Research article

The subprime crisis contagion effect on Developed countries

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Abstract

The objective of our work is to test the presence of the contagion phenomenon caused by the mortgage American said "subprimes"crisis. First, we are going to present the effect of contagion, a literature review, and in a second part an empirical investigation on the phenomenon of crisis contagion: we applied an correlation analysis as well as an estimation of a model to error correction (asymmetric) not linear (ECM) to measure the contagion between the markets of developed countries and the emergent countries. Estimation exercises shows that there is pure contagion cases and the other interdependence contagion cases. Furthermore we found that United States are the country source of contagion during the financial crisis of subprimes. We notice the existence of the contagion in other stock market country (French, Canadian, German, British, Brazilian, Indian, Chinese, Italian and Russia). This result means that the contagion of the American financial crisis is begun with the developed countries and waq propagated in emerging countries.

1. Introduction

The last two decades were characterized by a structural and organizational movement of modification in the international financial system: globalization, deregulation, financial innovation.... Indeed, during this period, we notice a serious increase of the difficulties in financial markets. Besides, during the last fifteen years, the financial markets of several countries were got (touched) by crises the scale of which is deep. These crises are more and more violent and more in more couteuses both in losses on the financial market and in loss on the real economy.

Throughout decade 1990, The financial crises spread(broadcast) on an international scale. We take as examples the crisis of the European Monetary System in 1992, the considerable fluctuations in the courses (prices) on diverted markets (raw materials), the collapse of certain emerging markets which led(drove) to the Mexican crisis in 1994 and especially to the panic.

Today, we are in front of a financial crisis which strikes the planet. It is the crisis of mortgages at risk of United States. Indeed, in 2007, the prices of the real estate fell, the rates climbed and the bad borrowers begin to be in trouble. They sold their houses, so that they do not undergo a heavier loss, contributing to the fall in prices of the real estate. From then on, the theoretical risk of being lacking on their credit becomes real.

The purpose of this work is to study the effect of the current financial crisis caused by the subprime mortgage crisis Americans and its heavy effects which got (touched) the big financial centers almost everywhere in the world.

The objective of our work is to test the presence of the phenomenon of contagion caused by the mortgage American said crisis "subprimes". We are going to begin by presenting the effect of contagion, a review of the literature, and then an empirical investigation on the phenomenon of contagion of this crisis: we go applied an analysis of correlation as well as an estimation of a model to correction of error (asymmetric) not linear (ECM) to measure the contagion between the markets of G7 and the BRIC. G7 indicates seven developed countries (the United States, Canada, Japan, the United Kingdom, Germany,

France and Italy). The term BRIC is an acronym which indicates the group of trained country by Brazil, Russia, India and China. The BRIC is emerging countries with strong growth, by which the weight in the world economy increases in this beginning of century.

We shall use the day efficiencies of the stock indexes of these countries during period going from April 2006 to January 2009. This work is organized as follows: we are going to begin by synthesizing a review of empirical literature relative to the contagion and its methods of detection, in the second we are going to present the methodology econometric, and finally we are going to present all the found results.

2. The contagion literature Review:

Further to the emergence of the crises these last decades, the studies of contagion was the object of several works, many works were interested in the contagion further to the recent financial crises. However, we must note that these studies became intensified especially after the release of the crisis of Southeast Asia in 1997. And we must note that there is some contagion studies before the Asian crisis, King and Wadhwani (1990) tested if the distribution changes before and after the crisis and they used this methodology to test the presence of the contagion between the assets market of United States, England and Japan. They found that the correlations increased well after the crash of the American market of 1987.

Forbes and Rigobon (1999) put the hypothesis which the correlations through countries tend to increase during the crises. Consequently, treat this correlation as an effect of contagion can be biased if adjustments for this co-movement are not made. Their empirical tests based on data of a sample of country of Asia, Latin America and U.S.A. indicates the absence of contagion in the adjusted coefficients. Besides, with the same data, the non-adjusted coefficients present an effect of contagion. Fratzscher (1998) in his studies after the Asian crisis compares the impact of Latin America and Asia crisis on emergent economy, by using various definitions of the contagion. The author found that the big financial and commercial integration is the main cause of the distribution of the crises in the regional savings. Masih and Masih (1999) examined the dynamic links of long and short terms between the Asian and international emergent stock markets. They found that the contagion played a big role in the functioning of these markets.

Baig and Goldfajn (1998) applied a test of correlation to the other types of financial markets: the markets of the sovereign debts, the exchanges and the interest rate. They concluded that the existence of the contagion during the Asian crisis was more evident on the markets of the sovereign debts and the exchange markets.

Forbes and Rigobon (2001), in their works, defined the contagion as being the significant increase in the links between markets after the realization of a shock on a country (or a group of countries). In that case, the co-movements between two markets are measured by their coefficient of correlation. Then, the contagion is evident when the correlation increases significantly during the period of crisis. In fact this increase suggests that there is intensification of the links or the transmission mechanisms between both markets in question. However, if the increase is not statistically significant, we attend only a phenomenon of interdependence and not contagion.

Several other works on the effect of contagion were elaborated, and they tried to compare the degrees of the financial links before and after the crisis independently of the fundamental.

They also used different very developed approaches as the study of the correlations (Baig and Goldfajn, 1998, Park and Song, 1999, Forbes and Rigobon, 2001), other has utilized the processes ARCH and GARCH (Edwards, 1998), the tests of causality (Masih and Masih, 1999, Khalid and Kawai, 2003, Sander and Kleimeir, 2003) as well as the estimation of models ECM via tests of cointegration (Tan, 1998).

We must mention that the Asian crisis was the episode the most used in these various works. Other authors tried to test the stability of the links between financial markets during the period of crisis by using the coefficient of correlation. Indeed, the contagion is measured by the statistically significant increase in the coefficient of correlation.

In this context, Baig and Goldfajn (1998) tested the evidence of the contagion between the financial markets of the Thailand, Malaysia, Indonesia, Korea and the Filipinos. They tested the statistical significativity of the increase of exchange markets correlation coefficients, stock market, the interest rate and the sovereign debts. They found the evidence of the contagion only in the first two markets. However, they found that the Thailand did not play an important role in the process of the contagion during the Asian good crisis whether it is the first source of crisis.

Park and Song (1999) analyzed the existence of the pure contagion between 4 countries of east Asia in particular the case of Korea. To converge on not biased tests, they tried to exclude the effect of the fundamental as well as the effect of the common shocks in particular that of the countries of Southeast Asia which can appear in the correlations between financial markets. They demonstrated that the Thailand crisis was not a source of contagion for Korea. Besides, Taiwan played an important role in the transmission of the contagion in Korea. Forbes and Rigobon (2001) applied the same approach of correlation, and they tested the statistical significativity of the increase of the coefficients of

correlation adjusted by the way of the heteroscedasticity. They concluded that the distribution of the Asian crisis was only of the interdependence between markets financiers and not of the contagion. Indeed, the crisis in Thailand passed from a country to other via permanent channels which also existed for the period of tranquillity. Rigobon (2001) confirmed this result by correcting the coefficients of correlations not only of the way of the heteroscedasticity but also the problems of simultaneity of the financial interactions and the omitted variables.

However, Tan (1998) used another approach, and it examined the nature and the importance of the contagion during the Asian crisis by using the evidence of the movements in stock markets. He studied the direction of the movements of stock indexes by estimating the model at correction of error (ECM) as well as the functions of impulsive answers. He used the decomposition of the variance of a model the VAR the observations of the indications of which are daily. The results of this work confirm the difference in the co-movements between stock indexes before and after the crisis, what demonstrates the effect of the contagion during the Asian financial crisis.

Masih and Masih (1999) tried to examine the dynamics of the various senses of causality between 8 stock markets (4 markets of Southeast Asia and 4 industrialized markets). In the regional context of Southeast Asia, the results) were substantial with the hypothesis of the contagion in particular the importance of the role played by Hon Kong in this contagion. Khalid and Kawai (2003) tried to identify and to test the contagion during the Asian crisis via three financial markets to know exchange markets, stock market and about the interest rate. In fact, they estimated a model the VAR by using a sample of daily observations for 9 Asian countries including Japan. They based themselves on the results of the tests of causality in the sense of Granger as well as the impulsive answers to clarify the interdependence between the markets of the various Asian countries. However, their results were not a support for the contagion.

Sander and Kleimeir (2003) utilized a new measure to know the change in the existence of the sense of causalities before and after the crisis. In fact, they used the methodology of the test of causality via a model ECM estimated with observations of the sovereign debts of the Asian markets and the other markets. They proved that the Asian crisis established new directions of causality which were not present before the crisis. These results are specifically regional following the example of Masih and Masih (1999). Thus, they supported the idea of the contagion whether it is a regional and not global affair.

Methodology

According Forbes and Rigobon (2001) we can identify the contagion between two financial markets if we manage to detect a significant increase in the correlation during the episode of the crisis. With this definition we can define the contagion from a significant increase of the co-movements of markets before and after the crisis. Thus, our objective will be to try to measure these co-movements and to see if they change behavior during the crisis or not. To d this we will do two tests : The first one is to estimate the significant increase of the correlations between the quiet period and the period of crisis. Whereas the second is to verify the not linearity in the model ECM.

3. Test de correlation

For a simple linear mode $y_t = \alpha + \beta x_t + \varepsilon_t$ (1)

with $E(\varepsilon_t) = 0, \ E(\varepsilon_t^2) < \infty$

Two financial series are xt and yt the coefficient of correlation is measured by $\rho_{(x_t y_t)} = \dfrac{cov(x_t y_t)}{\sigma_{x_t}\sigma_{y_t}}$

The adjusted coefficient of correlation is then ρ^* such as

$$\rho^* = \frac{\check{n}}{\sqrt{1 + \delta[1 - (\rho)^2]}} \qquad avec \ \ddot{a} = \frac{V^c(x_t)}{V^t(x_t)} - 1$$

Where "c" and "t" indicate respectively the periods of crisis and quiet.

Indeed, δ represent the relative increase in $V(X_T)$ between two periods of crisis and tranquillity.

So, to test statistically the increase of an adjusted coefficient of correlation, we shall use following both alternative hypotheses:

$$\begin{cases} H_0: \rho_1^* = \rho_2^* \\ H_1: \rho_1^* > \rho_2^* \end{cases}$$

With :

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

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

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

$$t = (\rho_1^* - \rho_2^*)\sqrt{\frac{n_1 + n_2 - 4}{1 - (\rho_1^* - \rho_2^*)^2}}$$

With, t follows Student in $(n_1 + n_2 - 4)$ degrees of freedom. Then, if we accept H_1, it means that the coefficient of correlation between both markets increased significantly between the quit period and the crisis period, then it is the evidence of the contagion. However, if we retain the hypothesis H_0, the increase of the coefficient of correlation reflects only the interdependence between both markets.

Cointegration and ECM models

Unit root test series: ADF test:

First, we verify the order of integration of the series (x_t) and (y_t) by using the Dickey-Fuller Augmented test (ADF).it is a parametric test, it bases on the estimation of an autoregressive process. The general model ADF is presented as follows:

$$\Delta X_t = \lambda + \delta t + \alpha X_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta X_{t-j} + \varepsilon_t$$

Where λ the constant, t measure the trend and p measure the optimal number of delays which allows to clear the error term. In fact, Dickey and Fuller (1981) consider three basic models:

Model without constant nor determinist trend:

$$\Delta X_t = \alpha X_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta X_{t-j} + \varepsilon_t$$

Model with constant without determinist trend:

$$\Delta X_t = \lambda + \alpha X_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta X_{t-j} + \varepsilon_t$$

Model with constant and determinist trend:

$$\Delta X_t = \lambda + \delta t + \alpha X_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta X_{t-j} + \varepsilon_t$$

From these equations, we test H_0 of unit root against H_1 the alternative hypothesis of absence of unitarian root. The application of the test ADF requires the selection of the number p of delays. The value of p can be determined, either by the criteria of Akaike and Schwartz, or by making vary the delay until it will be significant. The test ADF is made to determine the order of integration. Once we define the order of integration, we shall proceed to the cointegration test.

Linear ECM :

According to Engel and Granger (1987), the cointegration test is presented as follows: if the linear combination zt of two series xt and yt not stationary, will be stationary, then both series are said cointegrated. So, the ECM model is represented as follows:

$$\Delta y_t = \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \sum_{i=1}^{q} \lambda_i \Delta x_{t-i} + \delta z_{t-1} + \varepsilon_t \qquad (2)$$

Where z_{t-1} is the balance error of the long-term relation and δ is the speed of adjustment towards the long-term balance. This speed produces, every time there is deviation, the system towards the balance or towards the stability.

The contagion modeling via the non linear ECM:

The first article of not linear ECM is established by Granger-Lee (1989) and was developed by Escribano and Pfann (1998). These authors considered that the model linear ECM is based on restrictive conditions:

- The long-term balance is only.

- The adjustment with regard to the balance is symmetric.

However, the hypothesis of the balance uniqueness does not verify the economic reality which considers the existence of the asymmetric situations as for example the stability and the crisis, what engenders a multiplicity of the balances. This reality is modelled by the not linear ECM (asymmetric) by provoking the asymmetry at the level of the term of correction of error zt which will be shared in two positive and negative elements. He so allows the creation of two balanced situations characterized each by a specific adjustment speed.

Escribano-Pfann method

Escribano-Pfann (1998) shared the error correction term (le terme de correction d'erreur), in the model ECM, in two positive and negative parts such as:

$$z_{t-1}^{+} = \begin{cases} z_{t-1} \\ 0 \end{cases} \qquad \text{if } \Delta z_{t-1} > 0$$

$$\text{If not}$$

$$z_{t-1}^{-} = \begin{cases} z_{t-1} \\ 0 \end{cases} \qquad \text{if } \Delta z_{t-1} < 0$$

$$\text{If not}$$

Then, the new ECM representation will be

$$\Delta y_t = \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \sum_{i=1}^{q} \lambda_i \Delta x_{t-i} + \delta_1 z_{t-1}^{+} + \delta_2 z_{t-1}^{-} + \varepsilon_t \qquad (3)$$

According to Escribano-Pfann (1998), if δ_1 is statistically different of δ_2, we accept the hypothesis of existence of a significant asymmetry in the ECM model. Otherwise, we retain the initial model:

$$\Delta y_t = \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \sum_{i=1}^{q} \lambda_i \Delta x_{t-i} + \delta z_{t-1} + \varepsilon_t$$

To resume:

Forbes and Rigobon (2001) have defined the contagion as a significant increase in the links between markets after the realization of a shock on a country or group of countries .

In our study, we will represent these links by the co-movements between stock markets.

We consider x_t and y_t the respective daily stock indexes of the crisis source country and the affected country. The test of the contagion consists in examining the behavior of the co-movements between these two series of stock indexes before and after the crisis.

The co-movements are modelled by the relation of long-term balance represented by the equation:

$$y_t = a + b x_t + z t,$$

When x_t and y_t are cointégrated. According to Escribano-Pfann (1998), the distribution of the term of correction of error z_{t-1}, in two elements Z_{t-1}^+ et Z_{t-1}^-, lead in following both situations:

- First Situation: $\Delta z_{t-1} > 0$ imply $\frac{\Delta x_{t-1}}{\Delta y_{t-1}} < \frac{1}{b}$

- Second Situation: $\Delta z_{t-1} < 0$ imply $\frac{\Delta x_{t-1}}{\Delta y_{t-1}} > \frac{1}{b}$

where b, is the relationship between the stock indexes variation at a balanced situation.

We suppose that the second situation represents in fact the increase of the co-movements between the stock indexes variations of (the links between stock markets) both countries, what proves the existence of the contagion according to the definition of Forbes and Rigobon (2001a). In fact, this increase is considered by the adjustment coefficient δ_2. Then, to accept the existence of the contagion passed on of x_t towards yt, it is necessary that δ_1 and δ_2 (of model 3) are significantly different. A sufficient condition will be: the statistical significativity of the coefficient δ_2 . In fact, this condition is introduced to consider the importance of the second situation and to confirm our supposition.

4. Empirical analysis:

We will analyze the contagion through the co-movements between stock markets. We shall so use daily data of the different stock indexes for G7 and BRIC markets.

In our study of correlation, we used two periods. A quiet period from April 2006 to August 2007. And a crisis period from August 2007 to January 2009. Concerning the not linear model ECM estimation, we used stock indexes series concerning the period from April 2006 to January 2009. In fact, this period contains two under periods (tranquility and crisis).

5. Results and discussion

Correlation test: The application of the correlation between the indexes in normal period and that of the crisis allows us to construct different matrix: Matrix of the correlations adjusted coefficients of quiet and crisis period, and their 't' student.

The use of the adjusted correlations coefficients allows to determinate the country susceptible to be the source of contagion. According to the matrix of correlations adjusted coefficients (appendix table 1 and table 2), we found that a significant increase of the correlations adjusted coefficients between stock markets: American, French, German and British. We interpret this increase as being a proof of contagion. Furthermore, we can conclude according to these results, the presence of phenomenon of contagion between the emergent stock markets because of the significant increase of these coefficients between quiet period and the period of crisis

According to the t student matrix, (appendix table 3), we found the countries susceptible to beings a source of contagion for the developed and emergent countries. We detected that United States is the source of pure contagion towards three countries: France, Germany and the United Kingdom stock markets. We found this result according to the correlations adjusted coefficients of the United States as country source of the crisis with these three countries are significant (t, student USA, France2.6934, USA, Dutch land 4.4536, USA, GB 3.0323).

Furthermore, we found that the Italian stock market seems to affecting three countries (Brazil, Russia, India) with free significant degree of 5 % and Japan in a 10% .additionally, the Brazilian stock market is affecting five countries : Canada, Italy, Japan, Russia, and India, this is proved with student t relative to the correlations adjusted coefficients during the period of crisis are significant.

Stationarity and non linear ECM results:

To began cointegration study we must do a stationnarity test, and we use the ADF (Augmented Dickey-Fuller) on the series of the stock indexes of the various countries of the sample.

We notice that all the residues are stationary (the calculated statistics ADF is superior to the critical value) (appendix table 4), so there is a linear cointegration relation between the stock indexes series. The existence of the cointegration relation means that these series share stochastic long-term trends.

Then, we estimate the not linear model ECM by using the approach of Escribano and Pfann (1998). Concerning the non linear ECM results (table 5 and 6 for other case) we remark that the majority of the adjustment coefficients δ_i for i=1,2 are negative and significant translating the existence of the plans of correction towards the balance.

According to the table 5, we remark that the stock index of the United States (Dow Jones IA) is cointgrated with all other stock indexes (Canada, France, Germany, the United Kingdom, Italy, Japan, Brazil, Russia, India and China); because all the values of the test ADF on residues Z_t are lower than the critic value with 5 % freedom degree .

So, we notice, according to the Ficher test the existence of four ECM asymmetries situations, among ten cointegration relations. This non linearity appears in the relation between the United States and France, the United States and Germany, the United States and the United Kingdom, the United States and Brazil.

In fact, we rejected the hypothesis H_1 in these four cases with respective probability ((0.01913), (0.000016), 0.000826), (0.000112)) which are lower than 0.05. Thus, for these four cases, δ_1 and δ_2 are statistically different. We also notice that in these four cases, the coefficient δ_2 is always statistically significant. However, the coefficient δ_1 was not significant.

This so confirms our supposition on the correspondence enter the second situation where $\frac{\Delta x_{t-1}}{\Delta y_{t-1}} > \frac{1}{b}$ seized by the coefficient of adjustment δ_2 and the increase of the co-movements for the crisis period.

Thus, via the combination of the ECM term error asymmetry and the statistical significativity of the coefficient δ_2, we conclude that France, Germany, the United Kingdom and Brazil are affected by the United States.

While, the other relations between the United States and the rest of the countries of the sample to know Canada, Italy, Japan, Russia, India and China are only relations of interdependence. This result, confirms in our previous conclusions of the correlation approach, which indicates that the United States is the country source of the crisis

According to board 6, we found relations of not linear cointegration between all the stock indexes. For the majority of the developed and emergent countries, we found results of pure contagion between:

France => USA

Germany => USA

UK => France

France => UK

Germany => France

UK => Germany

Germany => UK

UK => India

Canada=> USA

Italy => France

Brazil => USA

Canada => Germany

Italy => Brazil

Brazil => Canada

Canada => Japan

Italy => India

Canada=> Brazil

Japan => Canada

Russia => USA

India => UK

China => France

Russia => Canada

India => Russia

China => Brazil

Russia => France

Russia => UK

Then we identify the cases of pure contagion and the other cases are interdependence contagion.

We can conclude, according to our empirical results, that the United States are the country source of contagion during the financial crisis of subprimes. We also notice the existence of the contagion in other stock market country (French, Canadian, German, British, Brazilian, Indian, Chinese, Italian and Russia). This result means that the contagion of the American financial crisis is begun with the developed countries then propagated in emerging countries.

6. Conclusion

The objective of our work is to analyze the mechanisms of the appearance and the transmission of this crisis and to show the existence of a possible effect of contagion between developed and emergent markets. In our analysis we use a sample of eleven countries belonging to the G7 and BRIC, using for each country the stock index as a variable indicating the financial market.

Our study was based on the tests of correlation adjusted coefficient (adjusted coefficient de correlation tests) by the way of hétéroscédasticity and the not linear mechanisms of correction of error (ECM) developed by Escribano and Pfann (1998). Our first findings bring to light a significant change of the co-movement between stock markets after the shock. In fact, the techniques used, allowed us to support the hypothesis of pure contagion for certain stock markets of the developed and emergent countries during this crisis.

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Appendix

Table 1. Matrix of the coefficients correlations adjusted of quiet period

	USA	Canada	France	Germany	UK	Italy	Japan	Brazil	Russia	India	China
USA	1	0.1386	0.0568	0.036	0.0498	0.0055	0.0086	0.0363	-0.0041	-0.0047	0.0081
Canada	0.1682	1	0.0579	0.0246	0.0382	0.0418	0.0701	0.0485	0.0269	0.0062	0.0002
France	0.0753	0.0629	1	0.0557	0.0963	0.0915	-0.0085	0.0561	-0.0236	0.0196	0.0052
Germany	0.0546	0.0306	0.0637	1	0.231	0.0932	-0.0198	0.0914	0.0612	0.0725	-0.0004
UK	0.0619	0.039	0.0904	0.1913	1	0.0693	-0.0182	0.0523	-0.0239	0.05	0.0065
Italy	0.0069	0.043	0.0866	0.0772	0.0699	1	-0.0012	0.0286	0.0344	0.0019	0.0249
Japan	0.0114	0.0756	-0.0084	-0.0172	-0.0193	-0.0013	1	0.0434	0.0343	-0.0112	-0.002
Brazil	0.0592	0.065	0.069	0.0984	0.0686	0.0372	0.0538	1	0.0358	-0.0133	0.0232
Russia	-0.0069	0.0372	-0.0299	0.0679	-0.0324	0.0462	0.0438	0.0368	1	0.0389	-0.0078
India	-0.0092	0.01	0.029	0.0935	0.0787	0.0029	-0.0166	-0.016	0.0454	1	0.0206
China	0.0175	0.0004	0.0085	-0.0005	0.0112	0.0428	-0.0034	0.0306	-0.01	0.0226	1

Table 2. Matrix of the coefficients correlations adjusted by the period of crisis

	USA	Canada	France	Germany	UK	Italy	Japan	Brazil	Russia	India	China
USA	1	-0.0596	0.1361	0.1764	0.131	-0.0677	-0.0281	-0.0353	-0.0145	-0.0024	-0.0115
Canada	-0.0726	1	0.0353	-0.0015	0.0179	0.0795	0.0426	0.161	0.0967	0.0066	-0.0079
France	0.1792	0.0384	1	0.5675	0.3642	-0.0635	-0.0344	-0.0582	0.017	0.013	-0.0393
Germany	0.2622	-0.0019	0.6191	1	0.4054	-0.0757	-0.0476	-0.0678	0.0139	0.015	-0.0343
UK	0.1623	0.0182	0.3446	0.3421	1	-0.0804	-0.0054	-0.0653	0.0057	-0.0074	-0.0268
Italy	-0.0848	0.0817	-0.0601	-0.0627	-0.081	1	0.0694	0.1378	0.1145	0.0561	0.0175
Japan	-0.037	0.0459	-0.0342	-0.0413	-0.0057	0.0729	1	0.1203	0.0239	0.1031	0.0334
Brazil	-0.0576	0.2135	-0.0717	-0.0731	-0.0856	0.1783	0.1486	1	0.1749	0.0639	0.0367
Russia	-0.0244	0.1328	0.0216	0.0155	0.0077	0.1528	0.0305	0.1799	1	-0.0134	0.0284
India	-0.0047	0.0107	0.0192	0.0194	-0.0117	0.0875	0.1525	0.0766	-0.0156	1	0.061
China	-0.0249	-0.0139	-0.0638	-0.0486	-0.0464	0.0301	0.0546	0.0483	0.0363	0.0669	1

Table 3. T-STUDENT

	USA	Canada	France	Germany	UK	Italy	Japan	Brazil	Russia	India	China
USA	0	-5.298	2.0831	3.7146	2.1343	-1.925	-0.966	-1.8819	-0.2733	0.0595	-0.5177
Canada	-6.5001	0	-0.5922	-0.6882	-0.5335	0.9881	0	2.9651	1.8303	0.0106	-0.2146
France	2.6934	-0.644	0	15.6028	7.2834	-4.113	-0.6804	-3.0155	1.0669	-0.1726	-1.1703
Germany	4.4536	-0.856	17.49	0	4.6402	-4.489	-0.7275	-4.2265	-1.2394	-1.5069	-0.8882
UK	3.0323	-0.545	6.8837	3.9962	0	-3.968	0.335	-3.1067	0.7797	-1.5091	-0.8755
Italy	-2.4147	1.016	-3.8872	-3.7007	-3.9991	0	1.8582	2.8777	2.1046	1.4226	-0.194
Japan	-1.272	-0.778	-0.6757	-0.632	0.3544	1.9509	0	2.0183	-0.2733	3.0162	0.9326
Brazil	-3.0831	3.9344	-3.7245	-4.5599	-4.0922	3.732	2.493	0	3.6787	2.0316	0.3526
Russia	-0.4596	2.5159	1.3541	-1.3746	1.0539	2.8092	-0.3489	3.7863	0	-1.3746	0.9508
India	0.1167	0.0171	-0.255	-1.9452	-2.3776	2.2219	4.4978	2.4385	-1.6016	0	1.059
China	-1.1141	-0.379	-1.9	-1.2604	-1.5142	-0.332	1.5241	0.464	1.2164	1.1624	0

Tableau 4. Stationarity test result :   Test ADF

	Calculated ADF		Critic value 5%		
country	level	First difference	level	First difference	I(d)
USA	-0.43373	-23.92352	-2.8661	-1.9399	I(1)
Canada	-0.68934	-21.57152	-1.9399	-1.9399	I(1)
France	0.19285	-21.42167	-2.8661	-1.9399	I(1)
Germany	-0.68512	-20.34067	-2.8661	-1.9399	I(1)
UK	-0.77846	-21.5049	-2.8661	-1.9399	I(1=
Italy	1.382126	-17.94903	-2.8661	-2.8661	I(1)
Japan	-1.28690	-16.6123	-1.9399	-1.9399	I(1)
Brazil	-1.33628	-17.23863	-2.8661	-1.9399	I(1)
Russia	-0.91581	-16.76144	-1.9399	-1.9399	I(1)
India	-0.23045	-15.52269	-1.9399	-1.9399	I(1)
China	0.413114	-14.28143	-1.9399	-1.9399	I(1)

Table 5. ECM non linear result : United States case:

	ADF	Critic value (5%)	Cointegration)	δ1 (t-student)	Δ2 (t-student)	Test F H0: δ1=δ2	Contagion
USA => Canada	-10.30225	-1.9400	YES	0.079010 (2.260545)	-0.031260 (-0.850756)	4.028034 (0.045214)	No
USA => France	-10.83019	-1.9400	YES	0.169684 (5.285548)	0.142973 (3.81706)	5.636684 (0.019131)	yes
USA => Germany	-10.74127	-1.9400	YES	0.183873 (5.873904)	-0.138652 (-4.013082)	19.17859 (0.000016)	yes
USA => UK	-11.24289	-1.9400	YES	0.129163 (3.398303)	-0.086565 (-1.952583)	11.59747 (0.000826)	yes
USA => Italy	-9.842044	-1.9400	YES	0.069815 (1.787175)	-0.000285 (-0.006343)	1.167326 (0.280400)	No
USA => Japan	-10.86064	-1.9400	YES	0.032207 (0.599060)	-0.023839 (-0.352860)	0.056424 (0.812324)	No
USA => Brazil	-12.09168	-1.9400	YES	0.104543 (3.792467)	-0.056674 (-2.119689)	15.20060 (0.000112)	yes
USA => Russia	-11.38957	-1.9400	YES	0.001991 (0.641865)	0.001396 (0.479740)	0.016436 (0.898033)	No
USA => India	-11.07612	-1.9400	YES	0.070934 (1.948403)	-0.007745 (-0.199268)	2.945017 (0.086677)	No
USA => China	-10.71800	-1.9400	YES	0.008649 (0.471571)	-0.019980 (-0.970207)	0.830795 (0.362421)	No

*yes: contagion case; *No: interdependence case