Crisis and Financial Contagion: The Subprime Crisis

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Abstract
Our purpose in this paper is to examine financial contagion using the DCC GARCH (1, 1) technique and a correlation test. Our sample includes stock returns of 10 emerging markets from 1 January 2005 to 01 July 2010. The DCC GARCH (1, 1) results indicate a significant conditional correlation between emerging markets returns (Argentina, Brazil, Korea, Honk-Kong, Indonesia, Malaysia, Mexico, Shanghai, Singapore and Taiwan) and the American market during the subprime crisis except for the Shanghai market (China). Moreover, defining contagion as a significant increase of relationships across markets and adjusting correlation coefficients to control for heteroscedasticity, we notice a contagion effect from the US towards Argentina, Brazil, Korea, Honk-Kong, Malaysia, Mexico and Singapore.

Key words: Subprime crisis, international financial contagion, DCC GARCH, Stock market return.

Introduction
These recent years brought news about financial crises propagating frequently and often provoking economic depressions. Financial contagion is closely surveyed within the financial crises literature. Indeed, the study of crises and their repercussions on economic activity helps find out how an initial specific shock in a country is quickly transmitted to many markets across the globe.

The term financial crises includes a set of crises notably exchange, banking and stock markets crises. A financial crisis may be specific to some countries as it may start in a country and then, through a contagion effect, spreads out to become international. Economics literature distinguishes between many financial crises models and classifies them in three generations. First-generation crises are initially described by Flood and Garber (1984), then by Krugman (1997). These models aim at studying the occurrence of speculative shocks and their impact on exchange reserves. They assume that crises are triggered when macroeconomic fundamentals are not respected. Second-generation crises are reported by Obstfeld (1994) and Cole and Keho (1996). These models have been developed during the crises which hit the European monetary system between 1992 and 1993, considered as the first experiences of financial globalisation.
Obstfeld (1994) views the crisis as a result of a conflict between the fixed exchange regime and the government’s will to pursue a more expansionist monetary policy. When actors start anticipating a possible abundance in fixed exchange regimes, the resulting pressures on interest rates push governments to agree on such a decision. Third-generation crises emerged out of the Asian crisis. Described by Krugman (2001), Cartapanis and Gilles (2002), these models combine first and second-generation crises known as twin crises. It is a combination of banking and exchange crises. Generally speaking, third-generation crises reveal the fragility of the banking and financial spheres of the economy. In this case, the crisis is considered as a banking panic phenomenon that moves the economy from a good equilibrium to crisis equilibrium.

Economics literature distinguishes between different definitions of financial contagion. However, the most used definition is that of Eichen green et al. (1996) who view contagion as a significant increase in a crisis probability in a country conditioned by the occurrence of a crisis in another country. This definition is very privileged in studies which model the occurrence of crises through exchange rate collapse. However, in practice, this definition requires a sample of countries most of which experienced a crisis.

It is possible to distinguish another definition of contagion which calls for market volatility. In this case, contagion occurs when volatility spreads out from the financial market of the country in crisis to other financial markets of other countries. Empirically speaking, analysis of financial markets movements shows that stock prices volatility often increases during a period of financial turmoil. Thus, this definition uses volatility increase in order to identify the crisis. Accordingly, contagion is measured as the spread of this volatility to another market.

Forbes and Rigobon (2001) elaborated their own definition stipulating that contagion is a significant increase in links between markets, after a shock in a country or in a number of countries. The significant increase in links between financial markets implies generating or intensifying new transmission channels during the crisis period independently from fundamentals and responding to a crisis in a given country. Generally speaking, contagion refers to the expansion of a country’s financial markets disturbances to financial markets of other countries. This expansion is observed through co-movements (correlation) between exchange rate, the spreads on liabilities and capital mobility. The rest of this paper is structured as follows. Section 2 presents the different contagion models. Section 3 reports the different contagion transmission mechanisms. Section 4 describes methodology.

Contagion Models

After providing different definitions of contagion, we find it fit to present the different models it integrates. The theoretical and empirical studies attempting to explain the causes and mechanisms of contagion differ according to the approach taken (real, financial, investors’ behaviour).

Fundamentals-based contagion models

These models analyse transmission of contagions from one country or market to another essentially with reference to fundamentals (Dunguey & Tambakis 2003). This type of contagion is channelled through business, finance or exchange operations (Dehove (2003). According to Masson (1998), fundamentals-based contagion models highlight business relations as a crisis propagation vector. This model relies on the fact that devaluation in a country may reduce competition of prices against partner countries (at the level of importations) and competitors (at the level of exportations) which consequently harms their trade balance. The incurred harm in trade balance will be perceived as an economic weakness by market actors who lose trust and
draw their capitals precipitating then a new crisis. The financial channel reveals that countries are linked by their presence in a stock or loans portfolio of a related third country. In the case of international loans, it is the common creditor’s channel which explains the agents’ postponement effects on other countries. Mechanically speaking, portfolio adjustment, arising out of the need to seek liquidity to compensate for the incurred losses following the crisis in a first country, diffuses rationing and liquidity crisis.

**Investors’ behaviour contagion models**

These models consider contagion as a consequence of a behavioural phenomenon which can be explained by different channels:

- It can be due to excessive arbitration operations, reflecting the investors’ tendency to adjust their portfolios in order to maximise their usefulness.
- It can translate an illiquidity situation of international financial markets as suggested by Calvo (1998) and Golgfajn and Valdés (1995).
- It can be a problem of information asymmetry characterized by higher costs and uncertainty pushing investors to adopt a mimetic behaviour (Dehove (2003).

**Crises transmission mechanisms according to contagion model**

Contagion has been subject of a vast academic literature Eichengreen et al.1996; Forbes and Rigobon, 2001, 2002). Many studies are conducted to determine the causes and the deficiencies at the origin of contagion. Nevertheless and despite a controversy on a universal definition of contagion, these studies agree on two approaches. The first approach relates the channels of contagion to interdependence between countries (Eichengreen et al, 1996; Glick and Rose 1999; Van Rijckeghem and Weder, 2000; 2001). The second approach considers the main cause of contagion the rational or irrational attitude of investors whether individually and/or collectively, specifying then the notion of ‘pure contagion” (Masson, 1998; Forbes and Rigobon, 2000; Pritsker (2000).

**Theories Non-contingent to Crises**

Generally speaking, these theories assume that transmission mechanisms following a shock are not significantly different from those prior to the shock or the crisis. Accordingly, excessive co-movements between markets are by nature a continuation of the pre-crisis links (Masson, 1998; Forbes and Rigobon, 2000; Kaminsky and Reinhart, 2000). This approach is often qualified as “fundamental contagion”. It is identified through repercussions or spillovers resulting from the interdependences via economic, trade or financial links. Real or trade links, mentioned by Eichengreen et al, (1996) and Glick and Rose (1998), result when a first devaluation move reduces competition of prices of the partner countries or exporting competitors. In this case, anticipations of current balances degradation prevail, which may precipitate new crises. In other words, these partner countries end up by devaluing their currencies in order to re-launch their exports.

**Theories Contingent Crises**

Cailleteau and Vidon (1999) reveal that the microfinancial approach, as empirically observed, seems to have a number of characteristics common to second-generation models. Among these characteristics, the authors particularly mention non-linearity. Cailleteau and Vidon’s (1999) analysis helps explain this phenomenon by the fact that contagion presents itself as an attack purely speculative and unpredictable in the sense that its explosion strictly remains arbitrary. Change in operators’ anticipations is self-fulfilling. Finally, this is translated by the coexistence of many possible balances of fundamentals initially identical. Moreover, Cailleteau and Vidon (1999) show that second-generation models have been developed to study a crisis of a given currency while considering contagion as an aggravating factor. Masson (1998) refers to the objective of banking panic models developed by Diamond and Dybvig (1983). This reference allowed him to define pure contagion. Indeed, Masson (1998) signals that that this contagion, with the resulting panic, may be described as a steady equilibrium leap in a situation of panic across markets or countries. It is against this background that economists referred in their studies to the theories contingent to crises. This current supports the idea that crises propagation is specific and binding. In other words, crises borrow fundamental transmission channels different from those prevailing before the crisis or even absent during the period of financial instability. This current is essentially based on multiple equilibriums; endogenous liquidity shocks. The main result obtained from studies of second-generation monetary crises models is that self-fulfilling crises may occur despite convenient macroeconomic conditions. This progress in theories of monetary crises points to multiple equilibriums. Worth noting is that in a context of contagion, multiple equilibriums is important as well. If a “virus” moves from country to another, it moves victims from a good equilibrium mode to a bad equilibrium mode. This latter condition may be characterised by devaluation in case of an exchange crisis, a decrease in stock prices, capital flights or a default on debts. Multiple equilibrium mechanisms are visible when a crisis is used as an umbrella to other countries. It is a stochastic equilibrium in which the risk is extra-economic. Masson (1998) elaborates a model explaining how a crisis in a country may gear investors’ anticipations, moving the economy from a good equilibrium to a bad equilibrium. To this end, the author proposes a model with as variables interest rate, debt, trade balance and exchange reserves. Thus, the passage from a good to a bad equilibrium is not arbitrary since it depends on the model’s parameters. Accordingly, the economy will or will not be in a “crisis zone” which makes it vulnerable to a bad equilibrium condition. Similar to Masson (1998), Forbes and Rigobon (2000) show that transmission of shocks is channelled through a change in investors’ anticipations which provoke in their turn disequilibrium. Moreover, they define contagion as a sudden increase in economic links between two or more countries. This shift contagion is unique from other conventional interdependencies. It is measured by the exceptional increase in stock returns correlation, capital flows, propagation speed of a shock, speculative attack probability, or, finally, market volatility. In real terms, it is a contagion of “stress and financial panic”.

**Empirical test on contagion: the Subprime Crisis**

The aim of this section is to test the presence of pure contagion through examining stock markets during the subprime crisis. This contagion translates the significant differences in the relationships between markets during two periods: a quiet period and a crisis period. In this context, we use weekly stock market indices returns of ten countries, between January 2005 and July 2010. Our procedure is twofold. The first section examines, using the DCC-GARCH model, the contagion effect of the subprime crisis over 10 emerging stock markets. Our aim is to find financial contagion evidence in these markets. The second section, we try to identify the
existence of “pure contagion”, by testing the statistical significance of the increase in the adjusted correlation coefficient of heteroscedasticity (Forbes and Rigobon (2001)).

Data and Sample

Our sample includes the following:

- **US (Dow Jones)**
- **Asian countries:** Korea (KOSPI Composite Index), Hong-Kong (Hang Seng Index), Indonesia (Composite Index Jkse), Malaysia (TSE Bursa Malaysia KLCI), Singapore (Straites Times Index), Shanghai (SSE Composite Index) and Taiwan (TSEC Weighted Index).
- **Latin American countries:** Argentina (Merval Buenos Aires), Brazil (IBOVESPA) and Mexico (IPC MXX).

Data cover the period between 1 January 2005 and 01 July 2010. This period is divided into two sub-periods to be able to examine the possible change in co-movement relations.

Then, we suppose that the explosion of the subprime bubble occurred in 1 August 2007. Starting from this date, we divide the total period into the following two sub-periods:

- **First sub-period:** from 01-01-2005 to 31-07-2007 (pre-crisis period)
- **Second sub-period:** from 01-08-2007 to 01-07-2010 (crisis period)

We use weekly stock markets indices; i.e. a total of 290 observations per country. The sample for the quiet period includes 136 observations against 154 for the crisis period. Data is taken from Yahoo-France database.

Model specification

Engle’s (2002) DCC-GARCH model is an extension of Bollerslev et al.’s constant conditional correlation (1992). It is used to test the dynamic relationship between the American market and Latin American and Asian markets. Following Engle (2001), returns are assumed under the following process after filtration.

\[ r_t \mid F_{t-1} \sim N(0, H_t) \]  \hspace{1cm} (1)

And

\[ H_t \equiv D_t R_t D_t \]  \hspace{1cm} (2)

Where \( D_t \) is the \( k \times k \) diagonal matrix of time-varying standard deviations from a univariate GARCH with \( \sqrt{h_{it}} \) on the \( i^{th} \) diagonal, and \( R_t \) is the time-varying correlation matrix. The log-likelihood of this estimator can be written:

\[
L = -\frac{1}{2} \sum_{t=1}^{T} \left( k \log(2\pi) + 2 \log|H_t| + r_t' H_t^{-1} r_t \right)
\]

\[
= -\frac{1}{2} \sum_{t=1}^{T} \left( k \log(2\pi) + 2 \log|D_t R_t D_t| + r_t' D_t^{-1} R_t^{-1} D_t^{-1} r_t \right)
\]  \hspace{1cm} (3)

\[
= -\frac{1}{2} \sum_{t=1}^{T} \left( k \log(2\pi) + 2 \log|D_t| + \log|R_t| + e_t' R_t^{-1} e_t \right)
\]
Where \( \varepsilon_i \sim N(0, R_i) \) are the residuals standardized on the basis of their conditional standard deviations.

First, the conditional variances for any individual asset can be obtained from the univariate GARCH model:

\[
h_{it} = \omega + \sum_{p=1}^{P} \alpha_p r_{it-p}^2 + \sum_{q=1}^{Q} \beta_q h_{it-p} \quad \text{for } i = 1, 2, 3, \ldots, k
\]  

(4)

With the usual GARCH restrictions of non-negativity and imposed stationarity, such as non-negativity of variances and \( \sum_{p=1}^{P} \alpha_p + \sum_{q=1}^{Q} \beta_q < 1 \).

Then, the proposed dynamic correlation structure is:

\[
Q_i = (1 - \sum_{m=1}^{M} \alpha_m) - \sum_{n=1}^{N} \beta_n) \bar{Q} + \sum_{m=1}^{M} \alpha_m (\varepsilon_{i-m} \varepsilon_{i-m}^{'}) + \sum_{n=1}^{N} \beta_n Q_{i-n}
\]  

(5)

\[
R_i = Q_i^{-1} Q_i^{*^{-1}}
\]  

(6)

Where \( \bar{Q} \) is the unconditional covariance of the standardized residuals resulting from the univariate GARCH equation. And \( Q_i^{*} \) is a diagonal matrix composed of the square root of the diagonal elements of \( Q_i \). That is

\[
Q_i^{*} = \begin{bmatrix}
\sqrt{q_{11}} & 0 & \cdots & 0 \\
0 & \sqrt{q_{22}} & \cdots & 0 \\
\vdots & \vdots & \ddots & \vdots \\
0 & 0 & \cdots & \sqrt{q_{kk}}
\end{bmatrix}
\]  

(7)

The typical element of \( R_i \) will be \( \rho_{ij} = \frac{q_{ij}}{\sqrt{q_{ii} q_{jj}}} \), and the matrix \( R_i \) will be a positive definite/constant. The K assets’ covariance matrix \( H_i \) is thus a positive definite/constant and can be written as \( H_i \equiv D_i R_i D_i^{'} \).

**Results and interpretation of estimations**

Descriptive statistics examine normality of distribution. The series normality is tested by symmetry coefficients (Skewness) and flatness (kurtosis).
Table 1: Descriptive Statistics of Weekly Stock Returns  
Total Period from 01/01/2005 to 01/07/2010

<table>
<thead>
<tr>
<th>indice</th>
<th>USA</th>
<th>ARGENTINA</th>
<th>BRAZIL</th>
<th>KOREA</th>
<th>HONG KONG</th>
<th>INDONESIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>-0.000519</td>
<td>-0.005951</td>
<td>0.005456</td>
<td>0.002249</td>
<td>-0.000712</td>
<td>0.001106</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.547962</td>
<td>0.693843</td>
<td>0.668296</td>
<td>0.170319</td>
<td>2.241911</td>
<td>0.115867</td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.200298</td>
<td>-2.840322</td>
<td>-0.223245</td>
<td>-0.229288</td>
<td>-2.912533</td>
<td>-0.704917</td>
</tr>
<tr>
<td>Standar Dev</td>
<td>0.047495</td>
<td>0.178095</td>
<td>0.057007</td>
<td>0.035218</td>
<td>0.219113</td>
<td>0.056619</td>
</tr>
<tr>
<td>Skewness</td>
<td>5.015221</td>
<td>-13.77956</td>
<td>5.146162</td>
<td>-1.073762</td>
<td>-4.419375</td>
<td>-7.093011</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>65.97312</td>
<td>223.6362</td>
<td>65.81565</td>
<td>11.25811</td>
<td>146.3961</td>
<td>85.88048</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>48116.98</td>
<td>597398.2</td>
<td>48789.67</td>
<td>879.7657</td>
<td>249406.9</td>
<td>85434.20</td>
</tr>
<tr>
<td>Probability</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
</tr>
<tr>
<td>Observations</td>
<td>284</td>
<td>290</td>
<td>289</td>
<td>290</td>
<td>290</td>
<td>290</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>indice</th>
<th>MALAYSIA</th>
<th>MEXICO</th>
<th>SHANGHAI-CHINA</th>
<th>SINGAPORE</th>
<th>TAIWAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.001259</td>
<td>0.003572</td>
<td>0.002030</td>
<td>-0.002444</td>
<td>-0.001549</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.066530</td>
<td>0.197711</td>
<td>0.139447</td>
<td>0.153205</td>
<td>0.094102</td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.097121</td>
<td>-0.179285</td>
<td>-0.148979</td>
<td>-1.066391</td>
<td>-0.649100</td>
</tr>
<tr>
<td>Standar Dev</td>
<td>0.020901</td>
<td>0.037966</td>
<td>0.042112</td>
<td>0.070083</td>
<td>0.048762</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.988230</td>
<td>0.237333</td>
<td>-0.116703</td>
<td>-12.14974</td>
<td>-8.216646</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>6.374925</td>
<td>9.120246</td>
<td>4.125689</td>
<td>184.8055</td>
<td>108.6307</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>184.8328</td>
<td>455.3328</td>
<td>15.96999</td>
<td>406528.3</td>
<td>138087.1</td>
</tr>
<tr>
<td>Probability</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000341</td>
<td>0.000000</td>
<td>0.000000</td>
</tr>
<tr>
<td>Observations</td>
<td>290</td>
<td>290</td>
<td>290</td>
<td>290</td>
<td>290</td>
</tr>
</tbody>
</table>

Table 1 indicates some statistical properties of the stock returns of the sample and of the two sub-periods. These results reveal that Argentina has the lowest mean (-0.005951) whereas the highest mean is that of Brazil (0.05456). As for the maximum return, it varies from de 2.241911 for Honk Kong to 0.066530 for Malaysia. However, minimum weekly returns range between -2.912533 for Honk Kong and -0.097121 for Malaysia. As for risk as measured by standard deviation, Argentina’s stock market has the highest risk level (0.178095) whereas Malaysia records the lowest risk level with a standard deviation of 0.020901.
Table 2: Quiet Period from 01/01/2005 to 31/07/2007

<table>
<thead>
<tr>
<th>indice</th>
<th>USA</th>
<th>ARGENTINA</th>
<th>BRAZIL</th>
<th>KOREA</th>
<th>HONG KONG</th>
<th>INDONESIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>-0.001474</td>
<td>0.002497</td>
<td>0.005287</td>
<td>0.005031</td>
<td>0.003654</td>
<td>0.006190</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.106977</td>
<td>0.073950</td>
<td>0.063536</td>
<td>0.068813</td>
<td>0.045704</td>
<td>0.067691</td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.200298</td>
<td>-0.103256</td>
<td>-0.082549</td>
<td>-0.066787</td>
<td>-0.063260</td>
<td>-0.091053</td>
</tr>
<tr>
<td>Std Dev</td>
<td>0.029670</td>
<td>0.031769</td>
<td>0.031232</td>
<td>0.024100</td>
<td>0.018763</td>
<td>0.026810</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>1358.855</td>
<td>34.78585</td>
<td>11.67628</td>
<td>6.630777</td>
<td>4.239813</td>
<td>27.48566</td>
</tr>
</tbody>
</table>

The standard deviations differences between the quiet period (table 2) and the crisis period (table 3) are more visible. These latter increased during the crisis period. This increase in volatility is of 3.17% for the US and 2.64% for Hong Kong and 2.46%, 2.32% and 2.22% respectively for Argentina, Singapore and Japan, reaching 0.85 % for Malaysia. Indonesia, Taiwan, Korea, Brazil, Mexico and Shanghai respectively registered an increase in volatility of 1.96%, 1.92%, 1.84%, 1.76%, 1.63% and 1.33%. These statistics reveal a high depreciation of indice prices associated with an accrued volatility.
Moreover, Table 3 shows that the individual indices means of the sample decreased during the crisis period, except for Indonesia.

The Skewness coefficient indicates the rejection of the Gaussian distribution for most series of daily returns during the two sub-periods. These statistics show an asymmetric mode. We notice that the series distribution is inclined to the left due to the negative skewness coefficients. Likewise, these series are leptokurtic (flat distribution tails) as the Kurtosis statistics indicate (>3). The Jarque and Béra (J-B) tests show that most series are not normally distributed. These two tests are significant for all countries under the 1% significance level.
Figure 1: Conditional Correlation between the emerging markets (Hong Kong, Argentina, Singapore, Japan, Malaysia, Indonesia, Taiwan, Korea, Brazil, Mexico and Shanghai) and the American market during 1 January 2005 to 1 July 2010.
Interpretation of the Results

The DCC GARCH (1,1) estimation allows us to examine crises propagation between emerging stock markets and the American market. Figure 1 illustrates conditional correlation of emerging markets returns. It is obvious that the correlation coefficient varies across time; sometimes negative and sometimes positive for all market except Malaysia. Consistent with the anticipations, conditional correlation coefficients between emerging markets and the American market are high during the 2008-2009 period. Figure 1 shows that the correlation between Asian emerging stock markets and the American one substantially increased during the 2007 Subprime crisis. This increase in correlation is more noticeable for Latin American countries with a coefficient moving from -0.4 before crisis to 0.8 after the crisis for Argentina alone. Moreover, for Asian countries, we notice an increase in correlation coefficient for Indonesia bypassing 80%. The results suggest that contagion between emerging markets and the American market is primarily influenced by the subprime crisis which has considerably affected conditional correlation. Conditional correlation coefficients, with the exception of China (Shanghai) considerably increased during the subprime crisis. The DCC model(s results indicate that during the 2008-2009 period, the subprime crisis had a significant impact on the conditional correlations between emerging stock markets and the American market. Consequently, it is appropriate to deduce that shocks affecting the American stock market significantly influence stock prices in emerging markets. This result is consistent with Forbes and Rigobon’s analysis (2002) who underlined that increase in correlation during a crisis period is due to an increase in the volatility of international stock markets which were affected by the crisis.

Correlation: A measure of pure contagion contagion

Presentation of the Test

The correlation coefficient is a measure used to study relationships between stock markets returns. Contagion, the, occurs when correlation significantly increases during a crisis period. This increase suggests that there is a strengthening of relationships or transmission mechanisms between two markets. Nevertheless, if this increase is not statistically significant, we are dealing with an interdependence phenomenon and not a contagion one. Forbes and Rigobon (2001b) illustrated that the increase in a correlation coefficient between two financial series may be biased following variation in the volatility of the shock-initiating market. This leads to heteroscedasticity problem. Accordingly, an adjustment may correct this bias. We opted for Forbes and Rigobon’s adjustment (2001). The test we use to check for the existence of a “pure contagion” phenomenon is inspired from the work of Collins and Biekpe (2003).

\[ \rho(x_t, y_t) = \frac{\text{cov}(x_t, y_t)}{\sigma_x \sigma_y} \]

The adjusted correlation coefficient used by Forbes and Rigobon (2001) is as follows:

\[ \rho^* = \frac{\rho}{\sqrt{1 + \delta [1 - (\rho^2)^2]}} \quad \text{avec} \quad \delta = \frac{\nu^c(x_t)}{\nu^c(x_t) - 1} \]
Where « c » and « t » designate respectively crisis and stability periods.

Indeed, \( \delta \) designates a relative increase in \( V(x) \) between the two periods of crisis and stability. To statistically test the increase in the correlation coefficient, we use the following 2 alternative hypotheses:

\[
\begin{align*}
H_0 : \rho^*_c - \rho^*_t &= 0 \\
H_1 : \rho^*_c - \rho^*_t &> 0
\end{align*}
\]

With \( \rho^*_c \) designating the correlation coefficient during the crisis period, and \( \rho^*_t \) is the correlation coefficient of the stability period.

- Accepting \( H_1 \) indicates that the adjusted correlation coefficient between the two markets has significantly increased between the two periods. This is a proof of pure contagion.

- Accepting the null hypothesis means that the increase is not statistically significant between the two periods. In this case, we witness an interdependence phenomenon between the two countries rather a pure contagion one.

The Student test suggested by Collins and Biekpe (2002) to test the significance of these hypotheses is given by the following:

\[
t = \frac{\rho^*_1 - \rho^*_2}{\sqrt{n_1 + n_2 - 4}}
\]

With \( t \) follows a Student at \((n_1 + n_2 - 4)\) degrees of freedom.

### Adjusted Correlation Results

**Table 3: Adjusted Correlation Coefficients**

<table>
<thead>
<tr>
<th>Source USA</th>
<th>Pre-crisis Adjusted correlation</th>
<th>Post-crisis Adjusted correlation</th>
<th>t-student</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA - ARGENTINA</td>
<td>-0.064860905</td>
<td>0.225527021</td>
<td>5.13205057</td>
</tr>
<tr>
<td>USA - BREZIL</td>
<td>-0.111558496</td>
<td>0.246959817</td>
<td>6.49485531</td>
</tr>
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<td>0.189739373</td>
<td>5.18037029</td>
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<td>USA – HONK-KONG</td>
<td>-0.045240893</td>
<td>0.198094897</td>
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<tr>
<td>USA - INDONESIA</td>
<td>-0.048028378</td>
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<td>0.47153715</td>
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<tr>
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<td>0.004454527</td>
<td>0.132434978</td>
<td>2.18229147</td>
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<tr>
<td>USA - MEXICO</td>
<td>-0.076483695</td>
<td>0.244421776</td>
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<tr>
<td>USA – SHANGAI-CHINA</td>
<td>0.029903699</td>
<td>-0.02413295</td>
<td>-0.91515166</td>
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<tr>
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<tr>
<td>USA - TAIWAN</td>
<td>-0.024279015</td>
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<td>1.21549538</td>
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</table>

With reference to these results, comparing the two periods is possible. According to Forbes and Rigobon’s definition [2001b] that contagion results from an increase in correlation between countries compared to the stability period, there is a contagion phenomenon. The American stock
market, origin of the subprime crisis, affected all countries except Shanghai, China. The adjusted correlation coefficient neatly increased just after the 2007 subprime crisis. However, t-Students values of the adjusted correlation coefficients are significant only for Argentina, Brazil, Korea, Honk Kong, Malaysia, Mexico and Singapore. The adjusted correlation coefficients between the American market and these markets increased between the two periods, this gives support to the pure contagion hypothesis after the subprime crisis. Yet, t statistics values for Taiwan and Indonesia (respectively 1.21 and 0.47) are inferior to the critical value shown in Table 3 (1.96), leading us to accept the null hypothesis according to which US stock returns have a statistically non-significant effect on Indonesia’s and Taiwan’s market returns. In this case, we witness an interdependence phenomenon between the two markets and the US market and not a pure contagion.

Conclusion

Applying DCC GARCH (1, 1) on stock markets returns of our sample allowed us to pinpoint to a significant increase in the dynamic correlations of emerging markets returns (Argentina, Brazil, Korea, Hong-Kong, Indonesia, Malaysia, Mexico, Shanghai, Singapore and Taiwan) with the American market during the subprime crisis, except for Shanghai. Emerging stock markets are tightly linked to the American market, noting a contagion between markets. Using this technique, we were able to generally examine contagion phenomenon. Thus, defining pure contagion as a significant increase in relationships across markets and adjusting the correlation coefficients to take into account heteroscedasticity, we came to the conclusion that there is a pure contagion phenomenon from the US to Argentina, Brazil, Korea, Hong-Kong, Malaysia, Mexico, and Singapore. With reference to the financial contagion literature, we noted that a shock in a given stock market modifies investors’ anticipations in another market, consequently moving the economy from a good to a bad equilibrium. Change in investors’ anticipations may be manifested in portfolios rebalancing. These changes, in a context of information asymmetry, may be amplified and transfer the crisis towards other markets and this despite the fundamentals whether positive or not.

References


