

Stock Markets Correlation: before and during the Crisis Analysis*

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Abstract. *The article studies the correlations between the stock markets of the greatest financial centers in the world, namely New York, London and Tokyo, in two different time intervals, namely before the global crisis that erupted in 2007 and during it, in order to determine whether the stock markets correlate more strongly during increasing or decreasing trends. The results of the analysis, carried out by means of multiple regressions, show that the links between the three stock markets were more intense during the crisis, on a decreasing trend respectively, than before the financial turmoil, when the stock indexes had an upward trend.*

Keywords: stock exchange; financial crisis; contagion.

JEL Codes: G01, G15, F30.

REL Codes: 8N, 11B.

* Ideas in this article were presented at the Symposium „The global crisis and reconstruction of economics?”, 5-6 November 2010, Faculty of Economics, Bucharest Academy of Economic Studies.

Introduction

The enhancement of the interdependences between international stock markets has brought major benefits to investors worldwide, who have the opportunity to diminish their risks by diversifying portfolios. Close links between markets have also led to lower transaction costs.

In the context of strengthening relations between markets, their trends have become increasingly correlated, so that, generally, major international stock markets register similar developments. Thus, in the expansion intervals of the economic cycle, stock markets have positive developments, but in time of crisis they are highly correlated on their decline.

Stock market crashes are probably the biggest risk assumed by investors, as in such circumstances the performances of stock can be quickly dispelled by the general market trend, even though normally there would be no reason for the price of that security to decrease. Systemic risk is the one that intervenes in such cases because investors follow the market trend and make massive sales, rather than devoting time to make assessments on whether to maintain portfolios. Investors' sense may thus be more important than economic fundamentals that should underpin investment decisions and the price formation.

Financial crises are characterized by sudden and simultaneous materialization of risks that in periods of normality seemed independent. As a result, the opportunities of risk sharing are significantly reduced just when they are needed the most, and that can cause a substantial threat to the global financial system.

If in times of normality, the stock markets are moderately correlated, the relationship between them intensify when sudden prices declines occur (Mink, Mierau, 2009).

This is largely due to the occurrence of the phenomenon of shift contagion, defined as a shift in the strenght of the transmission of shocks from a stock market in a one country to a stock market in another country (Rigobon, 2002).

Although the increased correlations between equity markets imply a possible decrease in risk sharing possibilities, it is not necessarily caused by an increased strength of the shock transmission between stock markets. Some studies have shown that the transmission power of the shocks does not change in times of crisis, compared with normal intervals on stock markets (Mink, Mierau, 2009).

The global financial crisis and its implications on stock markets

The sub-prime crisis began in mid 2007 with the outbreak of the housing market bubble in the US, which was accompanied by increased cases of default on mortgages sold in the sub-prime segment. Initially, the crisis has affected creditors, as they were faced with many cases of default, but problems have spread quickly across the entire US financial system since the credit institutions did not maintain the sub-prime loans in their portfolios, but sold them to other investors as *Collateralized Debt Obligations (CDOs)*. These securities have also been bought by investors outside the US and have been used as collateral for loans not only on US financial markets, but also in the rest of the world, so that financial problems have rapidly made their presence felt in the global financial system.

Given the fact that the money market began to prefigure the bankruptcies of leading investment banks, credit decreased, so that the real economy began to experience liquidity problems.

Basically, the crisis began with the bankruptcy of American Home Mortgage, one of the largest independent housing loan companies. Amid financial globalization, namely the multitude of relationships between investors and international financial institutions, the problems in the American markets have rapidly spread in Europe, amid the contagion phenomenon, given that European financial institutions had invested in toxic assets.

Thus, shortly after the American Home Mortgage bankruptcy, the problems at French bank BNP Paribas followed. The bank suspended three investment funds, citing problems in the US housing sector. In September, Northern Rock, the largest British mortgage bank, was near insolvency, leading to rapid migration of customers to other banks.

In March 2008, Bear Stearns, one of the big five investment banks on Wall Street, which was also near bankruptcy, was taken over by another big bank, JP Morgan Chase and the Federal Reserve and US Treasury have assured protection to economic agents that had lost from bankruptcy. However, in September 2008, another large investment bank, Lehman Brothers, was left to go bankrupt, as the US authorities considered that losses resulting from this failure would not be very large. This has led to a drastic reduction of investors' confidence in the business environment, along with the collapse of assets' prices and credit channels.

Companies Fannie Mae and Freddie Mac, which hold about half of the mortgage market (Forte and Pesce, 2009), were also nationalized in September. Subsequently, the largest insurance company in the world, American Insurance Group, was supported by the US state from public funds and nationalized, due

to the great systemic risk that its bankruptcy would have represented. However, this failed to halt panic in financial markets and improve the situation.

State take overs has been accomplished in Europe as well, Royal Bank of Scotland and Northern Rock in Britain being two important examples that were taken over by the British government. The entire euro area began to be affected by financial crisis, so that the governments of Belgium, Netherlands and Luxembourg's funds have injected about 11.2 billion euro in Fortis bank, while Dexia Bank has received an aid of 6.4 billion euros from Belgium, France and Luxembourg.

Besides saving bankrupt financial institutions, the monetary authorities have resorted to considerable reduction in key rates, supplied liquidity to a wide range of financial institutions, even to non-depository financial institutions, or have even purchased toxic assets.

All these interventions have led to a dramatic change of the role played by central banks. In past crises, they played the role of lender of last resort, in the 2008 crisis, they have assumed a new role, that of investor of last resort, through the asset acquisition programs for supporting markets and pumping liquidity in the economy (Roubini, Mihm, 2010).

The rapidity with which the problems of US financial markets have expanded internationally recalled that financial markets tend to move together through times of crisis.

Obviously, these problems were significantly transferred on the stock markets and the major stock indexes have suffered enormous losses.

In 2008, the shares offered on international markets have lost between 20% and 70% of values recorded in 2006 and 2007. In January 2009, the value of shares listed on US exchanges had fallen by 50% of the level it had in the first half of 2007. These losses have reported that the United States were in the worst economic recession in the last 75 years.

Stock markets in Europe have also experienced similar losses. The representative index of the London Stock Exchange, FTSE, fell by almost 50% in 2008, and a similar loss was recorded by the index of the Frankfurt Stock Exchange, DAX.

However, in late 2008, the Nikkei index of Tokyo Stock Exchange had lost about 55% of the value recorded in early 2007.

Methodology

For testing the interdependences between stock markets we have taken into account the representative indexes of the stock markets of the world's financial centers, namely the New York Stock Exchange (Dow Jones Industrial

Average), the London Stock Exchange (FTSE) and the Tokyo Stock Exchange (Nikkei).

The research is based on daily values of the three indexes between January 2003 and March 2010, period that I divided it into two intervals:

- *January 2003 – December 2006* – that pre-crisis period, when the global economy was in the expansion;
- *January 2007– March 2010* – the period when the global financial system has gone through crisis, with severe effects on real economy.

The collected data was modeled using multiple regressions, so that for each interval, each of the three indices was expressed related to the other two, according to 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_nikkei and dl_ftse are the time series of the three indices, a , b , c , d , e , f are coefficients associated with each of the exogenous variable, and ε_1 , ε_2 and ε_3 are the errors associated with the three regressions.

The purpose of the modeling is to estimate the coefficients associated to the indexes playing the role of exogenous variables, in order to determine their influence on the indexes representing endogenous variables.

I considered the two intervals in order to test whether the relations between international stock markets were stronger during the crisis or before the crisis.

Correlations between stock indexes

The graphs representing the evolution of the three indexes during the two intervals (Figure 1 and Figure 2) show that the stock markets had similar trends both before and during the crisis.

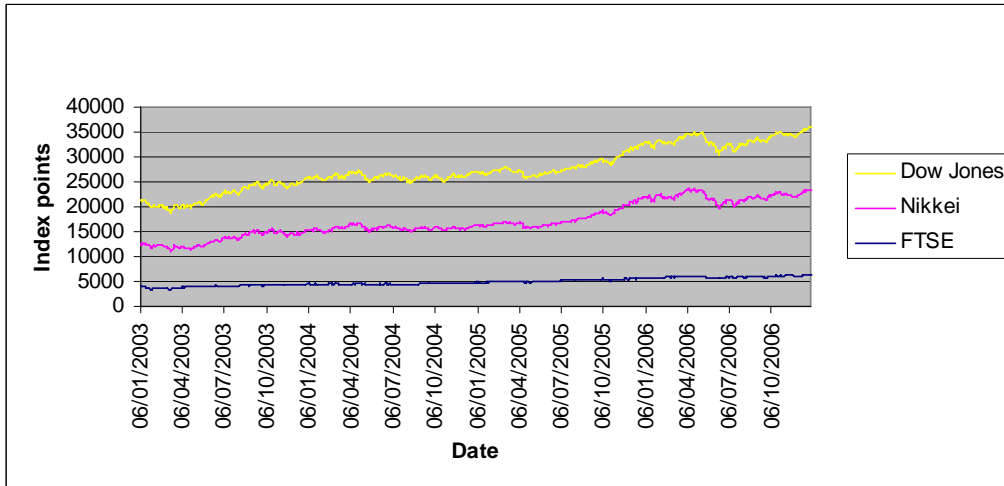


Figure 1. *Stock indexes evolution before the crisis*

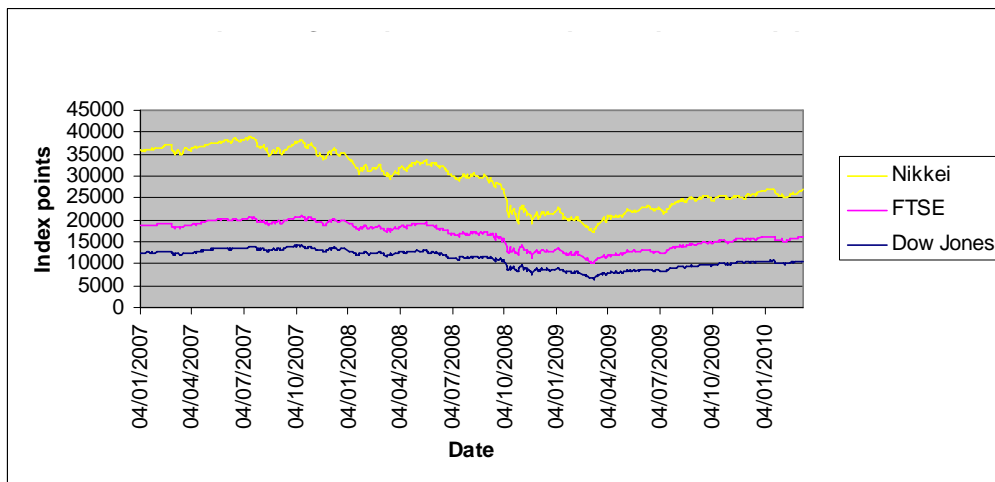


Figure 2. *Stock indexes evolution during the crisis*

By applying the regressions on data collected for the period before the crisis, I have obtained the following results:

Table 1

**Results of the regression with Dow Jones index as endogenous variable,
before the crisis**

Dependent Variable: DL_DOW				
Method: Least Squares				
Date: 10/12/10 Time: 09:54				
Sample (adjusted): 2 935				
Included observations: 934 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DL_NIKKEI	0.143082	0.018598	7.693316	0.0000
DL_FTSE	0.356639	0.026270	13.57596	0.0000
R-squared	0.253504	Mean dependent var		-0.000376
Adjusted R-squared	0.252703	S.D. dependent var		0.007725
S.E. of regression	0.006678	Akaike info criterion		-7.177929
Sum squared resid	0.041560	Schwarz criterion		-7.167566
Log likelihood	3354.093	Hannan-Quinn criter.		-7.173977
Durbin-Watson stat	2.391728			

Table 2

**Results of the regression with FTSE index as endogenous variable,
before the crisis**

Dependent Variable: DL_FTSE				
Method: Least Squares				
Date: 10/12/10 Time: 09:53				
Sample (adjusted): 2 935				
Included observations: 934 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
S.E. of regression	0.007608	Akaike info criterion		-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 3

**Results of the regression with Nikkei index as endogenous variable,
before the crisis**

Dependent Variable: DL_NIKKEI				
Method: Least Squares				
Date: 10/12/10 Time: 09:55				
Sample (adjusted): 2 935				
Included observations: 934 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 var		-0.000737
Adjusted R-squared	0.119183	S.D. dependent var		0.012152
S.E. of regression	0.011405	Akaike info criterion		-6.107452
Sum squared resid	0.121222	Schwarz criterion		-6.097090
Log likelihood	2854.180	Hannan-Quinn criter.		-6.103501
Durbin-Watson stat	2.139019			

For this period, estimated coefficients related to exogenous variables in the three regressions are:

$$dl_dow = 0,356639 \times dl_ftse + 0,143082 \times dl_nikkei$$

$$dl_ftse = 0,462944 \times dl_dow + 0,087534 \times dl_nikkei$$

$$dl_nikkei = 0,417337 \times dl_dow + 0,196688 \times dl_ftse$$

From the three regressions I have deduced the following:

- a change of 100 index points in FTSE has determined a change in the same direction, by 35.6639 points, of Dow Jones, and a change in Nikkei of 100 index points has led to a change in the same direction, of 14.3082 points, in the Dow Jones index;
- a modified 100-point Dow Jones printed a change in the same direction, by 46.2944 points of the FTSE index and a change in the Nikkei index of 100 points has conducted to a 8.7534 points move the in the same sense of the FTSE index;
- an increase of 100 points in Dow Jones index has led the change with 41.337 points in the same sense of the Nikkei index, while the amendment to the FTSE of 100 index points determined the change of Nikkei in the same direction with 19.6688 points.

For data sets during the crisis, I have obtained the following results:

Table 4

**Results of the regression with Dow Jones index as endogenous variable,
during the crisis**

Dependent Variable: DL_DOW				
Method: Least Squares				
Date: 10/12/10 Time: 09:49				
Sample (adjusted): 2 741				
Included observations: 740 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DL_FTSE	0.618712	0.032648	18.95120	0.0000
DL_NIKKEI	-0.071619	0.027492	-2.605119	0.0094
R-squared	0.359330	Mean dependent var		0.000219
Adjusted R-squared	0.358462	S.D. dependent var		0.017377
S.E. of regression	0.013918	Akaike info criterion		-5.708525
Sum squared resid	0.142965	Schwarz criterion		-5.696074
Log likelihood	2114.154	Hannan-Quinn criter.		-5.703724
Durbin-Watson stat	2.785531			

Table 5

**Results of the regression with FTSE index as endogenous variable,
during the crisis**

Dependent Variable: DL_FTSE				
Method: Least Squares				
Date: 10/12/10 Time: 09:49				
Sample (adjusted): 2 741				
Included observations: 740 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DL_DOW	0.529078	0.027918	18.95120	0.0000
DL_NIKKEI	0.310067	0.022847	13.57173	0.0000
R-squared	0.482623	Mean dependent var		0.000152
Adjusted R-squared	0.481922	S.D. dependent var		0.017882
S.E. of regression	0.012871	Akaike info criterion		-5.865028
Sum squared resid	0.122253	Schwarz criterion		-5.852577
Log likelihood	2172.060	Hannan-Quinn criter.		-5.860227
Durbin-Watson stat	2.849046			

Table 6

**Results of the regression with Nikkei index as endogenous variable,
during the crisis**

Dependent Variable: DL_NIKKEI				
Method: Least Squares				
Date: 10/12/10 Time: 09:52				
Sample (adjusted): 2 741				
Included observations: 740 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DL_DOW	-0.127232	0.048839	-2.605119	0.0094
DL_FTSE	0.644158	0.047463	13.57173	0.0000
R-squared	0.237172	Mean dependent var		0.000658
Adjusted R-squared	0.236139	S.D. dependent var		0.021226
S.E. of regression	0.018551	Akaike info criterion		-5.133873
Sum squared resid	0.253979	Schwarz criterion		-5.121422
Log likelihood	1901.533	Hannan-Quinn criter.		-5.129072
Durbin-Watson stat	2.486360			

For the crisis period, estimated coefficients related to exogenous variables in the three regressions are:

$$dl_dow = 0,618712 \times dl_ftse - 0,071619 \times dl_nikkei$$

$$dl_ftse = 0,529078 \times dl_dow + 0,310067 \times dl_nikkei$$

$$dl_nikkei = 0,644158 \times dl_ftse - 0,127232 \times dl_dow$$

From the three regressions I have deduced the following:

- at an amend of 100 points in FTSE, the Dow Jones has changed in the same direction by 61.8712 points, while a 100 points change in the Nikkei index has printed an opposite change, by 7.1619 points, to Dow Jones;
- a modified 100-point Dow Jones printed, during the crisis, a change in the same direction, with 52.9078 points on FTSE index and a change in Nikkei of 100 index points has led to the modification of FTSE, by 31.0067 points, in the same sense;
- at an increase (a decrease respectively) of 100 points in the Dow Jones index, the Nikkei index decreased (increased respectively) by 12.7232 points, while the amendment to the FTSE by 100 index points, determined a change in Nikkei, in the same direction, by 64.4158 points.

The analysis has demonstrated that the relations between the three indices were stronger during the financial crisis that erupted in mid-2007 than before it.

While before the crisis, Dow Jones changed with 35.6639 points, in the same direction, at a 100 points change in FTSE, during the crisis, the US index changed with 61.8712 points at the same change of the English index. On the other hand, Dow Jones and Nikkei were negatively correlated during the crisis, and the Japanese index had a smaller influence on the American one during the financial turmoil. The negative correlation between the two indexes might be explained by the fact that, along with the outbreak of the crisis, investors began to close positions on the US market and placed their money in securities traded on the Tokyo Stock Exchange.

I found that FTSE index was more strongly influenced during the crisis both by Dow Jones and Nikkei. While before the crisis, the London index changed with 46.2944 points at a 100 points move of the US index, during the turmoil the influence of the American index has reached 52.9078 points, and the relationship between the two indexes remained positive. On the other hand, the influence of Nikkei on FTSE has grown considerably. Before the crisis, the FTSE index rose by 8.7534 points at an advance of 100 points in Nikkei, and during the crisis it changed by 31.0067 points at the same move of the Asian index, the two remaining positively correlated.

Before the crisis, Dow Jones showed a direct significant influence on Nikkei, so that when it increased by 100 points, the Asian index increased by 41.7337 points. During the crisis, however, the relationship between the two indices became negative, so that when the Dow was rising 100 points, Nikkei was falling by 12.7232 points. However, the relationship between the FTSE and Nikkei remained positive during the turmoil, becoming even more intense. Before the crisis, an increase of 100 in the London index determined an advance of 19.6688 points of the Japanese index, and the same change of FTSE induced an advance of 64.4158 points of Nikkei.

The fact that the correlation coefficients were closer to 1 for the values recorded during the crisis than for those recorded before the turmoil also shows that the relations between the three indexes were stronger during the financial turmoil than before it. The correlation coefficients for Dow Jones, FTSE and Nikkei before the crisis were 0.25, 0.21 and 0.12 respectively, while during the crisis they were 0.35, 0.48 and 0.23 respectively.

Conclusions

Stronger correlations between the three indices during the crisis, namely during the decline period, might be explained by the fact that investors panic in

a crisis is much more intense than the feeling of excitement during growth periods.

In times of crisis, panic determines massive sales that lead to the quotations collapse, and bad feelings feed themselves on, as most investors rush to liquidate holdings in order to avoid higher losses. However, in these moments, speculators, who desire to buy at low prices, make acquisitions, so that the supply and demand are balanced.

Acknowledgements

This article is a result of the project „Doctoral Program and PhD Students in the education research and innovation triangle”. This project is co funded by European Social Fund through The Sectorial Operational Programme for Human Resources Development 2007-2013, coordinated by The Bucharest Academy of Economic Studies.

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