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# Correlation of International Stock Markets Before and During the Subprime Crisis

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*The recent financial crisis has spread to markets worldwide. The correlation of evolutions registered by international capital markets is one of the effects of globalization. The speed at which problems on the American financial markets extended globally, starting with 2007, has reminded that financial markets have the tendency to go through crisis periods simultaneously. The present paper proposes to analyze the correlation between international capital markets. To this end, we have considered it appropriate to run an econometric test to indicate whether connections between world capital markets are stronger during times of growth or during periods of crisis. Economic and financial integration has been shown to quickly spread negative effects as well, not just positive ones.*

Key words: *stock markets, subprime crisis, contagion, correlation, volatility*

JEL Classification: *F36, G01, G15*

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## 1. Introduction

Crises expand rapidly from one market to another and stock markets are impacted in very brief periods of time. History has shown that, as a general rule, financial markets tend to go through crises simultaneously.

As capital market connections intensified, their trends have become more and more correlated and, in general, the world's large stock markets post similar evolutions. Thus, during the growth stage of the economic cycle, stock markets register positive evolutions, but as a crisis occurs, their falls become strongly correlated as well.

The strengthening of interdependencies of international stock markets has brought major benefits to investors worldwide, who have the possibility of lowering their risks by diversifying their portfolios. Tight connections between markets have also lowered trading costs.

Stock market crashes are probably the biggest risk investors take, because in such situations, the performance of stock can be easily and quickly shattered by the market's general trend even if there are no reasons for the price of the respective stock to drop. Risk has the biggest say in such cases because investors follow the market trend and sell-off massively instead of taking the time to evaluate the opportunity of maintaining their portfolios. Market sentiment can thus become more important than economic fundamentals that should be at the base of investment and price setting decisions.

Financial crises are characterized by the sudden and simultaneous materialization of risks that, during normal times, seemed independent. As a result, risk lowering opportunities are considerably reduced just when the need for them is greater, which causes significant threats to the global financial system.

The first clues that signaled the recent financial crisis emerged in the summer of 2007 when two hedging funds managed by investment bank Bear Stearns entered difficulty. The funds had invested in instruments based on high risk mortgage loans. That was the

beginning. Gradually, the crisis spread internationally and the fall of the financial sector stirred chaos across the entire economy. The situation of financial markets worsened starting September 2008, with the bankruptcy of American investment bank Lehman Brothers. Financial market confidence dropped considerably and risk premiums rose to extremely high levels.

Even if at the beginning of the economic crisis there was the perception that developed economies in Europe would avoid recession, the financial systems of those respective countries were affected worse than expected and authorities were slow to react. European financial markets entered blockage in the last part of 2008, fueled by fears of the banking system's exposure to the problems in the USA and the delay in adopting measures to support financial institutions. The financial crisis spread rapidly to the real economy, as lending to companies and households dropped.

After an initial recovery period, the crisis reached emerging countries. In the last quarter of 2008, many emerging economies faced problems with their local currencies and stock markets. Currency exchange rates were under pressure in all regions, causing a combination between currency depreciation and lowering of foreign reserves.

The IMF noted in spring 2009 in its World Economy Outlook report that the level of pressure brought about by the international financial crisis on emerging markets reached the peaks touched during the Asian crisis of 1997-1998. Significant withdrawals from emerging capital markets suggested that investors from developed countries started leaving emerging markets from the third quarter of 2008. The IMF warned that in developed economies too the current crisis was more severe than any similar event that occurred after 1980 and all segments of financial systems, in all regions, were affected. Emerging countries that had tight financial ties with developed countries were considerably affected by the crisis too. The year 2009 was marked by a downfall of stock markets, followed by a spectacular recovery.

The fact that financial markets tend to go through crisis periods at the same time is underscored by the international impact of the 1987 crisis, by how the fall of Asian markets at the end of the last century influenced the evolution of stock markets worldwide or by how the recent subprime crisis in the USA was reflected on international capital markets.

## 2. Literature review

According to the literature in the field, financial crises tend to strengthen correlations between markets instead of weakening them.

The 1987 crisis, which affected developed countries and countries in Latin America, was caused by the crash of the American stock exchange and spread to several markets. Bennett and Kelleher (1988) have shown that, during times of high volatility, markets were more tightly correlated. Also, they have underscored the fact that cross-market volatility was high above average during the financial crisis of October 1987.

Lin and Ito (1994) find that contemporaneous correlations of stock returns across U.S. and Japanese stock markets are significant and tend to increase during a high volatility period. They have shown that, during the 1987 crisis, there was increased correlation of gains measured every hour between the S&P 500 and the Nikkei 225 indexes.

The stock market crash at the end October 1997, whose epicenter was in Asia, also became a global phenomenon, spreading even to countries in Central and Eastern Europe, in a domino effect.

Forbes and Rigobon (2002) have shown that, during the Asian crisis of 1997 and the crash of the capital market in the USA in 1987, there was only interdependency and not contagion between markets, where contagion is defined as significant change in cross-market linkages during

times of turbulence.

One of the tendencies noted about financial crises is that they tend to become shorter and, at the same time, more intense. Most of the time, stock prices recover in about three years, during which time they still register declines, though not very severe ones. Emerging markets generally register bigger price declines and longer recovery periods than developed markets. Before the crisis, stock prices tend to grow and the amplitude of growth registered on emerging markets is higher. Another tendency is that, for brief periods, correlations of stock on different capital markets register high values, while throughout longer periods of time, they tend to decrease (Horobet, 2005).

If during normal times stock markets correlate moderately, relations between them intensify when sudden price drops occur (Mink and Mierau, 2009). This is largely due to the occurrence of the phenomenon known as “shift contagion,” defined as significant change in cross-market linkages after a shock to an individual country or group of countries (Rigobon, 2002).

Markwat, Kole and van Dijk (2009) find that stock market contagion operates according to a domino effect, where local emerging market crashes evolve into more severe regional or even global crashes.

Although the strengthening of correlations between capital markets implies fewer possibilities to diversify risk, such as strengthening is not necessarily caused by an increase in the force with which shocks are transmitted across stock markets. Studies have shown the power of transmission of shocks does not change during times of crisis compared to intervals of normality on stock markets (Mink and Mierau, 2009).

Markets were affected during subprime crisis, especially in countries with large financial sectors such as Belgium, France, Germany, Iceland, Ireland, Holland, Switzerland, the UK and the USA. Starting mid-2007, stock market indexes in these countries dropped almost simultaneously (Mink and Mierau, 2009).

Throughout this paper, we have attempted to analyze the correlation between international capital markets and have considered it opportune to perform an econometric test to indicate whether connections between international capital markets are stronger during times of growth or during times of crisis and therefore decline.

### 3. Data and methodology

To test interdependencies of capital markets we have considered the representative indexes of stock markets in the world's main financial centers, namely that of the New York Stock Exchange (Dow Jones Industrial Average), that of the London Stock Exchange (FTSE) and that of the Tokyo Stock Exchange (Nikkei).

The analysis entails utilizing time series representing the daily values of the three stock market indexes between January 2004 and May 2011, a period we have divided into two intervals:

- January 2004 – June 2007 – before the crisis, when the global economy was in the expansion stage of the economic cycle
- July 2007 – May 2011 – when the global financial system and the world economy went through difficult times marked by the advent of the financial crisis in the United States, its expansion worldwide, the global recession and the time of economic recovery.

The data has been modeled using multiple regressions, thus for each interval, each of the three indexes has been expressed in relation to the other two, as in the equations below:

$$dl\_dow = a \times dl\_ftse + b \times dl\_nikkei + \varepsilon_1$$

$$dl\_ftse = c \times dl\_dow + d \times dl\_nikkei + \varepsilon_2$$

$$dl\_nikkei = e \times dl\_dow + f \times dl\_ftse + \varepsilon_3$$

where:  $dl\_dow$ ,  $dl\_ftse$  and  $dl\_nikkei$  represent the stationned time series of the three stock market indexes,  $a$ ,  $b$ ,  $c$ ,  $d$ ,  $e$ ,  $f$  are the

coefficients associated to each of the exogenous variables, and  $\varepsilon_1$ ,  $\varepsilon_2$  and  $\varepsilon_3$  are the associated errors of the three regressions.

The purpose of modeling is to estimate the coefficients associated to stock market indexes playing the role of exogenous variables to determine their influence on stock market indexes playing the role of endogenous variables.

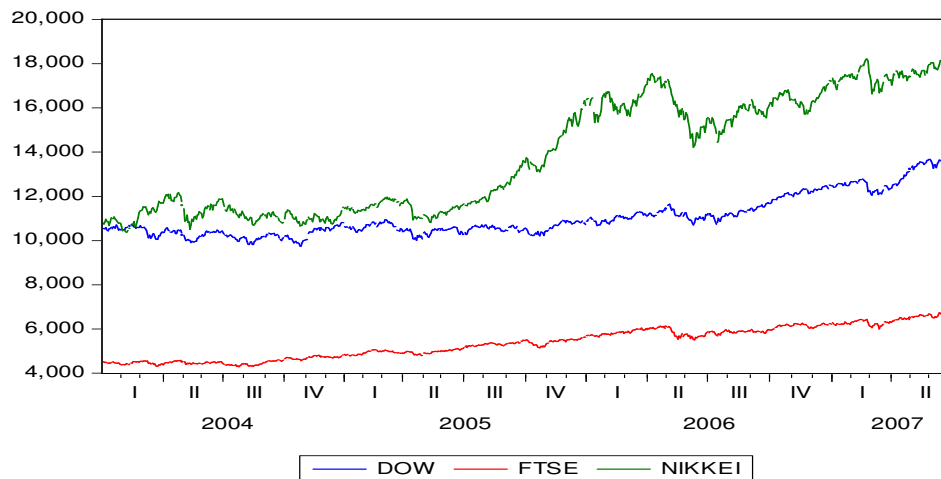
We have considered the two intervals to test whether relations between international stock markets were stronger during the financial-economic crisis that broke out mid- 2007 or during the normal period before the crisis.

#### **4. Results of the analysis and interpretation**

Following the graphics that represent the evolution of stock market indexes in the two intervals analyzed (Figure 1 and Figure 2), we may note the three indexes had similar trends both before and during the crisis.

Figure 1

## Evolution of stock market indexes before the crisis



Source: <http://finance.yahoo.com/>

For the interval January 2004 – June 2007, the estimated coefficients for exogenous variables are found in the equations below:

$$dl\_dow = 0.356639 \times dl\_ftse + 0.143082 \times dl\_nikkei$$

$$dl\_ftse = 0.462944 \times dl\_dow + 0.087534 \times dl\_nikkei$$

$$dl\_nikkei = 0.417337 \times dl\_dow + 0.196688 \times dl\_ftse$$

Out of the three regressions, we deduce the following:

➤ upon the change of the FTSE index by one percentage point, the Dow Jones changed in the same direction by 0.35 points, and a one percentage point in the Nikkei moved the Dow Jones index by 0.14 points, in the same direction;

➤ a change of one percentage point in the Dow Jones imposed, in the interval before the crisis, a change in the same direction, by 0.46 points, on the FTSE, and a change of one

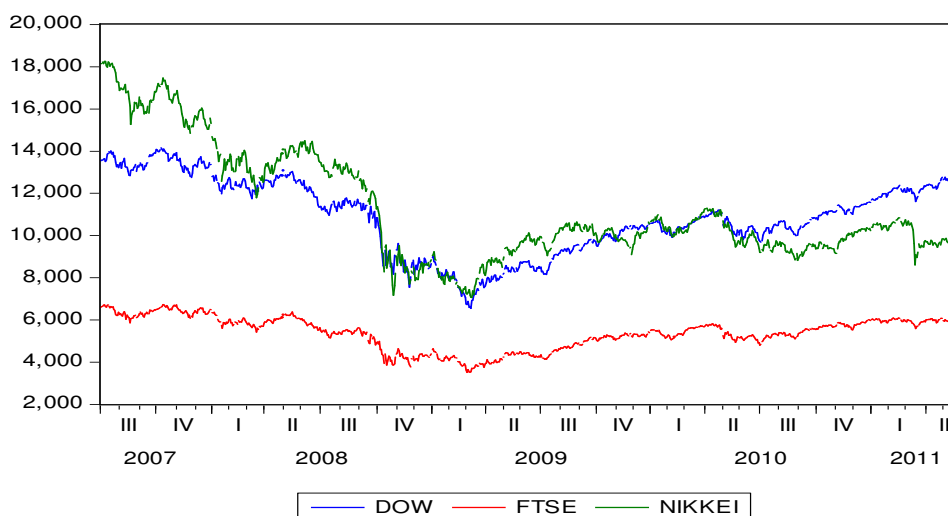


percentage point in the Nikkei determined a 0.08-point change, in the same directions, of the FTSE;

➤ a change of one percentage point in the Dow Jones determined a 0.41-point change, in the same direction, of the Nikkei, while a change of one percentage point in the FTSE determined a 0.19 point change, in the same direction, of the Nikkei.

Figure 2

### Evolution of stock market indexes during the crisis



Source: <http://finance.yahoo.com/>

For the interval July 2007 – May 2011, the estimated coefficients for exogenous variables are found in the equations below:

$$dl\_dow = 0.618712 \times dl\_ftse - 0.071619 \times dl\_nikkei$$

$$dl\_ftse = 0.529078 \times dl\_dow + 0.310067 \times dl\_nikkei$$

$$dl\_nikkei = 0.644158 \times dl\_ftse - 0.127232 \times dl\_dow$$

The interpretation of these coefficients suggests that:

➤ a change of one percentage point in the FTSE determined a 0.61-point change, in the same direction, of the Dow Jones, and the change of one percentage point in the Nikkei determined a 0.07point change, in the opposite direction, of the Dow Jones;

➤ a change of one percentage point in the Dow Jones determined, during the crisis, a 0.52 - point change, in the same direction, of the FTSE, and the same change in the Nikkei led to a 0.31-point change, in the same direction, of the FTSE;

➤ with the rise (respectively, the decline) by one percentage point of the Dow Jones, the Nikkei has declined (respectively, has risen) by 0.12 points, while on the change by one percentage point of the FTSE, the Nikkei moved in the same direction by 0.64 points.

## 5. Conclusions

The research has shown the relations between the three indexes analyzed have been stronger during the financial crisis that broke out mid-2007 than before the crisis.

If, before the crisis, the Dow Jones index changed by 0.35 points in the same direction at the one-point change of the FTSE, during the crisis, the change of the American index had reached 0.61 points at the same change of the London index. On the other hand, the Dow Jones was correlated negatively with the Nikkei during the crisis, and the Japanese index had a lower influence on the American index than before the crisis. The negative correlation between the two indexes could be explained by the fact that, with the advent of the crisis in the United States, investors started closing positions on the American market and invest their money in stock traded on the Tokyo Stock Exchange.

The FTSE index was influenced more during the crisis both by the Dow Jones and the Nikkei. If, before the crisis, the London index changed by 0.46 points at the one-point change of the Dow Jones, during the crisis, the influence reached 0.52 points and the relation between the two indexes remained positive. On the other hand, the influence of the Nikkei on FTSE increased considerably. Before the crisis, the FTSE increased by 0.08 points as the Nikkei grew by one point, and during the crisis, it changed by 0.31 points along with the same change in the Japanese index.

Before the crisis, the Dow Jones showed a direct and significant influence on the Nikkei, therefore at the one-point change of the American index, the Japanese index increased by 0.41 points. During the crisis, however, the relation between the two indexes reversed, so, in general, when the Dow increased one percentage point, the Nikkei dropped by 0.12 points. On the other hand, the relation between the FTSE and the Nikkei remained positive during the turbulence on financial markets and even intensified. Before the crisis, a one percentage point increase in the London index triggered a 0.19-point increase in the Japanese index, and during the crisis, the same change in the FTSE triggered a change of 0.64 points in the Asian index.

The fact that values registered by correlation coefficients were bigger (closer to 1) for the interval during the crisis than for the interval representing the time before the crisis also shows the relations between the three indexes were stronger during the crisis than before it occurred. The correlation coefficients for the Dow Jones, the FTSE and the Nikkei are shown in the table below.

Table 1

## Correlation coefficients associated to regression equations

Endogenous variable	January 2004 – June 2007	July 2007 – May 2011
Dow Jones	0.253	0.377
FTSE	0.219	0.483
Nikkei	0.120	0.217

*Source: our own calculations using Eviews software*

Correlations are strong between the three stock market indexes during the crisis, namely on the decline, than during the growth interval before the crisis, which can be explained by the fact that investor panic at times of crisis is more intense than enthusiasm expressed during growth periods.

At times of crisis, panic determines massive sell-offs that cause stocks to fall, and the negative sentiment fuels itself as most investors rush to sell and avoid bigger losses. However, these are times when speculators appear on the scene and, wishing to buy stock at low prices, perform transactions and balance the ratio between supply and demand.

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## Appendix

Results for the estimated regressions

I.The interval January 2004 – June 2010

Table 2

**Results of the regression where the endogenous variable is the Dow Jones index, in the interval before the crisis**

Dependent Variable: DL\_DOW

Method: Least Squares

Date: 05/17/11 Time: 09:54

Sample: 1/05/2004 6/29/2007

**Included observations: 817 after adjustments**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DL_NIKKEI	0.143082	0.018598	<b>7.693316</b>	0.0000
DL_FTSE	0.356639	0.026270	<b>13.57596</b>	0.0000
R-squared	0.253504	<b>Mean dependent-</b>		0.000376
Adjusted squared	R-0.252703	<b>S.D. dependent</b>		0.007725
S.E. of regression	0.006678	<b>Akaike criterion</b>	<b>info-</b>	7.177929

Sum squared resid	0.041560	<b>Schwarz criterion</b>	-	7.167566
Log likelihood	3354.093	<b>Hannan-Quinn</b>	-	
Durbin-Watson stat	2.391728	<b>criter.</b>		7.173977

Table 3

**Results of the regression where the endogenous variable is the FTSE, before the crisis**

Dependent Variable: DL\_FTSE

Method: Least Squares

Date: 05/17/11 Time: 09:53

Sample: 1/05/2004 6/29/2007

Included observations: 817 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DL_DOW	0.462944	0.034100	13.57596	0.0000
DL_NIKKEI	0.087534	0.021663	4.040693	0.0001
R-squared	0.219263	Mean dependent var		0.000472
Adjusted R-squared	0.218425	S.D. dependent var		0.008606

squared			
S.E. of regression	0.007608	Akaike criterion	info- 6.917047
Sum squared resid	0.053948	Schwarz criterion	- 6.906684
Log likelihood	3232.261	Hannan-Quinn criter.	- 6.913095
Durbin-Watson stat	2.584753		

Table 4

**Results of the regression where the endogenous variable is  
Nikkei, before the crisis**

Dependent Variable: DL\_NIKKEI

Method: Least Squares

Date: 05/17/11 Time: 09:55

Sample: 1/05/2004 6/29/2007

Included observations: 817 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DL_DOW	0.417337	0.054247	7.693316	0.0000
DL_FTSE	0.196688	0.048677	4.040693	0.0001



R-squared	0.120127	Mean dependent-	0.000737
Adjusted squared	0.119183	var	
S.E. of regression	0.011405	S.D. dependent var	0.012152
Sum squared resid	0.121222	Akaike info-	6.107452
Log likelihood	2854.180	Schwarz criterion	6.097090
Durbin-Watson stat	2.139019	Hannan-Quinn criter.	6.103501

II. The interval July 2007- May 2011

**Table 5**

**Results of the regression where the endogenous variable is Dow, during the crisis**

Dependent Variable: DL\_DOW

Method: Least Squares

Date: 05/17/11 Time: 11:40

Sample (adjusted): 7/03/2007 5/13/2011

Included observations: 895 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DL_FTSE	0.619840	0.028632	21.64822	0.0000
DL_NIKKEI	-0.058223	0.023607	-2.466363	0.0138
R-squared	0.377012	Mean dependent var	-7.39E-05	
Adjusted R-squared	0.376314	S.D. dependent var	0.016508	
S.E. of regression	0.013037	Akaike criterion	info-5.839851	
Sum squared resid	0.151772	Schwarz criterion	-5.829132	
Log likelihood	2615.333	Hannan-Quinn criter.	-5.835755	
Durbin-Watson stat	2.790390			

Table 6

**Results of the regression where the endogenous variable is the  
FTSE, during the crisis**

Dependent Variable: DL\_FTSE

Method: Least Squares

Date: 05/17/11 Time: 11:41

Sample (adjusted): 7/03/2007 5/13/2011

Included observations: 895 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DL_DOW	0.555266	0.025649	21.64822	0.0000
DL_NIKKEI	0.281717	0.020341	13.84985	0.0000
R-squared	0.483661	Mean dependent-var		0.000119
Adjusted squared	0.483083	R-S.D. dependent var		0.017162
S.E. of regression	0.012339	Akaike criterion		5.949866
Sum squared resid	0.135961	Schwarz criterion		5.939147
Log likelihood	2664.565	Hannan-Quinn criter.		5.945770
Durbin-Watson stat	2.821600			-

Table 7

**Results of the regression where the endogenous variable is the  
Nikkei, during the crisis**

Dependent Variable: DL\_NIKKEI

Method: Least Squares

Date: 05/17/11 Time: 11:41

Sample (adjusted): 7/03/2007 5/13/2011

Included observations: 895 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DL_FTSE	0.627653	0.045318	13.84985	0.0000
DL_DOW	-0.116204	0.047116	-2.466363	0.0138
R-squared	0.217179	Mean dependent-var		0.000695
Adjusted squared	R-0.216302	S.D. dependent var		0.020805
S.E. of regression	0.018418	Akaike criterion		info-5.148781
Sum squared resid	0.302915	Schwarz criterion		-5.138062
Log likelihood	2306.080	Hannan-Quinn criter.		-5.144685

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Durbin-Watson	
stat	2.440688

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*Source of data for all tables: <http://finance.yahoo.com/>;our own calculations using Eviews software*