studies have reported that correlations between financial markets increase when volatility increases (Solnik et al.,1996). Thus, the benefits of international diversification lose their importance when portfolio managers most need them. The turbulence in the financial markets following the recent American financial crisis provides a vivid illustration of this phenomenon. Our study examines the importance of long and short-term interdependence of the United States and 21 other developed and developing countries, and its impact on international diversification following the subprime financial crisis. Contrary to most studies on comovements of international markets, which generally use stock market indices, our study uses a series of prices of exchange-traded funds, with the goal of providing empirical evidence of the real extent of the possibilities of international diversification offered to American investors. Our study offers an in-depth analysis of comovements between stock markets, based on econometric techniques which allow us to illustrate the variable nature over time of interdependencies between markets, both in the short and the long-term and at the level of extreme values.

Our results, based on data provided by iShares, suggest that the benefits of international diversification in the short term have diminished significantly. Indeed, the degree of short-term interdependence, measured by conditional correlations, increased after the financial crisis, as indicated by the increase in the conditional correlation of daily iShare returns. In addition, using the two moments and fourn moments VaR, to analyze the risks of potential losses of two internationally diversified portfolios during the periods before and after the financial crisis, the results suggest that when asymmetry and kurtosis are considered important factors in the calculation of the adjusted VaR, the VaR increases considerably compared to that at two points in time. However, this increase is much greater after the financial crisis due to the great volatility during this period, as well as the existence of more extreme values. The results for the VaR suggest that international diversification after the financial crisis was much less efficacious due to potential losses which increased substantially.

However, analysis of contagion and long-term interdependencies first suggests that the financial crisis was transmitted by an effect of interdependence and not contagion. This result signifies that the effect of international diversification has diminished but still exists. Concerning long-term interdependence, we observe that the intensity of the cointegration with the United States differed from one country to another before the crisis, but that this cointegration disappeared for all countries after the crisis while correlations increased. This means that the effect of long-term international diversification persists and is still relevant.

Thus, we can conclude that, during the subprime financial crisis, short-term interdependencies between the American market and the other financial markets under study, measured by dynamic correlations and the VaR, significantly increased so that the short-term benefits of international diversification diminished considerably. Nonetheless, analysis of contagion and cointegration demonstrate that, despite the extent of the financial crisis, international diversification remains relevant.

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