Research on the effect of financial contagion in the subprime crisis

Aymen JEBRI, Faouzi JILANI and Naoufel LIOUANE

Department of accounting and finance

Faculty of Economic Sciences and Management of Tunis, Tunisia

Tél : 216 – 22 974 891   *E-mail :* aymen.jbr@gmail.com

Abstract

In this paper, we are interested in the propagation of the mortgage crisis " subprime " throughout the stock markets of the five developed economies namely the United States, being the country of origin of the crisis, France, Great Britain, Germany and Japan during the period ranging from 03/01/2006 to 25/02/2009, i.e. 778 observations for each country on a daily frequency. To verify the existence of financial contagion, we used the techniques of simple and adjusted correlations and the study of causality and co-integration in order to clarify the relationship of temporal combination and dynamic analysis of residues in series with modeling multivariate GARCH. We have, thus, shown that the relationship that did not exist during the tranquil period, did play an important role during the crisis period, demonstrating a phenomenon of "pure contagion" and not of " normal interdependencies ". Keywords: Contagion, Subprime Crisis, transmission channels, DCC GARCH

Keywords: Financial contagion, mortgage crisis, subprime

1. Introduction

Economic history was punctuated by several periods of crises whose disturbances are increasing on the stock exchanges. These periods are always accompanied by substantial aggravations affecting the real sphere and the economic activity. Each crisis is unique with its own features, the thing that renders its identification quite challenging.

Some aspects such as appearance and propagation of crises were disclosed. However, the complexities caused by the perpetual mutations of global economy remain incomprehensible. One of the most common phenomena is " Financial Contagion ". Indeed, the economic cycle was shaken during the last decade by a succession of crises simultaneously hitting several geographic areas.

It is the case for the Asian crisis of July 1997 that caused the channeling of the contingency spreading, hence, from Thailand to a large part of Asia. We also note the explosion, in the United States, of the Internet bubble in 2000 and the Housing crisis in 2007, the latter being a consequence of the mortgage loans that went through a major phase of effervescence and growth.

The consequences of this crisis on the American, the European and the global economy in general, push us to dwell on the subject. Very recent but very devastating, given the observed damage in a short time, it leaves room for an additional reflection over the appearance of all these episodes that are heading for the same direction, insofar as the occurrence of a crisis in some countries is transmitted to others following determining factors identified according to the phenomenon of contagion.

The significance of the impact of this phenomenon on financial stability has attracted the interest of many economists, hence, the extensive literature dealing with the crises transmission. To elucidate the Financial Contagion, *Forbes and Rigobon* (2000) suggested a comprehensive and simplified definition of the phenomenon. This is the notion of "Shift Contagion" according to which the latter is seen as a significant and brutal increase in the markets links.

In the course of this research, the focus will be on the study of the contagious effect of the U.S mortgage crisis. The questions this paper seeks to answer are the following :

▪ How to explain the mechanisms of the transmission of the crisis ?

▪ What are the econometric means deployed to dissect its contagious character for the different studied markets?

▪ Was the subprime crisis contagious?

2. The phenomenon of financial contagion :

Contagion is a term that refers to the process of transmission of a disturbance on the market from one country to another. The analysis of the transmission of the mechanisms of shocks in time breaks down into two controversial approaches. They seek answers to the following questions :

Is shock transmitted via channels proper to periods of crises i.e. via crises-contingent channels? Or, is this the work of the propagation of non-crises-contingent channels?

2.1. The approaches of "non-crises contingency":

The first approach is the result of the economic interdependence of several countries. The shock of a crisis departing from an affected economy generates a modification at the level of the macroeconomic fundamentals of the other economies.

This systematic effect of the simultaneity of shocks is the consequence of pre-existing channels such as fundamental economic bonds maintained by the countries. Calvo & Reingart (1996) and Kaminsky & Reinhart (2000) call this type of propagation based on fundamentals "fundamentals based contagion".

2.2. The approaches of "Crises Contingency":

The second approach assumes a change in the propagation mechanism of contagion during the crisis or just after it. Unlike the approach of non-crises-contingency, the transmission of a shock is no longer the work of the macroeconomic fundamentals or the continuing relationships of interdependence caused by the occurrence of a global or a specific shock. Indeed, the influence is made through cross-border links that did not exist during the period of tranquility. They are rather contingent and specific to the crisis.

3.   Nature of the subprime financial contagion   :

The transmission of a downturn in the U.S housing market towards the Euro zone is due to the implementation of the new structures of hedging, including credit derivatives that have taken place across the global economy through filtration. The extent of damage in the form of stock market and financial crises suggest about mechanisms of financial contagion. In this perspective, it is important to identify the contributions of different channels, whether mechanic or not in the spread of the real estate crisis of the Atlantic European countries.

3.1. Role of sales channel   :

The trade channel has a role in the contagion and the slowdown in the U.S. economy. On the one hand, the macroeconomic connections being held by the United States with countries contiguous, such as Canada, Mexico, the emerging Asia or the Euro zone experienced discernible disturbances from exports to America. This is the direct effect that fissures consumption and investment.

Moreover, not only are direct exports to the United States affected, but also exports to the rest of the world. This is the second indirect "Echo" effect that is more severe than the direct one. In such a situation, the structure of world trade is simulated.

Nevertheless, it seems inappropriate to judge whether the creditor channel effect is accentuated by comparing the two periods before and after the crisis, because there are two factors : The first is related to the evolution and development of the weight of emerging economies, and the second is associated with financial liberalization and expansion of international trade. These factors have significantly sensitized economies to external shocks.

3.2 Monetary policy transmission channel :

Another factor has played a major role in the mechanical contagion between the markets. These are the monetary steps taken by the central banks.

The first action was started in late 2003 by the Bank of England, followed by the Fed in August 2004, and finally the European Central Bank in 2005. The time lag for the application of the same measure is an explanation for the "Delay" of the crisis' onset from one country to another. However, the outbreak is undeniable.

The transformation of the real estate crisis into a financial crisis is primarily due to the interest rate: Firstly, the characteristics of mortgage subprime rates fixed or variable, and secondly, the interest rate on households' loans directly related to long-term rates of reference. Also, the strong correlation of interest rates between countries, if long rates, explains better the common bond that unifies the United States and Europe.

3.3 Financial Channel or common shocks ?

The study of the history of the correlations which linked the American and European markets evokes the synchronization of these latter. The role of common shocks is frequently identified. A shock affecting the Atlantic has been often noticed following a slowdown in its activity and spreading in the Euro zone. As an example: the bursting of the technology bubble, the oil shocks, etc…

The analysis of the last thirty years of the evolution of U.S. GDP in the Euro area confirms many similarities. Therefore, it is difficult to confirm the role of the financial channel in the contagion of the mortgage crisis or to detect the contagious nature of the crisis over time.

3.4 What about the exchange rate channel ?

The evolution of the exchange rate significantly affects the competitiveness of partner countries. In fact, the origin of the real estate crisis, being American, is promoting the depreciation of the U.S. dollar. A decrease in the yields of U.S. assets and therefore a decline in stock prices are seen, which in consequence, made investors waive U.S. assets for others which countries offer more favorable monetary policies to the development of their currency.

The depreciation of the dollar insures a currency appreciation of floating exchange rate currency regime, such as the Euro. Third countries recorded when competitiveness loss accelerated, almost the same pace of decrease in interest rates due to the deceleration of the cadence of U.S. economic activity, (Policy (2007). Example, the exchange rate channel takes on the mechanic contagion.

4. Empirical Study : Financial contagion in the subprimes crisis

Certainly, the U.S. mortgage crisis is an unexpected event which is constantly growing, as the case for all the previous crises. In this regard, it is important to highlight the econometric and statistical tools that would study and evaluate the effects of the cross-border transmission of the crisis.

4.1. Understudy : Data used

To highlight the existence of contagion during the *"subprime"* crisis, we use daily returns of the stock indicators of five basing developed countries, namely , The U.S. *(S & P 500),* Great Britain *(FTSE 100),* France *(CAC40)* , Germany *(Dox 30)* and Japan *(Nikkei 225)*

Series of selected assets were collected from the DataStream database whose treatment was provided by the empirical two-party software: The first parts of descriptive studies and measurement are performed by co integration Eviews, and the results are integrated into a DCC-GARCH model, processed by Matlab.

However, following the theoretical developments as well as the graphical method (see Appendix 1) we have chosen the beginning of the mortgage "subprime crisis" dating back to July 2, 2007, the day of the collapse recorded by the global stock markets. Consequently, it is essential to identify the periods of stability and financial turmoil.

Definition of periods of study and the number of observations

Subprime crisis	Window of tranquility		Window turbulence		Overall period	
	Beginning	End	Beginning	End	Beginning	End
	03/01/2006	29/06/2007	02/07/2007	25/02/2009	03/01/2006	25/02/2009
Number of observation	367		410		778	

4.2. Measurement of contagion by the correlation approach

Studies of past crises contagion test the significant increase in the correlation coefficients between two economies during a period of stability to a financial disruption.

- The evidence of this increase suggests that there is a reinforcement of the links and the mechanisms of propagation between the markets in question, showing ″ pure contagion ″.

- If this increase is not statistically significant we are seeing only a phenomenon of « normal interdependence ». (Forbes and Rigobon, 2001)

▪ **Simple correlations : Normal transmission or contagion?**

The preliminary study is to identify a possible intensification of links between the different selected markets considered as an evidence of contagion. Henceforth, a simple correlation study by pair "Pair-Wise Correlation" is to be evoked; the results are outlined in Table 1 (Appendix 2).

✓ **Model**

Test the simple correlation between two variables (Countries, markets or assets) Xt and Yt to zero mean and finite variance based on test stability coefficient β of the equation :

$$Y_t = \alpha + bx_t + \varepsilon_t \qquad (1)$$

The correlation coefficient associated with the model (1) is :

$$e = corr(X_t, Y_t) = \frac{cov(X_t, Y_t)}{\sigma_X \sigma_y} \qquad (2)$$

✓ **Interpretation**

The descriptive analysis of the correlation values shows an increase in the market yields during the transition from one sub-period to another, which confirms the existence of a contagion from U.S to stock markets namely the Japanese, the French and the English.

Concerning the German market, the increase in the correlation coefficient is not significant hence the absence of a contagion effect from the USA to Germany. But it does not mean a total absence of links between them for the period of agitation. This is called the effect of interdependence.

▪ **Contagion by adjusted correlations: Forbes and Rigobon (2001)**

In order to overcome the different bias generated by calculating equation 1, Forbes and Rigobon identify a double equation model without restrictions. The simultaneous equations solve the problem of endogeneity and heteroscedasticity, caused by any form of interdependence between markets previously.

✓ **Model :**

$$\begin{cases} Y_t = \beta X_t + \lambda Z_t + \varepsilon_t & \Rightarrow \text{ Country affected by the crisis.} \qquad (3) \\ X_t = \alpha Y_t + Z_t + V_t & \Rightarrow \quad \text{Country of origin crisis.} \qquad (4) \end{cases}$$

Or Z_t : Latent variable that captures unobserved aggregate shocks.

ε_t and V_t : Aleatory Terms relating to structural shocks specific to countries.

The adjusted correlation coefficient ρ * is as : $\rho * = \frac{\rho}{\sqrt{1+\delta(1-\rho^2)}}$ (5)

With $\delta = \frac{\sigma_{xx}^H}{\sigma_{xx}^L} - 1$ (6)

The Variable δ shows the relative increase of the variance profitability index between the period of tranquility and that of the crisis. A possible increase reflects the existence of

contagion between markets involved. This finding needs to be confirmed via a statistical test of contagion, the test is as follows :

$$H_1: \rho^{*H} > \rho^{*L} \left\{ \begin{array}{ll} H_0: \rho^{*H} \leq \rho^{*L} & \Rightarrow \quad \textit{Absence of contagion} \\ \Rightarrow \textit{Présence of contagion} \end{array} \right.$$

Merrison (1983) proposes a statistic associated to the contagion test :

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

With t (n_1 + n_2 - 4) is the degree of freedom of the Student law followed by the statistics, knowing that this test is robust to the non-normality of the correlation coefficients.

✓ **Interpretation of results**

Table 2 (Appendix 2) shows that the adjusted coefficients exhibit higher correlations: It is a first step towards the confirmation of the contagious aspect of the subprime crisis. The test applied to the corrected values of the correlation coefficients captures the null hypothesis of non contagion at a critical threshold of 5%. During the subprime crisis, the evidence of contagion is confirmed for three relationships out of four.

4.3. Causality and Multivariate Johansen Co integration:

To show the existence of a contagion, the existence of an interdependent relationship between long-term financial markets is to be highlighted, through co integration relationships, modeling the permanent channels through which crises are usually spread between countries.

▪ **Johansen co integration test**

This test is based on the given values of a matrix resulting from the estimation of parameters by maximum verisimilitude by calculating the following Johansen statistic:

$$\text{Trace} = -T \sum_{i=r+1}^{n} Ln\left(1 - \hat{\lambda}_i\right) \qquad (7)$$

With T The number of observations ; $\hat{\lambda}_i$ The largest given value

The trace test statistic therefore the following assumptions :

H0 : Absence of co integration relationships between sets.

H1 : Presence of at least one co integrating relationship between the series.

For the decision rules The critical values of these tests are tabulated by Johanson and Juselius (1990) and Osterwald-Lenum (1992), according to which we accept the null hypothesis if the statistic is less than its critical value given at 5%.

The application of the Johansen test shows at least one co integration relationship, the presence of this relationship may indicate the existence of permanent channels in the transmission of shocks between countries, that is the evidence of contagion according to the specification of non-crises-contingent theories.

- **Terms of Model Errors ECM**

The VECM allows the integration of short-term fluctuations around the long-run equilibrium through the co integration relationship. This model is valid if and only if the coefficients are all significant and all the forces of the recall are negative. VECM A presentation in a bivariate framework is given by :

$$\Delta y_t = \emptyset + \sum_{i=1}^{p-1} \beta_i \, \Delta y_{t-1} + \beta_p y_{t-p} + \varepsilon_t$$

(8)

- ✓ y_t: Vector of endogenous variables; Coefficient vector at the origin

- ✓ β_i : Parameter vector to be estimated and the number of optimum delay.

From Table 2 (Appendix 3), we show that all coefficients are significant at the 5% level. In addition, the strength of recall is always negative. This writing VECM is enabled.

That confirms the existence of the interrelationship between the long-term markets. The disadvantage of this model is that it does not allow us to detect the direction of causality between countries. For this, we introduce a test of Granger causality.

- **Test Granger causality :**

The results in Table 3 (Appendix 3) appear to be logical and confirm those found in measures of adjusted correlation coefficients. In fact, since the probabilities are lower than the critical threshold of 5%, we reject the null hypothesis and accept the alternative hypothesis of the existence of causal relations.

The U.S. S & P_500 thus causes the other indices. The effect of " pure contagion "U.S mortgage market experienced by other markets is therefore justified.

4.4. Financial contagion by dynamic conditional correlations

In order to overcome the anomaly of heteroscedasticy, we can use a Garch model. It is restricted to the default choice of the Garch (1, 1), considered sufficient to take into account the bias identified.

- **DCC model**

The equation for the inter-view market is represented by an autoregressive process in which each variable yt model is based on a constant and its past values. The reduced form of this process is as follows:

$A(L)\, y_t = c + \varepsilon_t\,;$ $\qquad\qquad \forall\, t: 1, \ldots., N$ $\qquad\qquad$ *(9)*

- ✓ $\quad$ A (L) polynomial lag

The error term ε_t is subject to the financial innovation required for the establishment of the conditional variance; it must satisfy the following condition:

$\varepsilon_t / I_{t-1} \rightsquigarrow N(0, H_t)$

Subsequently, the DCC-MVGARCH is easily captured by the definition of a matrix of multivariate conditional variances: $\qquad Ht = Dt\, Rt\, Dt \qquad\qquad$ *(10)*

With;

- ✓ D_t : is a diagonal matrix of dimension $(n \times n)$ whose elements are deviations variable in time respecting individually specifying a univariate GARCH or values $\sqrt{h_{ii,t}}$; $\forall i = 1 \ldots. n$; On the 2nd diagonal.

- ✓ R_t is the matrix of dynamic correlations sized $(n \times n)$ varying in time.

The review of the adequacy of statistical conditional variances of variables is required and corresponds to the estimation of the variance equation of a GARCH (1,1).

hii,t =ci + ai hii,t-1 + bi $\varepsilon_{i,t-1}^2$; $\qquad \forall i: 1 \rightarrow N$ $\qquad\qquad$ *(11)*

Univariate GARCH process must satisfy the stationary condition ($a_1 + b_1 < 1$) and the positivity of variances (a_1 and $b_1 > 0$).

However, this model DCC involves a two-stage estimation of the conditional covariance matrix H_t .In a first step, we adopt the univariate GARCH model, and this involves estimating the volatilities $\sqrt{h_{ii,t}}$. The second addresses processing residues, measured in the first step, based on their estimated standard deviations:

$$ui,t \quad = \varepsilon_{i,t} / \sqrt{h_{ii,t}} \qquad\qquad (12)$$

Where the terms $U_{i,t\ t}$ is used to estimate the parameters of the conditional correlation. It therefore gives the evolution of the correlation in the DCC model;

$$\varphi_t = (1 - \alpha - \beta)\bar{\varphi} + \alpha\, \mu_{t-1} u'_{t-1} + \beta \varphi_{t-1} \qquad\qquad (13)$$

With:

✓ $\varphi_t = (q_{ij}, t)$ represents the matrix dimensioned (n × n) of the conditional covariance variant during the time u_t.

✓ $\bar{\varphi} =$ E $= (u_t u'_t)$, is the matrix (n x n) of non conditional covariance of standardized residues u $_t$ obtained during the first step of estimation.

✓ α, β Positive scalar parameters that satisfy ($\alpha + \beta < 1$). So, we can notice that beyond the fact that it allows us to take into account the dynamic correlation, the DCC reduces, also, the number of parameters to estimate.

Since φ_t has no unit values on the diagonal, we obtain the transformed dynamic correlation matrix $R_{t\ t}$

$$Rt = [diag\ (\varphi_t)]^{-1/2}\ \varphi_t [diag\ (\varphi_t)]^{-\frac{1}{2}} \qquad (14)$$

With: $[diag\ (\varphi_t)]\text{-}1/2 = diag\ (1/\sqrt{q_{u,t}}, \ldots, 1/\sqrt{q_{nn,1}})$

Thus, the diagonal elements composing the typical form of the correlation matrix are defined as positive in the following form:

$$\rho_{ij,t} = q_{ij,t}/\sqrt{q_{ii,t}\ q_{jj,t}};\qquad \forall (i,j) = 1,2,\ldots.n\ et\ i \neq j \qquad (15)$$

To estimate the two parameters α and β DCC model can be passed by maximum likelihood estimation.

▪ DCC estimation

Modeling type MVGARCH allows us to determine the variance-covariance dynamics necessary to clear the residue matrix of conditional correlations evolving residues.

Conditional Correlations Matrix

	USA	FRA	ALL	GB	Japan
United States	1.0000				
France	0.31220	1.0000			
Germany.	0.17600	0.22735	1.0000		
Britain	0.33344	0.73865	0.50820	1.0000	
Japan	0.06188	0.10972	0.21663	0.11325	1.0000

The values obtained in this review show a significance of correlations between the stock markets studied. One can also note the strong dependence of volatility between countries, especially in the European system, the example of the correlations between the French and British markets which is about 0.73865, and the German and British market (0.50820).

These results lead us to conclude evidence of transmission of shocks in particular, between markets and generally similar between the countries of the region. To summarize, we can say that the findings emerged confirm the model's ability to capture a first DCC feature of financial time series, particularly the dynamic correlations.

5. Evidence of dynamic conditional correlations

According to Figure 1 Annex 4, the conditional correlation coefficient increases during the period of crisis and becomes more volatile. These significant changes mainly correspond with periods of financial instability, and explain the occurrence of the benefit cross-border contagion of the subprime crisis.

All the studied markets show a volatility that is completely independent from the innovations ($\alpha_i = 0$) and, thus, an intensification of shocks. The existence of a strong dependence to markets is synonymous with the subprimes shock transmission through channels existing in the period of financial stability.

. The result in Table 2 (Appendix 4) shows more sensitive correlations to shocks since innovation is significant and equal to 0.1096. Hence, we found that the important autoregressive effect of correlations is around 0.8720. The sum of the coefficients adheres to both the conditions of positivity, stationarity and persistence.

6. Conclusion

The objectives of this paper are multiple: deciphering the mechanisms of the transmission of the subprime crisis, and this was dealt with in the first part. Furthermore, getting around the problem of the contagious effect of this crisis requires econometric tools discussed in the second part. To do so, various processes were undertaken: Starting with the simple correlation coefficient and the adjusted correlation coefficient for the heteroscedasticity, which provides a review of the significant and transient correlation between markets, synonymous with the enhancement of co-movements. This promotes the presence of a mechanism for the transmission of shocks.

www.macrothink.org/ijafr

However, this type of approach does not provide information on either the direction or intensity of the transmission or the degree of stability or change links. To overcome these shortcomings, causality tests and co integration tests relationships are discussed. The findings, departing from the estimation of the ECM equation, foreshadow the obviousness of the housing crisis shock transmission through channels specific to the crisis. The linearity of the relationship of long-term equilibrium induces its uniqueness, which models the reality of asymmetric financial developments

Furthermore, the presence of the bias of heteroscedasticity of residues generated by regressions, denounces the lack of reliability of these analyzes. Henceforth, a new approach is integrated to present the variability of the volatility and the resulting effects. The application of the model of dynamic correlations MVGARCH assured the illustration of the evolution over time of the inter-market correlations. The results of the analysis authenticate the extent of changes on markets behavior. These findings suggest the economic weight generated by the United States over Europe, in a context of liberalization and financial innovation, as well as the interaction of regional markets.

References

ARVAI, Zsofia et János VINCZE, Janos. « Financial crises in transition countries: models and facts » MNB Working Papeer, (2000).

BILLIO, Monica et PELIZZON Luiji. «Contagion and interdependence in stock markets: Have they been misdiagnosed?», Journal of Economics and Business, 55, (2003), 5 p.

CARTAPANIS, André. « Le déclenchement des crises de change : qu'avons-nous appris depuis dix ans ? », Economie International, 97, (2004), 43p.

CORETTI, Giancarlo, PESENTI, Paolo et ROUBINI, Nouriel. «Paper tigers: a model of the Asian crisis», European Economic Review, 43, (1999), 25p.

DEHOVE, Mario. « Crises financières deux ou trois choses que nous savons d'elles », Document de travail, Conseil d'Analyse Economique, (2003).

DORNBUSH, Rudiger et CHUL PARK Yung et CLAESSENS Stijn. «Contagion: how it spreads and how lit can be stopped», Forthcoming World Bank Research Observer, (2000).

FLOOD, Robert et GARBER, Peter « Collapsing Exchange Rate Regimes: Some Linear Example», Journal of International Economics, 17, (1984), 13p.

FORBES, Kristin et RIGOBON, Roberto. «No contagion, only interdependence: Measuring Stock Market Co-Movement», the journal of Finance, 57, (2002), 5 p.

FORBES, Kristin et RIGOBON, Roberto. «Contagion in Latin America: Definitions, measurements and policy implications », NBER Working Paper, (2000).

GLICK, Reuven et ROSE, Andrew. «Contagion and trade: Why are currency crises regional?», Jounal of international Money and Finance,18, (1999), 14 p.

IRWIN, Gregor. Et VINES David. «A Krugman - Dooley - Sachs third generation model of

the Asian financial crisis », Economic and Social Research Council (ESRC) - Global Economic Institutions, Working Paper Series, 46, (1999).

KAMINSKY, Graciela et REINHART, Carmen. «The Twin crises: The causes of banking and balance of payments problems», American Economic Review, 89, (1999), 3 p.

KODRES, Laura et PRITSKER, Matthew. «A Rational Expectations Model of

Financial Contagion, Board of Governors of the Federal Reserve System», mimeo, (1998).

KRUGMAN, Paul. «A Model of Balance of Payments Crises », Journal of Money, Credit and Banking, 11, (1979), 14p.

LANDIER, Augustin et COHEN, Elie. « Crise des subprimes : le point de vue de deux économistes », Le Monde, (2007).

Bajari et al., 2008 Bajari, P., Chu, C., Park, M., December 2008. An empirical model of subprime mortgage default from 2000 to 2007. Working Paper 14625, NBER.

Dell'Ariccia et al., 2009 Dell'Ariccia, G., Igan, D., Laeven, L., 2009. Credit booms and lending standards: evidence from the subprime mortgage market. Discussion paper 2009-14S, European Banking Center.

Demyanyk and Van Hemert, 2011 Y. Demyanyk, O. Van Hemert Understanding the subprime mortgage crisis Review of Financial Studies, 24 (6) (2011), pp. 1848–1880

Gerardi et al., 2009 Gerardi, K.S., Lehnert, A., Sherlund, S.M., Willen, P.S., February 2009. Making sense of the subprime crisis. Working Paper 2009-2, Federal Reserve Bank of Atlanta.

Harding et al., 2009 J.P. Harding, E. Rosenblatt, V.W. Yao The contagion effect of foreclosed properties Journal of Urban Economics, 66 (3) (2009), pp. 164–178

Johansen and Whiteley, 2008 Johansen, A., Whiteley, N., 2008. A modern perspective on particle filters. In: Inference and Estimation in Probabilistic Time-Series Models. Isaac Newton Institute for Mathematical Sciences, University of Cambridge, pp. 28–35.

Keys et al., 2010 B.J. Keys, T. Mukherjee, A. Seru, V. Vig Did securitization lead to lax screening? Evidence from subprime loans Quarterly Journal of Economics, 125 (1) (2010), pp. 307–362

MASSON, Paul. «Contagion: macroeconomic models with multiple equilibria», Journal of International Money and Finance, 18, (1999), 4 p.

MORRIS, Stephen et SHIN, Hyun Song. «Rethinking Multiple Equilibria in Macroeconomic Modelling», paper prepared for the NBER Macroeconomics Annual , MIT Press, (1998)

TOBIAS, Adrien. « Liquidité et contagion », Revue de la stabilité financière, Banque de France, 11, (2008).

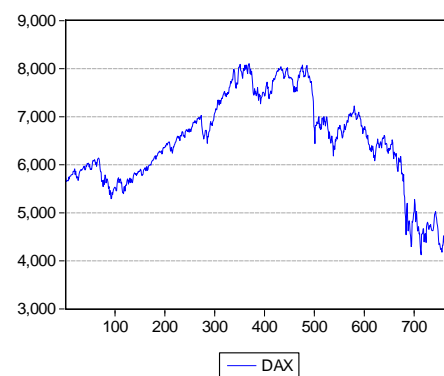VALDES, Rodrigo, « Emerging Market Contagion: Evidence and Theory », Documentos de
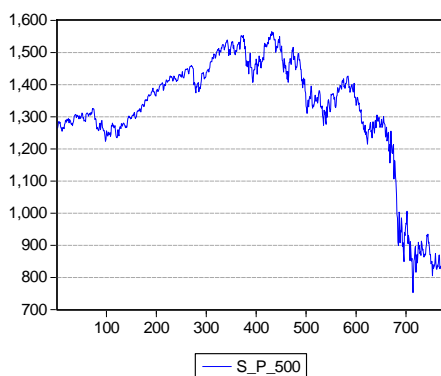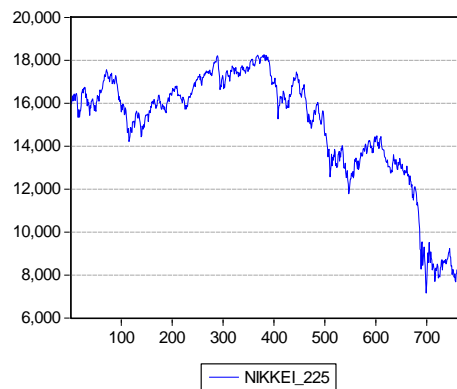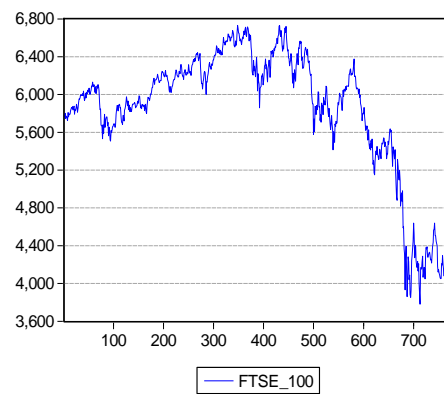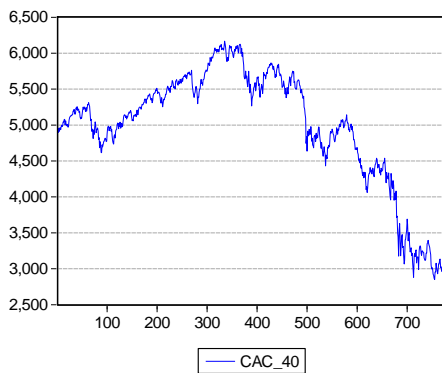
Trabajo del Banco Central, Central Bank of Chile, (1997).

VAN RIJCKEGHEM, Caroline et WEDER, Beatrice. « Financial contagion: Spillovers through Banking Centers », The contagion conference, (2010).

Appendix

Appendix I: Raw Series

Figure 1: Evolution of indices

Appendix 2:   Series of profitability

Table 1: simple correlations of the yields series

Correlation table: global period

	CAC_40	DAX_30	FTSE_100	NIKKEI_225	S & P_500
CAC_40	1.000000	0.004541	0.581143	-0.009964	-0.124547
DAX_30	0.004541	1.000000	0.160133	0.066865	0.250358
FTSE_100	0.581143	0.160133	1.000000	-0.049948	-0.067712
NIKKEI_225	-0.009964	0.066865	-0.049948	1.000000	-0.013495
S & P_500	-0.124547	0.250358	-0.067712	-0.013495	1.000000

Correlation table: period of disruption

	CAC_40	DAX_30	FTSE_100	NIKKEI_225	S_P_500
CAC_40	1.000000	0.004541	0.581143	-0.009964	-0.124547
DAX_30	0.004541	1.000000	0.160133	0.066865	0.250358
FTSE_100	0.581143	0.160133	1.000000	-0.049948	-0.067712
NIKKEI_225	-0.009964	0.066865	-0.049948	1.000000	-0.013495
S_P_500	-0.124547	0.250358	-0.067712	-0.013495	1.000000

Correlation table: period of stability

	CAC_40	DAX_30	FTSE_100	NIKKEI_225	S_P_500
CAC_40	1.000000	0.008507	0.658539	-0.017559	-0.131116
DAX_30	0.008507	1.000000	0.123353	0.067475	0.278924
FTSE_100	0.658539	0.123353	1.000000	-0.053020	-0.083041
NIKKEI_225	-0.017559	0.067475	-0.053020	1.000000	-0.013640
S_P_500	-0.131116	0.278924	-0.083041	-0.013640	1.000000

Table 2: Adjusted Correlations yields series

country	Period of stability				Period of crisis			
	ρ_L^*	T-statist	Probability	Contagion	ρ_H^*	T-statist	Probability	Contagion
USA -FRA	-0.089381	-2.376405	0.0180	Yes	-0.133764	-2.671485	0.0079	Yes
USA-GER	0.002270	0.063514	0.9494	No	0.305378	5.866817	0.0000	No
USA -RU	0.036958	0.841476	0.4006	No	-0.090441	-1.683159	0.0931	Yes
USA -SAP	-0.029307	-0.994904	0.3204	yes	-0.012435	-0.275537	0.7830	Yes

Appendix 3 : Cointegration and causality

Table 1 : Johanson cointegration test

N° of cointegration relationship	Eigen valeur	Trace statistic	Critical value 5%
Aucune*	0.058645	114.2385	69.81889
Au plus 1	0.054292	67.52251	29.79707
Au plus 2	0.018675	14.57233	21.13162

Indicated rejection of the alternative hypothesis H_1

Table 2 : Estimated VECM

Index	Significance	Standard dev	T-statis	Restoring force
S&P-500	-0.404147*	0.02236	-18.0773	Negative
Cac-40	-0.232910*	0.03024	-7.70129	Negative
Dax-30	-0.203289*	0.02020	-10.0627	Negative
FTSE-100	-0.290980*	0.02774	-10.4901	Negative
Nikkei-225	-0.059201	0.03707	-1.59712	Negative

The coefficient is significant at 5%

Table 3: summary of causal relationships identified

Index	Direction of causality	Probability	Decisions
Nikkei-225	S & P500 causes Nikkei-225	0.02144	
FTSE-100	S & P500 causes FTSE-100	5.5E-73	Rejection of H_0: Existence of causality
Cac-40	S & P500 causes Cac-40	1.4E-42	
Dox-30	S & P500 causes Dox-30	1.0E-50	

Appendix 4:   The Dynamic Conditional Correlation Estimation

Graph 1. Dynamic conditional correlation of the S&P500 index with the other currencies
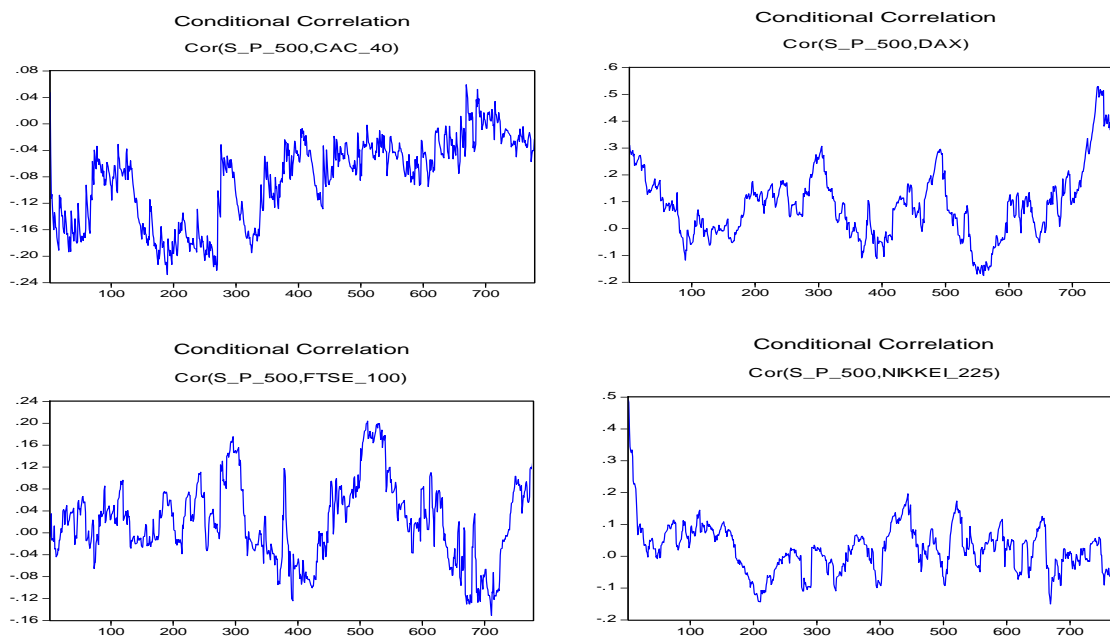
Table 1: Estimating parameters of the equation for the variance

country	c_i	a_i	b_i	Volatility persistence (a_i+b_i)
United States	1.21E-06 (3.682613)	0.079993 (5.892060)	0.917494 (65.66625)	0.997487
Britain	1.63E-06 (2.595816)	0.123309 (6.564087)	0.877137 (51.78348)	0.999999
Germany	3.50E-06 (3.347012)	0.127015 (0.488420)	0.864812 (38.83362)	0.991827
France	2.79E-06 (2.994992)	0.123703 (6.337362)	0.871882 (41.45724)	0.995585
Japan	4.19E-06 (2.687460)	0.122496 (6.326670)	0.867562 (38.92844)	0.990058

Table 2: Estimated model parameters DCC - MVGRACH (1.1)

Parameters	Valued	$T_{student}$	Persistence $(\alpha_{DCC} + \beta_{DCC})$
α_{DCC}	0.109698	4.801996	0.981755
β_{DCC}	0.872057	32.35467	