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A Dynamic Analysis of Financial Contagion: The Case of the Subprime Crisis

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Abstract

This paper examines contagion phenomenon during the 2007 subprime crisis. It empirically attests for contagion through a DCC GARCH (1.1) and an adjusted correlation test over 13 emerging and developing stock markets during the 11/03/2005 to 31/07/2010 period. Applying the DCC GARCH (1.1) over a sample of market indices returns helped detect a significant increase in dynamic correlations of the returns of the following markets: Mexico, Argentina, France, Germany, Great Britain, Italy, Malaysia, Japan, China and Singapore with the US market during the subprime crisis. Exceptions are noted for the Tunisian and Egyptian markets. On the other hand, using the pure contagion definition which assumes a significant increase in links between markets during the crisis, it was possible to check through adjusted correlations coefficients the presence of pure contagion across the US market and the following markets: Argentina, Great Britain, Italy, Malaysia and Japan.

Key Words: financial contagion, subprime crisis, dynamic conditional correlation, stock returns.

I. Introduction:

During the last decades, and since the collapse of the Bretton Woods system 1971, many are the crises which had shaken international markets including both emerging and developing markets. These key historic downturns explicitly track down particularly the growing financial vulnerability of those countries which are developing and open to international financial markets following policies of financial liberalization conducted at the beginning of the 1980s. Indeed, in a context of financial globalization enforced by financial liberalization, the growing volume of debts financing speculative investments is seen as the trigger of financial crises whose scope on the one hand revived debates on

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the theoretical foundations of financial crises, and on the other hand re-launched discussions on the mechanisms likely to intensify propagation of these violent "ravages". Currently, the international financial system has been hit by a serious crisis since summer 2007 whose manifestation initially surfaced on the real estate market soon affected the entire financial system.

Against these upheavals which made of the current crisis an international ordeal, it is quite important to question whether contagion has been the source of this bottleneck situation. Indeed, this paper tries to bring about some answers, thanks to the theories focusing on explaining contagion phenomena and to econometric modeling approaches used to decipher the phenomenon at the heart of this crisis. Our aim is then to empirically explain contagion in this crisis as a transmission mechanism across the US market and the other examined markets, using the DCC GARCH(1.1) technique and the test of adjusted correlation coefficients.

This paper is structured as follows. The first section reviews the theoretical and empirical literature. The second presents the methodology and data. The third section presents and interprets the results. A fourth section concludes the paper.

II. Review of Literature:

Although contagion has recently attracted much attention especially of economists, several are the theoretical and empirical studies which treated this crises transmission mechanism. The abundance in contagion research in the financial literature made assigning a single definition to the concept even a harder task to carry out. Indeed, the multitude of studies on the topic is at the origin of the diversity in defining contagion.

Generally, contagion describes the transmission of a country's financial markets disturbances to other countries' financial markets. Marais (2004)

Dornbusch & al(2000) define financial contagion as the transmission of markets shocks or imbalances. This process of transmission is possible when volatility stretches from the financial market of the country in crisis to the financial markets of other countries. Perricoli &Sbracia(2001).

Other authors stipulate that contagion occurs when there is a mutual influence and that channels of contagion relate to interdependence, whether real (Eichengreen, Rose & Wyploz (1996)), or financial. This latter is referred to as mechanical contagion. (Calvo & Reinhart (1996)). Mechanical contagion describes non contingent theories of crises. Other authors associate the presence of contagion with the significant increase of economic interdependence. In the financial literature, this describes contingent theories to crises. These theories put to the fore the investor's behavior. Masson(1998) and Forbes & Rigobon(2000) respectively qualified these theories as "pure contagion" and "shift contagion".

II-1 Contagion theories:

Financial literature distinguishes between two types of contagion: mechanical contagion resulting from real and financial interdependences between countries (Calvo & Reinhart(1996) and Kaminsky &Reinhart(1998)), and psychological contagion focusing on the investor's behaviour.

In fact, Forbes&Rigobon(2000) oppose two categories of contagion theories: non contingent theories and contingent theories. The first category assumes that transmission mechanisms following a shock are not significantly different from those prior to the crisis, whereas, the second category stipulates that the mechanisms during or just after the shock are significantly different from those before the shock.

- Contingent theories: This current endorses the idea that financial crises follow channels of transmission basically different from those which prevailed before the shock, or which were even inexistent during the financial instability period. (Forbes & Rigobon(2000)), Pritsker(2000)). This category is primarily based on: multiple equilibriums, endogenous liquidity and political contagion[3].

- Non contingent theories: This approach assumes that transmission mechanisms following a shock are not significantly different from those prior to the crisis. In other words, co-movements existing between markets represent only a continuation of pre-crisis interdependences. Moreover, Forbes & Rigobon(2000) reveal that these theories can be categorized into four fundamental channels; trade, coordination of economic policy , learning and random shocks[4].

II-2 Investors' behavior:

The distinction between contingent and non contingent theories to crises reveals the crucial role of investors' behavior in the transmission process and especially with regard to financial contagion. This points to the heavy role of increased financial integration, as treated by Pritsker(2000) and Dornbush & al (2000). In this regard, the authors insist that investors can make decisions which are ex-ante individually rational, leading to excessive co-movements.

Conceptually, Dornbush & al (2000) distinguish three forms of investors' behaviour as follows;

- Liquidity and incentive problems: it is a form of individual rational behaviour associated with liquidity and other constraints on investors. Dornbush & al(2000)[5]
- Information asymmetries and coordination problems: it is about another consideration which is able to generate contagion. This presumes mainly that investors are imperfectly informed. Indeed, in the absence of information investors assume that a financial crisis in one country may cause the emergence of a similar one in other countries. Dornbush & al (2000), Calvo (1999)).[6]
- Changes in the rules of the game: contagion can also occur when there is a change in investors' assessment of the rules governing international financial transactions. (Calvo(1999), Park (1999).

II- 3 A preview of contagion models

Studying contagion, the theory has identified many possible contagion channels (Eichengreen et al (1996) , Kaminsky and Reinhart(2000), Forbes and Rigobon(2001), Dornbusch et al (2000)). Following these studies, we identified the main models representing and explaining contagion. Indeed, the six channels proposed by Dehove (2003) that Dornbusch et al(2000) are classified into three categories as follows :

- Fundamentals-based contagion which distinguishes between business channel, finance and change.

- Investors' behavior-based contagion which distinguishes portfolios arbitration channels, liquidity and information asymmetries.

- Institutional change-based contagion induced by a crisis within a country.

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[3] « *Crisis contingent theories of how shocks are transmitted internationally can be divided into three mechanisms: multiple equilibria, endogenous liquidity, and political economy* » *(Forbes and Rigobon, 2000, P15)*

[4] « *…These theories can be divided into four broad channels: trade, policy coordination, country reevaluation, and random aggregate shoks* » *(*Forbes and Rigobon, 2000, P17*)*

[5] See also; Pritsker(2000), Aglietta(2002), Van Rijckeghem & Weder(2000), Goldfajn & Valdès(1997)

[6] See also; Cheung & al (2009), P2-P3)

III. Methodology and empirical evidence:

In order to empirically analyze contagion in this paper, we use Forbes and Rigobon's definition (2001) which assumes that contagion is a significant increase in the links between markets following a shock in a country or a group of countries.

Thus, in view of conducting this empirical investigation, we align ourselves with the work of Chiang, Jeon and Li (2007). These authors tried to study the Asian crisis using a DCC-Garch(1.1) model and a test of adjusted correlation coefficients.

III-1 Dynamic conditional correlations' asymmetric model (DCC-GARCH (1.1)) Engle(2002)

First, we specify returns equation as follows:

$$r_t = \gamma_0 + \gamma_1 r_{t-1} + \gamma_2 r_{t-1} + \varepsilon_t \qquad \text{With;} \qquad \text{(II.1)}$$

$$r_t = (r_{1,t}, r_{2,t}, ..., r_{n,t})', n = 13; \varepsilon_t = (\varepsilon_{1,t}, \varepsilon_{2,t}, ..., \varepsilon_{n,t})'; et \varepsilon_t \left| \tau_{t-1} \right. \sim N(0, H_t)$$

The DCC-GARCH (1.1) asymmetric model may be operationalised by rewriting the variance-covariance matrix (H) as such that $H_t = D_t R_t D_t$

where: D_t = diagonal $\{\sqrt{h_{it}}\}$: diagonal matrix of time-varying standard deviations. The elements in D are generated according to GARCH (p, q) process that may be written as :

$$h_{it} = w_i + \sum_{p=1}^{Pi} \alpha_{ip} \varepsilon^2{}_{it-p} + \sum_{q=1}^{Qi} \beta_{iq} h_{it-q} \qquad \forall i = 1,2 \qquad \text{(II.2)}$$

$R_t = \{\varrho_{ij,t}\}$: conditional correlation coefficients matrix

Engle (2002) used a GARCH-type structure to model conditional correlation dynamics. Indeed, an (M, N) order DCC process is written as follows :

$$R_t = (Q_t^*)^{-1} Q_t (Q_t^*)^{-1}$$
$$Q_t = (1 - \sum_{m=1}^{M} a_m - \sum_{n=1}^{N} b_n)\overline{Q} + \sum_{m=1}^{M} a_m (\xi_{t-m} \xi'_{t-m}) + \sum_{n=1}^{N} b_n Q_{t-n} \qquad \text{(II.3)}$$

with :

$\xi_t = \{\varepsilon_{it} / \sqrt{h_{it}}\}$: is the vector containing standardized residuals ;

$\overline{Q} = E(\xi_t, \xi_t')$: the unconditional variance-covariance matrix ;

(a_m, b_n) : the parameters that are supposed to intercept respectively, effects of shocks and lagged dynamic correlations at the contemporaneous level of these latter.

Q_t^* : is the diagonal matrix containing the square root of the elements of the main digonal Q_t..

Conditional correlations are written as follows:

$$\rho_{12,t} = \frac{E_{t-1}(r_{1,t} r_{2,t})}{\sqrt{E_{t-1}(r_{1,t}{}^2) E_{t-1}(r_{2,t}{}^2)}} \qquad \text{(II.4)}$$

The parameters of the DCC model are estimated by the maximum likelihood technique. Engle (2002) illustrated that the log-likelihood function may be estimated as follows :

$$L = -\frac{1}{2}\sum_{t=1}^{T}(n\log(2\Pi) + 2\log|D_t| + \log|R_t| + \varepsilon_t{}' R_t{}^{-1}\varepsilon_t) \qquad \text{(II.5)}$$

The estimation proceeds twofold. The first consists in substituting the matrix ® with an identity matrix in the log-likelihood function. The advantage of such procedure is allowing for obtaining the sum of the univariate GARCH models' likelihood function. The second is to estimate the parameters of the equation (II.5) by adopting the likelihood function. This allows for obtaining dynamic correlations between the examined variables.

The GARCH (1,1) is given and written as :

$$h_{it} = w_i + \sum_{p=1}^{Pi}\alpha_{i\,p}\varepsilon^2{}_{it-p} + \sum_{q=1}^{Qi}\beta_{iq}h_{it-q} \qquad \forall i = 1,2$$

with:

α : squared lagged residuals

β : lagged conditional variance

ω : Asymmetric term

The parameters (α, β, ω) of the DCC model are estimated by a maximum likelihood. Engle (2002) showed that the log-likelihood function may be estimated as:

$$L = -\frac{1}{2}\sum_{t=1}^{T}(n\log(2\Pi) + 2\log|D_t| + \log|R_t| + \varepsilon_t{}' R_t{}^{-1}\varepsilon_t)$$

III-2 Correlation test: measurement of pure contagion

The correlation coefficient is considered probability and statistics-wise as an indicator of the link between two variables. It is admitted then that two variables are correlated if these latter progress in a common fashion (Mignon, 2008).

We give two stochastic variables respectively ri and rj denoting stocks returns in two different markets. In order to test the relationship binding these returns, we will use the following simple linear model:

$$y_{i,t} = \alpha + \beta x_{i,t} + \varepsilon_{i,t}$$

$$E(\varepsilon_{i,t}) = 0 \qquad E(\varepsilon_{i,t}{}^2) \prec \infty \qquad E(x_{j,t}\varepsilon_{it}) = 0$$

In this context, Forbes and Rigobon (2001) propose an adjusted correlation coefficient defined as follows:

$$\rho^* = \frac{\rho}{\sqrt{1 + \delta[1 - (\rho)^2]}} \qquad \text{Avec} \quad \delta = \frac{V^c(x_t)}{V^t(x_t)} - 1$$; where « c » and « t » respectively denote the crisis and the stability periods.

Indeed, (δ) denotes the relative increase within $V(x_t)$ between the stable and the crisis periods. Hence, in order to statistically test the increase of an adjusted correlation coefficient, we use the following two hypotheses:

$$\begin{cases} H_0 : \rho_1^{*} = \rho_2 \\ {}^{*} \\ H_1 : \rho_1^{*} \succ \rho_2^{*} \end{cases} \qquad \text{With;}$$

ρ_1^{*} : The crisis period correlation coefficient

ρ_2^{*} : The stable period correlation coefficient

Still, to test the two hypotheses, we will use a Student test where the test statistics is defined as follows:

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

Then, accepting H_1 is about highlighting contagion between two markets, whereas the null hypothesis H_0 implies that the increase in the correlation coefficient reflects solely interdependence between the two markets.

IV. Empirical evidence:

The aim of this paper is then to empirically test for contagion of the US subprime financial crisis towards a set of emerging and developed stock markets. The paper first examines the effect of the subprime crisis on the 12 examined markets using a GARCH-DCC (1.1), and second it attempts to identify the presence of pure contagion by testing the statistical importance of the increase in heteroskedasticity's adjusted correlation coefficients and this between the quite and the crisis period (Forbes and Rigobon, 2001).

IV-1 Data:

The study examines international transmission of the subprime financial crisis making us retain stock markets indices as a variable. At this level, we notice that the data used in this study are daily stock markets data in terms of stock markets indices for some tests and these indices' daily returns of the 13 markets examined (Ii,t) which are computed as follows :

Rit=100*log (Ii,t/Ii,t-1)

with ; Ii,t : stock market's indice i at day t

Ii,t-1 : stock market's indice i at day t-1

Ri,t : indice's return of stock market i at day t

The retained data are stock indices, considered as reference indices for the sample's different markets. These latter are taken from internet[7] and priced in US dollar to eliminate any problems related to change rate variations.

The considered sample includes 13 stock markets of which 7 developed markets and 6 emerging markets, classified in terms of geographical location. The groups are as follows:

*Emerging markets :

-Africa : Egypt(EGX), and Tunisia(Tunindex)

-Latin America : Mexico(IPC), Argentina(Merval)

-Pacific/ Asia : Malaysia(KLSE), China(ShangComp)

*Developed markets :

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[7] http://fr.finance.yahoo.com/

-North America: US(S&P500)
-Pacific/ Asia : Japan(Nikkei225), Singapore(STI)
-Europe : France(CAC40), Germany(DAX), GB(FTSE100), Italy(MIB30)
The study period ranges between 11/03/2005 and 12/03/2010 using daily data with a total of 1250 observations for each market.
This period is divided into two sub-periods:

- Pre-crisis period between 11/03/2005 and 31/07/2007

- Post-crisis period between 01/08/2007 and 12/03/2010

The first period totals 595 observations while the second period totals 655 observations. We notice that in this study we use the US S&P500 as a reference.

IV-2 Results and interpretations:

IV-2-1 Descriptive statistics of the variables :

A number of statistical tests have been conducted on the variables of our sample. The tables in appendice 1 summarize the main output.
Table (1.1) shows that over the total period (11/03/2005 to 12/03/2010), the studied emerging markets have very low means and are negative for the Merval variable (-8.91^{E}-05). The same table illustrates that Tunisia has average daily returns reaching 0.102%. Nevertheless, the lowest average return is that of Argentina (-8.91^{E}-05). Table (1,1) then shows an advantage for countries with positive returns (5 countries) against one country with a negative average return.
Mexico and Tunisia have the highest standard deviations between maximum returns and minimum returns. In this line of thinking, the Chinese market will be the most stable in the long run given that the maximum and minimum values are low and close to zero.
Table (1.4) indicates that over the same period, the studied developed countries have negative means, where Germany has the highest daily return compared to the other developed markets (-0.0108%).
However, the lowest mean is recorded for the MIB30 variable (-0.0589%). Germany has the highest standard deviation between maximum and minimum returns compared to other developed markets.
Volatility analysis shows that the standard deviation increased between the pre-crisis and the crisis periods.
Examining standard deviations during the crisis period, we notice a significant increase respectively for l IPC, Merval , KLSE, ShangComp registering the following values 0.018, 0.023, 0.017 and 0.023. Indeed, risk for emerging countries is seen in relatively high standard deviations, which illustrate higher volatility in prices and instability of returns.
Analysing volatility in the developed markets, we note an increase of standard deviations of the following markets: CAC40, DAX, FTSE100, MIB30, Nikkei225, S&P500 and STI, registering the following standard deviations respectively (0.02), (0.019), (0.018), (0.0199), (0.022), (0.020), (0.018) where the Japanese market is found the most volatile among these markets.
Statistics-wise, most of the series have either leftward or rightward flat skewness. Then, we note that most emerging and developed countries' returns have skewness coefficients either inferior or superior to zero, i.e. leftward and rightward distributions.
On the other hand, most examined variables have significant kurtosis coefficients, where for all variables they are superior to 3, in which some countries like Tunisia for example, register kurtosis coefficients reaching up to (434.8326). This shows a concentration of observations around the mean, which is an additional source of risk.

IV-2-2 Estimation of the asymmetric DCC-GARCH (1.1) model

Table (2.1) : Results of the estimation of the GARCH (1.1) model[8]

	Return equation			variance equation			
	α_0	α_1	α_2	β_0	β_1	β_2	**Persistence**
CAC40	0.0007** (2.471)	-0.0910* (-2.727)	0.0806* (2.621)	3.08E-06* (5.315)	0.104* (7.275)	0.882* (56.847)	**0.986**
DAX	0.0009* (2.913)	-0.0739** (-2.159)	0.0862* (3.261)	4.30E-06* (6.0652)	0.0969* (7.214)	0.881* (55.765)	**0.977**
FTSE100	0.0005** (2.241)	-0.0843* (-2.718)	0.0589*** (1.925)	1.15E-06* (3.555)	0.0967* (8.0694)	0.899* (75.663)	**0.995**
MIB30	0.0003** (1.0892)	-0.143* (-4.842)	0.310* (11.587)	2.25E-06* (4.216)	0.110* (7.564)	0.879* (56.740)	**0.989**
IPC	0.0010* (2.763)	0.0735** (2.330)	0.0741** (2.292)	6.61E-06* (5.351)	0.114* (6.666)	0.860* (50.410)	**0.974**
Merval	0.0005 (1.208)	0.0116 (0.360)	-0.0311 (-0.823)	1.25E-05* (5.900)	0.0967* (7.156)	0.863* (49.969)	**0.959**
KLSE	0.0004** (1.451)	-0.0008 (-0.107)	0.0890* (5.201)	0.0003* (95.316)	0.0117* (63.210)	-0.995* (-3418.313)	**-0.983**
Nikkei225	0.0004** (1.310)	0.0020 (0.0621)	0.253* (11.091)	3.17E-06* (3.237)	0.123* (7.403)	0.869* (50.899)	**0.992**
Shangcomp	0.0013* (2.699)	0.0013 (0.0437)	0.0607*** (1.788)	1.15E-05* (7.210)	0.0666* (7.316)	0.906* (80.959)	**0.972**
STI	0.0006** (2.389)	-0.0358 (-1.1552)	0.292* (11.144)	1.88E-06* (5.0578)	0.0978* (8.123)	0.894* (75.179)	**0.991**
Tunindex	0.0001** (2.152)	-0.0335 (-1.341)	0.0242* (3.945)	8.89E-06* (12.457)	2.836* (26.466)	0.0228** (2.309)	**2.858**
EGX30	-0.0073* (-3.874)	0.285* (11.896)	-0.252** (-2.113)	0.0018* (28.121)	1.222* (7.499)	-0.0287* (-2.657)	**1.193**

-, **, and *** indicate statistical significance at the 1%, 5% and 10% levels*

Table 2.1 illustrates the results of the estimation of the return and variance equations. The results together indicate that the correlations of most studied markets are significant at the 1%, 5% and 10% with lagged squared residuals noted by β_1 and with lagged conditional variance noted by β_2 . Likewise, we note that the sum of these two coefficients is close to the unit for most markets which indicates persistence of volatility in time, except for the following markets: Tunisia, Egypt and Malaysia which have persistence values respectively as follows: (2.858), (1.193) and (0.991).
According to table 2.1, it is clear that asymmetry is very weak and significant at the 1% level for the entire sample. This conclusion confirms the adequacy of the model. It would be relevant then to proceed to the second phase of our analysis which is estimating dynamic conditional correlations through a graphic representation.

IV-2-3 Estimation of dynamic conditional correlations:

[8] *-level of variance persistence is computed by the sum of the coefficients found at the variance equation* $\beta_1 + \beta_2$
-the z-Statistic are mentioned at the table above between parenthesis.

Estimating the DCC-GARCH (1.1) model allowed for examining the propagation extent of the crisis between the emerging-developed markets and the US market. These statistics indicate conditional correlation of the studied markets' returns (emerging-developed markets). Also, these statistics allowed us to see that it is clear that the correlation coefficients vary in time. They are positive and negative variations for all the studied markets. (see appendice 2)

Against these statistics, we note that conditional correlations between the emerging-developed markets and the US market are higher during the 2008-2009 period.

This increase is clearly important for the emerging and developed markets, of which the most serious ones are the following markets: a clear increase for some European markets like the GB market (FTSE100) which records an increase reaching (-0.2) during the pre-crisis period to (0.8) following the crisis. Likewise, the Italian market (MIB30) moved from (-0.1) in 2006 to (0.8) between 2008 and 2009.

Similarly, it is visible that this increase is equally important for some Latin American markets like Argentina (Merval) which moved from (-0.3) during the pre-crisis period to (0.9) between 2008 and 2009.

Likewise, Asia is no exception to these effects as the Japanese market (Nikkei225) recorded an important increase moving from (-4) during the pre-crisis period to (6) following the subprime crisis. Nevertheless, it is relevant following these conclusions to point out that the subprime crisis had no significant impact on the African markets where Tunisia and Egypt were found to be the least affected by this crisis, which had conditional correlations relatively stable with the US market.

Subsequently, the results of the DCC-GARCH (1.1) model indicate that during the 2008-2009 period the subprime crisis had a significant visible impact on the conditional correlations between the emerging-developed markets and the US market. Consequently, we can conclude that shocks affecting the US stock market had a significant effect on the stock prices of the emerging and developed markets. This result is coherent with Forbes and Rigobon's analysis (2002) which stipulates that increase in correlations during a crisis period is due to an increase in international stock markets volatility, which was affected by the crisis.

IV-2-4The results and interpretation of the adjusted correlation coefficient:

Table (2.2) adjusted correlation coefficient test

Source S&P500	Pre-crisis adjusted correlation coefficient	Post-crisis adjusted correlation coefficient	t-Student
S&P500-IPC	0,02099505	-0,00656815	0,93872071
S&P500-Merval	0,03623513	0,22480608	**-6,53700285***
S&P500-CAC40	-0,02664293	0,00870518	-1,20414656
S&P500-DAX	0,02837136	0,01879304	0,32610041
S&P500-FTSE100	0,04818087	0,39513242	**-12,5939472***
S&P500-MIB30	0,06587947	-0,02350327	**3,05518265***
S&P500-KLSE	0,04971364	0,20176983	**-5,23751696***
S&P500-Nikkei225	0,06951301	0,27916698	**-7,29970977***
S&P500-Shangcomp	-0,00438884	-0,00651614	0,07242223

S&P500-STI	-0,02643977	-0,00633739	-0,68450583
S&P500-EGX30	0,00772646	0,03875387	-1,05680866
S&P500-Tunindex	-0,01507009	-0,01760031	0,08613923

The results of the adjusted correlation test may be summarized in Table 2.2 which reports the estimations of stocks returns during the crisis and stable periods.

The obtained results indicate that the US market as the crisis trigger seems affected by the following markets: Argentina, GB, Italy, Malaysia and Japan. Then, the t-student of their adjusted correlation coefficients during the crisis are significant. This result supports a pure contagion hypothesis after the US market shock. These conclusions are consistent with Forbes and Rigobon's results (2002) which favour contagion through mechanisms contingent to the crisis.

Nevertheless, for the rest of the sample (Mexico, France, Germany, China, Singapore, Egypt and Tunisia) their adjusted correlation coefficients did not significantly increase where t-student values are respectively inferior to the critical value 1.96: ((0, 93872071), (-1,20414656), (0,32610041), (0,07242223), (-0,68450583), (-1,05680866), (0,08613923)). This leads us to accept for the mentioned markets the null hypothesis according to which the US stock returns had a statistically insignificant effect. Hence, we can say that for these markets it is solely about interdependence and not pure contagion with the US market.

It is necessary to note that the choice of the stability and crisis periods affects the study of contagion, given that it rests on the adjusted correlation coefficients stocks prices returns.

The obtained results will be represented in the following table:

Table (2.3): Identification of contagion and interdependence cases

	Pure contagion	Interdependence
Stock markets	Usa↔Argentina Usa↔GB Usa↔Italy Usa↔Malaysia Usa↔Japan	Usa↔Mexico Usa↔Germany Usa↔France Usa↔China Usa↔Singapore Usa↔Tunisia Usa↔Egypt

V. Conclusion:

Although important, defining contagion remains controversial. Most studies empirically testing contagion are interested in the progress of links existing before and those emerged after the crisis. The study we conducted to empirically test contagion is summed up into two tests; a DCC-GARCH (1.1) model and adjusted correlation tests.

Indeed, applying a DCC-GARCH (1.1) model stock markets returns allowed us to detect a significant increase in the dynamic correlations of emerging and developed stock markets returns (Mexico, Argentina, France Germany, GB, Italy, Japan, Malaysia, China and Singapore) with the US market during the subprime crisis except for the Tunisian and Egyptian markets. Then, using this model, we were able to examine contagion phenomenon. On the other hand, adopting a pure contagion definition as the significant increase of links between markets during a crisis period, we were able to check for through adjusted correlation coefficients the presence of pure contagion between the US market and the following markets: Argentina, GB, Malaysia and Japan.

These results obtained in our study prove the high degree of the international financial integration of the countries and specially the vulnerability of the financial markets.

Henceforth, the aim of researches in financial contagion is to identify the means through which countries could reduce their vulnerability to external shocks.

Indeed, our study reveals the importance of the intervention of the monetary and financial authorities to absorb shocks resulting from financial crises, as well as the need for the installation of more satisfactory methods of supervision in order to limit the financial risks of the markets instability, especially in emerging countries.

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Appendix 1

Table (1.1) : Descriptive statistics of emerging markets' daily returns (total period)

	IPC	Merval	KLSE	Shangcomp	Tunindex	EGX30
Mean	0.000456	-8.91E-05	0.000529	0.000582	0.001020	0.000408
Median	0.001435	0.001069	0.000524	0.001100	0.000840	0.000000
Maximum	0.104407	0.104316	0.198605	0.099603	0.360477	1.076939
Minimum	-0.072661	-0.129516	-0.192464	-0.092562	-0.357687	-1.068751
Std Dev	0.016344	0.019819	0.013733	0.020705	0.016106	0.049961
Skewness	0.148786	-0.705063	1.788404	-0.245977	0.039628	0.416203
Kurtosis	7.518939	8.832961	96.84043	5.782973	434.8326	369.8430
Jarque-Bera	991.2856	1740.575	426242.9	379.0478	8850003.	6504434.
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Statistical output by EVIEWS (version6.0)

Table (1.2) : Descriptive statistics of emerging markets' daily returns: (pre-crisis period)

	IPC	Merval	KLSE	Shangcomp	Tunindex	EGX30
Mean	0.001177	0.000368	0.000706	0.002352	0.001113	0.001657
Median	0.002261	0.001277	0.000821	0.001863	0.001059	0.000000
Maximum	0.065101	0.060860	0.026012	0.099603	0.360477	1.076939
Minimum	-0.059775	-0.077866	-0.047465	-0.092562	-0.357687	-1.068751
Std Dev	0.012977	0.014558	0.006885	0.017406	0.021974	0.066808
Skewness	-0.092277	-0.453881	-1.210869	-0.403633	0.035314	0.099597
Kurtosis	5.702903	5.143349	10.47208	8.276728	255.5999	237.5741
Jarque-Bera	171.8723	126.8710	1444.733	664.8959	1488824	1288503.
Probability	0.000000	0.000000	0.000000	0.000000	0.000000.	0.000000

Statistical output by EVIEWS (version6.0)

Table (1.3) : Descriptive statistics of emerging markets' daily returns: (crisis period):

	IPC	Merval	KLSE	Shangcomp	Tunindex	EGX30
Mean	-0.000221	-0.000519	0.000363	-0.001130	0.000931	-0.000766
Median	0.000561	0.000893	0.000000	0.000000	0.000645	0.000000
Maximum	0.104407	0.104316	0.198605	0.090343	0.036133	0.357556
Minimum	-0.072661	-0.129516	-0.192464	-0.080437	-0.050037	-0.179916
Std Dev	0.018958	0.023728	0.017931	0.023347	0.006612	0.025475
Skewness	0.269972	-0.665527	1.648484	-0.078411	-0.534581	3.596245
Kurtosis	6.925291	7.624847	64.58359	4.551404	13.36282	72.77830
Jarque-Bera	391.1778	577.0929	94768.25	58.65868	2618.314	122608.5
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Statistical output by EVIEWS (version6.0)

Table (1.4) : Descriptive statistics of developed markets' daily returns (total period)

	CAC40	DAX	FTSE100	MIB30	Nikkei225	S&P500	STI
Mean	-0.000345	-0.000108	-0.000176	-0.000589	-0.000491	-0.000309	-0.000136
Median	0.000246	0.001073	0.000322	0.000757	0.000198	0.000802	0.000440
Maximum	0.105946	0.107975	0.093842	0.107647	0.132346	0.109572	0.075305
Minimum	-0.094715	-0.074335	-0.092646	-0.088168	-0.121110	-0.094695	-0.092155
Std Dev	0.015767	0.015310	0.014396	0.015401	0.017889	0.015392	0.014720
Skewness	0.050958	0.129691	-0.137921	-0.081042	-0.428315	-0.371515	-0.391095
Kurtosis	11.10062	11.57581	11.26671	11.11836	11.45868	12.96355	8.492785
Jarque-Bera	3172.141	3557.903	3306.708	3129.120	3430.432	4737.502	1460.887
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Statistical output by EVIEWS (version6.0)

Table (1.5) : Descriptive statistics of developed markets' daily returns (pre-crisis period):

	CAC40	DAX	FTSE	MIB30	Nikkei225	S&P500	STI
Mean	0.000362	0.000700	0.000182	0.000182	0.000404	0.000290	0.000660
Median	0.000658	0.001461	0.000642	0.000845	0.000466	0.000857	0.001079
Maximum	0.025047	0.026051	0.034441	0.028277	0.035220	0.024270	0.030791
Minimum	-0.033109	-0.034633	-0.041850	-0.037905	-0.042304	-0.035343	-0.040367
Std Dev	0.009181	0.009467	0.008185	0.008404	0.010807	0.007142	0.008999
Skewness	-0.432806	-0.428458	-0.540493	-0.613666	-0.303229	-0.479213	-0.731855
Kurtosis	4.097995	3.675613	6.436212	4.923603	4.033419	5.350047	5.546796
Jarque-Bera	45.77675	27.88354	303.8566	121.4871	33.50073	150.2971	201.3344
Probability	0.000000	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000

Statistical output by EVIEWS (version6.0)

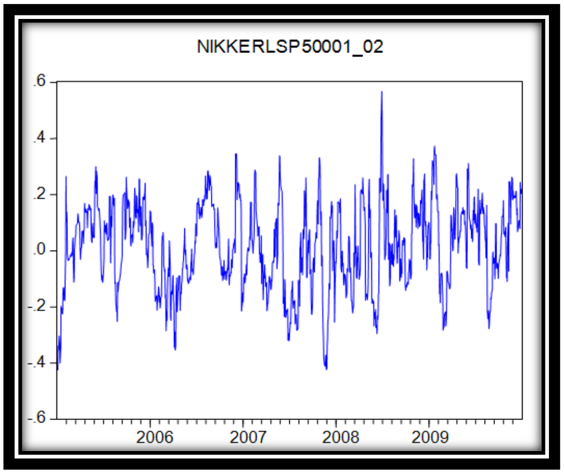
Table (1.6) : Descriptive statistics of developed markets' daily returns (crisis period):

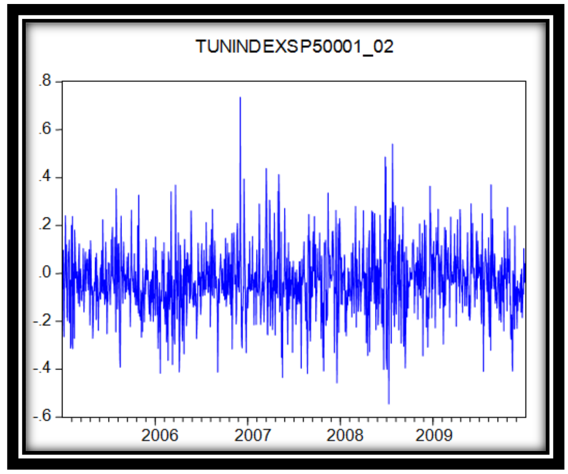
	CAC40	DAX	FTSE100	MIB30	Nikkei225	S&P500	STI
Mean	-0.001010	-0.000867	-0.000513	-0.001333	-0.001356	-0.000887	-0.000906
Median	-0.000351	8.77E-06	-2.41E-05	0.000435	-0.000286	0.000545	-0.000378
Maximum	0.105946	0.107975	0.093842	0.107647	0.132346	0.109572	0.075305
Minimum	-0.094715	-0.074335	-0.092646	-0.088168	-0.121110	-0.094695	-0.092155
Std Dev	0.020062	0.019227	0.018416	0.019940	0.022707	0.020407	0.018630
Skewness	0.165664	0.265049	-0.039318	0.063108	-0.292420	-0.219411	-0.205076
Kurtosis	8.078394	8.878644	7.936427	7.654584	8.448316	8.162243	6.197471
Jarque-Bera	645.3384	868.0831	607.3312	523.0560	724.3818	647.5467	250.7081
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

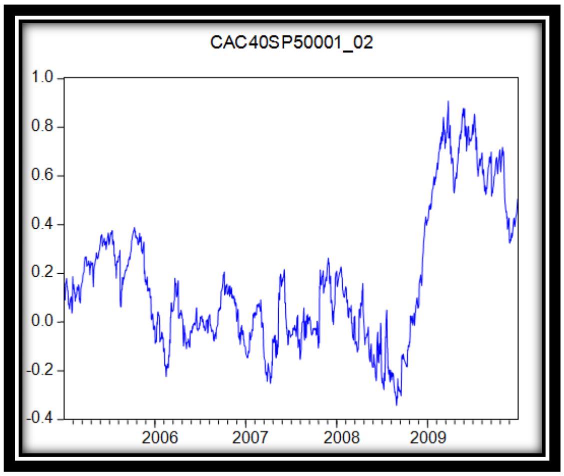
Statistical output by EVIEWS (version6.0)

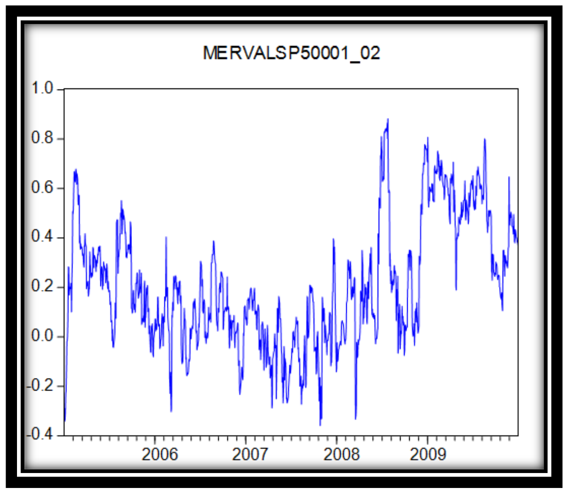
Appendice 2

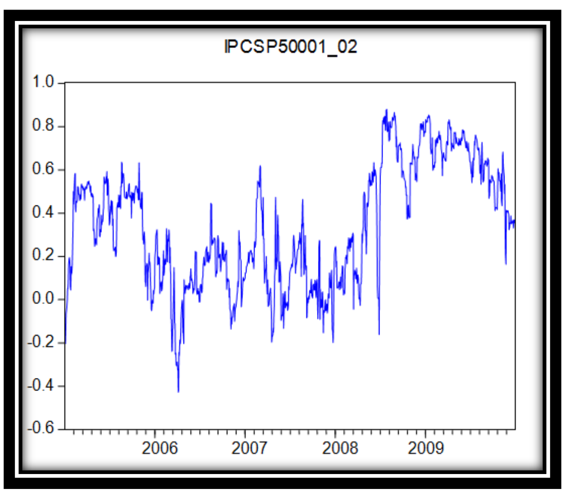
Figure (2.1) : Estimation of dynamic conditional correlations :

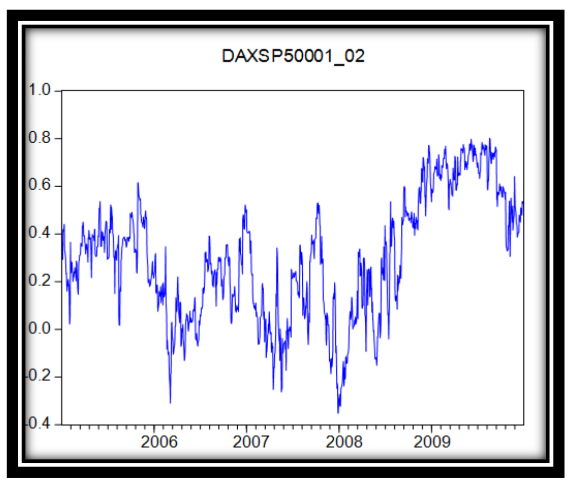


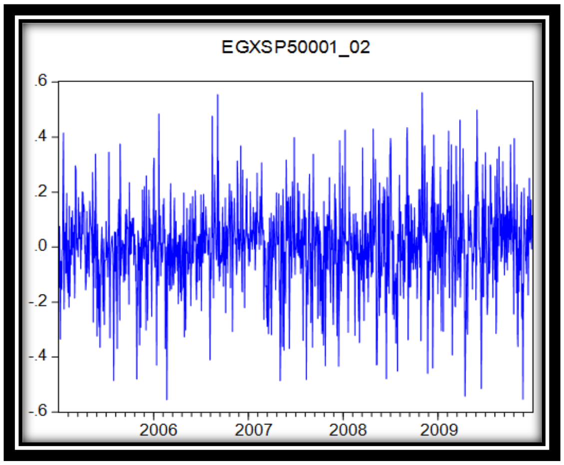


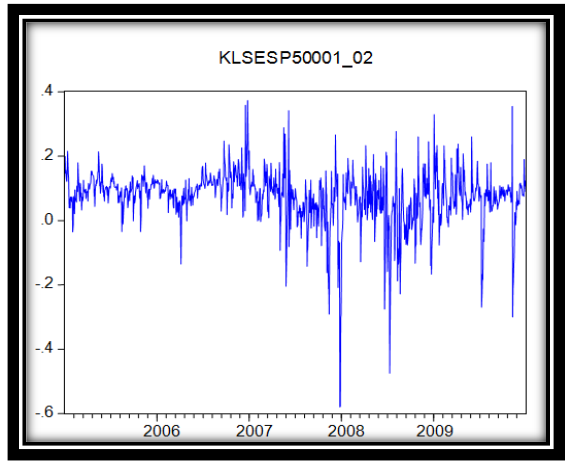


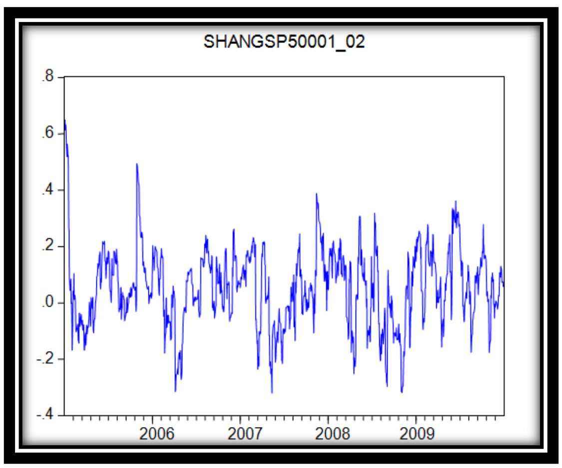


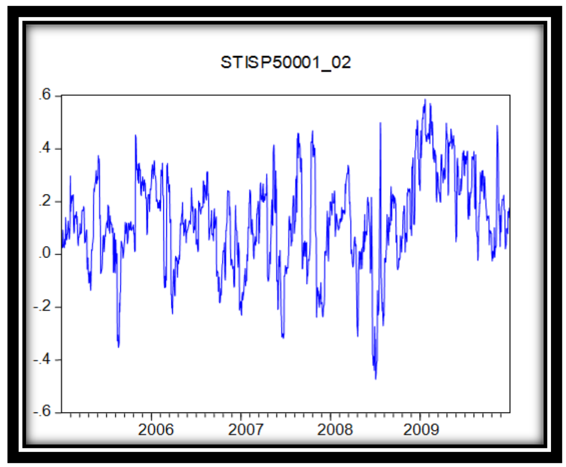


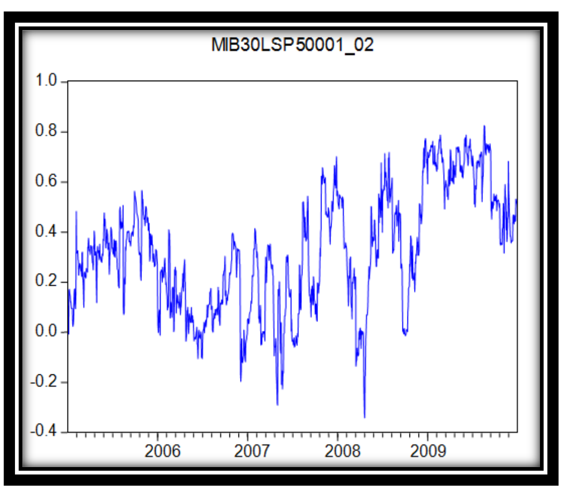


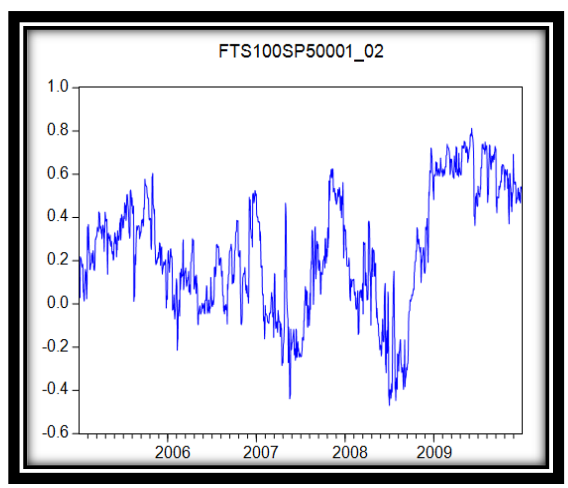












Figures by EVIEWS (version6.0)

- ✓ *Dynamic conditional correlations between emerging and developed markets (Egypt, Tunisia, Mexico, Argentina, Malaysia and China Japan, Singapore, France, Germany, Great Britain and Italy) and the US market during the period from markets 11/03/2005 to 12/03/2010.*