INTERNATIONAL EVIDENCE ON MARKET LINKAGES AFTER THE 2008 STOCK MARKET CRASH

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ABSTRACT

The 2008 crash was the most important global stock market crash in history since the Great Depression. In this paper, we study the contemporaneous co-movements of and the time-series lead/lag linkages between global stock markets after the 2008 stock market crash by using the time-varying correlation analysis, principal components analysis (PCA), and Granger-causality (G-C) statistical techniques. We find that correlation between global stock markets has increased and the benefit of global portfolio diversification has decreased since the 2008 stock market crash. The PCA technique can group global stock markets in terms of the similarities in their contemporaneous movements. Global investors can maximize the portfolio diversification benefit by investing in stock markets with high factor loadings in different principal components. Our PCA results indicate that all Asian stock markets, except the Japanese stock market, are lumped together in one principal component and the stock markets in the rest of the world are lumped together in another principal component. Our G-C test results show that the U.S. stock market has substantial influence on the European and Australasian stock markets. U.S. stock returns lead the European and Australasian stock returns (i.e., the past returns of the U.S. stock market can predict the future returns of the European and Australasian stock markets).

INTRODUCTION

Wor ld economies had a serious financial crisis in 2008. During the October 8, 2007-March 9, 2009 period, major global stock markets experienced the worst crash in history since the Great Depression. The U.S. stock market fell by about 56 percent during this period. All other major stock markets worldwide experienced similar tailspin.

The stock market crash of 2007-2009, as measured by American markets, began on October 9, 2007 when markets hit their all time highs and concluded on March 9, 2009 when markets bottomed (Wikipedia, 2011). While this financial crisis began in the USA in the fall of 2007, it spread globally within six months. Foreign governments and investors became victims of the globalization of financial markets. Global stock markets in the developed and emerging economies plummeted, reporting worse losses than experienced in decades. The resultant economic uncertainty froze credit, caused large financial institutions to collapse, and major businesses to fail. Foreign direct investment fell substantially as well. Unemployment grew significantly. Between 2007-2008, the Global Stock Market losses totaled $21trillion worldwide (Thompson, 2009).

As the markets began to improve (2009-2010), a recovery pattern emerged: developed economies were hit harder and took longer to rebound, on average, than developing and emerging markets. The S&P BMI

index for Developed Markets showed a -7.3% annualized return from 2007-2009 as compared to a +4.2% rise in stock market values for Emerging Markets during the same period. Developing and emerging markets had more conservative fiscal policies, and their financial institutions and monetary policies were less integrated with the developed financial markets. "By the time the big crisis in wealthy nations struck, emerging economies were far less vulnerable than many advanced economies. In the panicky months after the fall of Lehman past prudence was not enough to insulate countries from global recession. But once the free fall ended, the emerging world staged a strong recovery, even as advanced economies struggled" (Krugman, 2011).

Table 1 provides evidence that emerging markets rebounded faster and stronger than markets in developed economies. Comparing the October 2007-January 2009 period with the first six months of 2009, the U.S. DJIA moved from -38% to +7.4%, the British FTSE moved from -40% to +8.4 %, and the German DAX from -48% to +20%. The emerging markets improvements were more substantial during the same time period. The Indian market moved from -54% to +63%, the Indonesia market moved from -49% to +49%, and the Chinese markets moved from -67% to +46.3%.

Table 1: Percentage Changes of the Selected Stock Markets during the October 2007-January 2009 and January 2009-June 2009 Periods

Stock Markets	% Change Oct 2007 – Jan 2009	% Change Jan 2009 – Jun 2009
DJIA	-38	7.4
Malaysia	-38	19.9
S&P	-40	12.0
U.K.	-40	8.4
S. Korea	-47	29.5
Germany	-48	21.0
Indonesia	-49	49.6
France	-51	16.0
India	-54	63.0
Hong Kong	-59	43.0

This table compares the percentage changes in the global stock market indexes during the October 2007-January 2009 crash period with the January 2009-June 2010 recovery period. Source: Zaman, M.R. (2009). "The Causes and Ramifications of the 2008-2009.Meltdown of the Financial Markets on the Global Economy". (2009) Eurasian . Journal of Business and Economics, 2(4)63-76. (ONLINE) Available at: http:// www.ejbe.org/EJBE2009Vol02No04p63ZAMAN.pdf (Accessed in May 2011)

World markets followed a similar pattern in that, after the March 2009 bottom, many emerging markets rebounded quite strongly. In particular, the Australasian markets performed well. Specifically, the Indonesian market was the best performer in 2009 with a 87% gain. All sixteen Australasian markets as reported by Reuters (See Table 2) showed gains in 2009 ranging from Indonesia as the best and New Zealand the poorest performing market with a 18.9% gain.

The 2010 results were also positive for all markets but did not match the rate of return of the previous year. There was also not the same overall outperformance of the smaller nations vs. larger nations. However, the poorest performing markets were in larger countries while the best tended to be in smaller countries.

When taking a three-year perspective (2008-2010), the majority of markets had negative returns with the worst being New Zealand while the best market being Thailand with a 8% three year return. It should be noted that this 3 year analysis is somewhat skewed because it begins on January 1, 2008 while the market bottom was reached on March 9, 2009. What it does indicate is that the 2008 crash had such a devastating impact that the impressive returns of 2009 and 2010 could not overcome its impact.

Table 2: Australasian Stock Markets

Stock Markets	% Change in 2009	% Change in 2010	% Change 2008-2010
Indonesia	87.0	31.0	7.0
India	81.0	19.0	-6.0
Shanghai	80.0	2.0	-8.0
Taiwan	78.3	18.0	2.0
Singapore	64.5	18.0	0.0
Thailand	63.3	51.0	8.0
Philippines	63.0	30.0	-1.0
Hong Kong	52.0	20.0	-4.0
S. Korea	49.7	25.0	-2.0
Malaysia	44.8	33.0	3.0
Australia	30.9	10.0	-4.0
Japan	19.0	13.0	-6.0
New Zealand	18.9	3.0	-14.0

*This table compares the performance of the Australasian stock markets in 2009, in 2010, and during the 2008-2010 period that includes the 2008 crash. * Sources: 1) Vidya Ranganathan, Economic Editor, Asia Desk, Singapore. Thompson Reuters. Personal communication (January 3, 2011). 2) Reuter (2010) "Asia stock markets' 2009 performance; Sri Lanka tops:" retrieved from: http://in.Reuters.com/article/2010/01/01/markets-stocks-idINSGE60000320100101*

The objective of this paper is to study the linkages between the world's major stock markets during the October 8, 2007-July 26, 2010 period with emphasis on the post-2008 crash period. The remainder of the paper is organized as follows: The next section reviews the previous studies investigating the linkages between global stock markets. In the section that follows, we explain our data and methodology. We present our empirical findings in the section titled "Results." In the last section of the paper, we summarize our conclusions and offer our suggestions for future research.

LITERATURE REVIEW AND BACKGROUND

Studying the co-movements of global stock markets has long been a popular research topic in finance (see Joy et al., 1976, Hilliard, 1979, Maldonado and Saunders, 1981, Meric and Meric, 2011). Low correlation between national stock markets is often presented as evidence in support of the benefit of global portfolio diversification (see Levy and Sarnat, 1970, Solnik, 1974, Lessard, 1976, Watson, 1978, DeFusco et al., 1996).

High correlation and close lead/lag linkages between global stock markets imply less diversification benefit. Principal components analysis has been a popular statistical technique used in empirical studies to study the contemporaneous co-movements of global stock markets (see Philippatos et al., 1983, Meric and Meric, 1989 and 2011, Lee and Kim, 1993). Granger-causality analysis is widely used to study the time-series lead/lag linkages between global stock markets (see Ratner and Leal, 1996, Meric et al., 2002, Meric and Meric, 2011).

Although the globalization of the world's financial markets has contributed significantly to the welfare of nations, the history of global finance is also replete with many crises (see Christoffersen and Errunza, 2000). Studying eight major stock market crashes during the 1987-2001 period, Wang et al. (2009) find that the world's stock markets have experienced a major global crash approximately once every three years. Erb et al. (1995), Solnik et al. (1996), Aggarwal and Leal (1997), and Theodossiou et al. (1997) demonstrate that high volatility, which generally occurs during crisis periods, leads to high correlation between national stock markets and reduces the benefits of global portfolio diversification.

Events of global importance can have significant impact on global stock markets. Empirical studies demonstrate that the co-movement patterns of global stock markets change significantly after such events. Roll (1988), Malliaris and Urritia (1992), Arshanapalli and Doukas (1993), Lee and Kim (1993), Lau and

McInish (1993), and Meric *et al.* (2001a) study the effects of the 1987 stock market crash on the linkages between national stock markets. They find that the correlation between the word's stock markets increased and the benefits of global portfolio diversification decreased significantly after the 1987 stock market crash. By studying the effects of the 1997-1998 emerging markets crisis on the co-movements of global stock markets, Meric *et al.* (2000 and 2001b) and Yang *et al.* (2003) also find similar results.

The stock market crash of 2008 has received considerable attention in the recent finance literature. Wang et al. (2010 and 2011) study the determinants of stock returns during the 2008 crash. Meric et al. (2010a) compare the performance of exchange-traded sector index funds during the 2008 crash. Meric et al. (2010b) demonstrate that exchange-traded country index funds provided no diversification benefit to global investors during the 2008 stock market crash. The objective of this paper is to study the contemporaneous co-movements of and the time-series lead/lag linkages between national stock market indexes after the 2008 stock market crash.

DATA AND METHODOLOGY

The data of the study are drawn from the Yahoo/Finance database. The study covers all global stock markets in the database. The global stock markets included in the study and the stock market indexes used in the analysis are presented in Table 3.

Table 3: Stock Markets Included in the Study

Stock Market	Index
United States	S&P 500
Latin America	
Argentina	MerVal
Brazil	Bovespa
Mexico	IPC
Europe	
Austria	ATX
France	CAC 40
Germany	DAX
Holland	AEX
Norway	OSE All Share
Spain	Madrid General
Sweden	Stockholm General
Switzerland	Swiss Market
United Kingdom	FTSE 100
Australasia	
Australia	All Ordinaries
China	Shanghai Composite
Hong Kong	Hang Seng
India	BSE 30
Indonesia	Jakarta Composite
Israel	TA 100
Japan	Nikkei 225
South Korea	Seoul Composite
Malaysia	KLSE Composite
New Zealand	NZSE 50
Singapore	Straits Times
Taiwan	Taiwan Weighted

This table presents the list of the stock markets included in the study and the stock market indexes used in the analysis.

Stock markets in different parts of the world have different opening and closing hours. Therefore, weekly returns data are used in the analysis to study the linkages between the world's stock markets. The weekly stock market indexes are downloaded from the Yahoo/Finance database. The weekly stock returns are computed as the log difference in the indexes (Ln I_t/I_{t-1}).

Yearly rolling correlations are used to study the contemporaneous time-varying correlation between the U.S., Latin American, European, and Australasian stock markets during the October 8, 2007-July 26, 2010 period. The yearly rolling correlation coefficients are computed by starting with the first week and rolling the sample period ahead one week at a time. Specifically, the latest weekly observation is added while the earliest weekly observation is deleted. A total of 96 rolling correlation coefficients are computed for each pair of stock markets.

The Principal Component Analysis (PCA) technique is applied to the weekly index returns of the twenty-five stock markets to combine the stock markets into distinct principal components in terms of the similarities of their co-movement patterns during the October 8, 2007-July 26, 2010 period. The PCA technique is widely used in the empirical studies to study the co-movement patterns of national equity markets (see: Makridakis and Wheelwright, 1974, Philippatos *et al.*, 1983, Meric and Meric, 1989 and 2011, Lee and Kim, 1993, Lau and McInish, 1993). We examine the global portfolio diversification implications of the co-movements of the markets.

Granger (1969 and 1988) Causality is a useful statistical technique that can be used to study the lead/lag linkages between global stock markets. An independent variable X Granger-causes a change in dependent variable Y, if Y can be better forecasted with past values of both X and Y than just with past values of Y alone. The causality in the Granger sense does not imply a cause and effect relationship, but one of predictability. In empirical studies, the Granger-causality technique is often used to determine if the past index returns of a global stock market can be used to predict the future index returns of another global stock market (see, e.g., Ratner and Leal, 1996, Meric *et al.*, 2002, Meric and Meric, 2011). A detailed discussion of the Granger-causality technique can be found in Enders (1995). We use the Granger-causality technique to study the lead/lag linkages between the U.S., Latin American, European, and Australasian stock markets during the October 8, 2007-July 26, 2010 period.
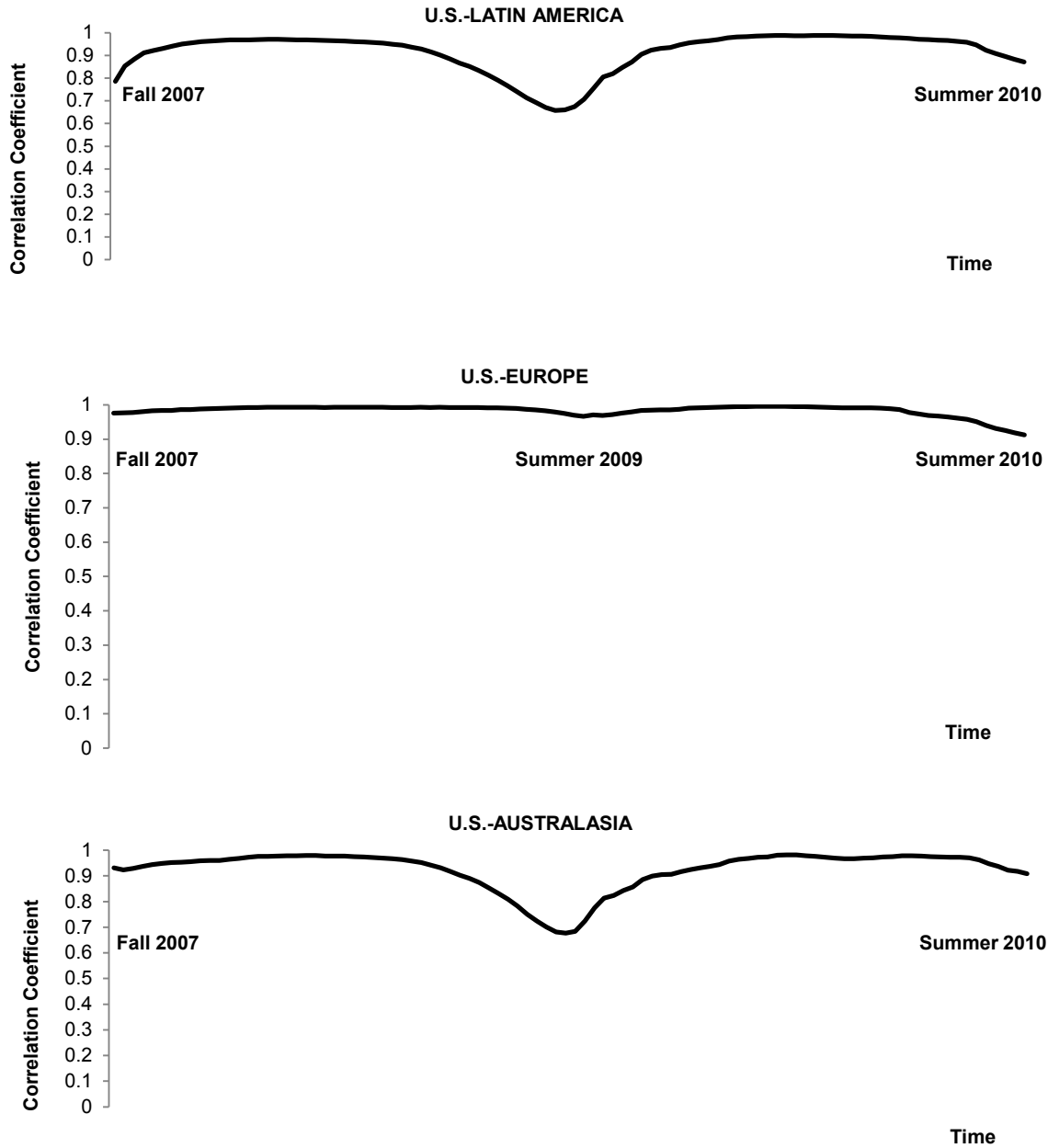
RESULTS

Time-Varying Correlations

The time varying rolling correlations of the U.S. stock market with the Latin American, European, and Australasian stock markets during the October 8, 2007-July 26, 2010 period are presented in Figure 1. The graphs indicate that there was a high correlation between the U.S. stock market and the Latin American, European, and Australasian stock markets during this period. The correlation coefficient is close to +1.0 with the European markets throughout the period. It shows some volatility with the Latin American and Australasian stock markets.

The correlation coefficient is somewhat low with the Latin American and Australasian stock markets in the fall of 2007. However, when the recessionary conditions became evident in the U.S. economy in the spring of 2008, the correlation coefficient started to climb and it remained at a very high level close to +1.0 throughout the stock market crash until the spring of 2009. When a strong bull market started in the U.S. in the spring of 2009 that continued until the fall of 2009, the correlation between the U.S. stock market and the Latin American and Australasian stock markets began to fall and the correlation coefficient fell below +0.7. The correlation with the European stock markets also fell somewhat during this period. However, it was still well above +0.9.

There was very high, close to +1.0, U.S. correlation with all three other stock markets during the fall of 2009 and the spring of 2010. However, correlation with all three markets fell noticeably in the summer of 2010 reaching +0.9 with the European and Australasian stock markets and slightly below +0.9 with the Latin American stock markets.

These results indicate that the U.S. stock market has been highly positively correlated with the stock markets in the other parts of the world and the global portfolio diversification opportunities have been limited for U.S. investors during the October 8, 2007-July 26, 2010 period.

Figure 1: The Rolling Correlation of the U.S. Stock Market with the Latin American, European, and Australasian stock Markets.

In this figure, the first graph shows the time-varying correlation between the U.S. and Latin American stock markets, the second   graph shows the time-varying correlation between the U.S. and European stock markets, and the third graph shows the   time-varying correlation between the U.S. and Australasian stock markets during the October 8, 2007-July 26, 2010 period.

Principal Components Analysis

The weekly index returns of the twenty-five stock markets in the sample were used as inputs in the SPSS Principal Component Analysis (PCA) program to study their contemporaneous co-movement patterns during the October 8, 2007-July 26, 2010 period. The PCA technique groups the variables (i.e., the index returns of the stock markets) into principal components in terms of the similarities of their movement patterns. The Varimax rotation was used to maximize the factor loadings of the stock markets in each principal component with similar movement patterns.   Using Kaiser's decision rule, statistically significant principal components with eigen values greater than one were retained for analysis (see: Mardia *et al.*, 1979, Marascuilo and Levin, 1983).

Stock markets with high factor loadings in the same principal component are highly correlated. The higher the factor loading of a stock market in a principal component, the higher is its correlation with the other stock markets with high factor loadings in the same principal component. There is less correlation between stock markets with high factor loadings in different principal components.   Therefore, to maximize global portfolio diversification benefit, investors should choose stock markets with high factor loadings in different principal components.

There are two statistically significant principal components for the October 8, 2007-July 26, 2010 period. The factor loadings of the two principal components are presented in Table 4. The cumulative variance explained by the two principal components is 74.344% (i.e., the two principal components explain 74.344% of the total variance in the original data matrix).   The first principal component explains 66.596% of the total variance. The second principal component explains 5.797% of the total variance.

Table 4: Principal Components Analysis

Stock Markets	Principal Components	
	Prin Comp #1	Prin Comp #2
U.K.	0.937	
France	0.931	
Germany	0.906	
U.S.	0.897	
Holland	0.893	
Switzerland	0.887	
Sweden	0.875	
Spain	0.873	
Austria	0.843	
Brazil	0.799	
Mexico	0.796	
Norway	0.782	
Australia	0.730	
Argentina	0.716	
Japan	0.708	
New Zealand	0.650	
Malaysia		0.772
Indonesia		0.680
Hong Kong		0.664
Taiwan		0.663
Shanghai		0.650
Singapore		0.645
Israel		0.623
South Korea		0.619
India		0.602
Eigen Value	16.649	1.449
Variance Explained	66.596%	5.797%
CumVar Explained	66.596%	74.344%

This table presents the factor loadings of the stock markets in the two statistically significant principal components during the October 8, 2007-July 26, 2010 period. Kaiser's significance rule was used in picking the two principal components for further analysis. According to this rule a principal component is statistically significant if its eigen value is greater than one.

The first principal component is dominated by the U.S., European, and Latin American stock markets. The Australian, Japanese, and New Zealand stock markets also have high factor loadings in the first principal component. All the stock markets with high factor loadings in this principal component are highly correlated and they were not good global portfolio diversification prospects for investors during the October 8, 2007-July 26, 2010 period.

Most Asian stock markets have high factor loadings in the second principal component. Investing in a portfolio consisting of these stock markets would not provide significant diversification benefit to global investors during the October 8, 2007-July 26, 2010 period. However, these stock markets were good global portfolio diversification prospects for the investors of countries with high factor loadings in the first principal component, including the U.S. investors, during this period. Similarly, the stock markets with high factor loadings in the first principal component could provide significant global portfolio diversification benefits to the investors of the stock markets with high factor loadings in the second principal component.

Linkages between the Markets

In this section of the paper, we study the lead/lag relationships between the U.S., Latin American, European, and Australasian stock markets with the Granger (1969, 1988) causality technique. The Sims (1980) test indicates that optimal lag-length is three trading weeks in the vectorautoregression model used in the analysis.

The time-series ordinary least squares regression equations used in the Granger-causality tests are as follows:

$$US_t = a_0 + a_1 US_{t-1} + a_2 US_{t-2} + a_3 US_{t-3} + a_4 LA_{t-1} + a_5 LA_{t-2} + a_6 LA_{t-3} + a_7 EU_{t-1} + a_8 EU_{t-2} + a_9 EU_{t-3}$$
$$+ a_{10} AU_{t-1} + a_{11} AU_{t-2} + a_{12} AU_{t-3} + e_t \qquad (1)$$

$$LA_t = b_0 + b_1 LA_{t-1} + b_2 LA_{t-2} + b_3 LA_{t-3} + b_4 US_{t-1} + b_5 US_{t-2} + b_6 US_{t-3} + b_7 EU_{t-1} + b_8 EU_{t-2} + b_9 EU_{t-3}$$
$$+ b_{10} AU_{t-1} + b_{11} AU_{t-2} + b_{12} AU_{t-3} + f_t \qquad (2)$$

$$EU_t = c_0 + c_1 EU_{t-1} + c_2 EU_{t-2} + c_3 EU_{t-3} + c_4 US_{t-1} + c_5 US_{t-2} + c_6 US_{t-3} + c_7 LA_{t-1} + c_8 LA_{t-2} + c_9 LA_{t-3}$$
$$+ c_{10} AU_{t-1} + c_{11} AU_{t-2} + c_{12} AU_{t-3} + v_t \qquad (3)$$

$$AU_t = d_0 + d_1 AU_{t-1} + d_2 AU_{t-2} + d_3 AU_{t-3} + d_4 US_{t-1} + d_5 US_{t-2} + d_6 US_{t-3} + d_7 LA_{t-1} + d_8 LA_{t-2} + d_9 LA_{t-3}$$
$$+ d_{10} EU_{t-1} + d_{11} EU_{t-2} + d_{12} EU_{t-3} + z_t \qquad (4)$$

where US stands for U.S. stock market index returns at year t, LA stands for Latin American stock market index returns at year t, EU stands for European stock market index returns at year t, and AU stands for Australasian stock market index returns at year t; a_0, b_0, c_0, and d_0 are the constants in the regressions; a_1 through a_{12} in the first equation, b_1 through b_{12} in the second equation, c_1 through c_{12} in the third equation, and d_1 through d_{12} in the fourth equation are the regression coefficients of the explanatory variables; e_t, f_t, v_t, and z_t are the white-noise error terms in the regressions.

The Granger-causality test results for the joint hypotheses of zero coefficients on all three lags for each stock market are presented in Table 5. In the test with the U.S. stock market as the dependent variable in Panel A of the table, the F statistics for the European and Australasian stock markets are not statistically significant. It indicates that past returns of the European and Australasian stock markets cannot be used to predict the future returns of the U.S. stock market. However, the F statistic for the Latin American stock markets is significant at the 10% level. It indicates that the past stock returns of the Latin American stock markets have somewhat strong power in predicting the future returns of the U.S. stock market.

The Latin American stock markets are the dependent variable in panel B of the table. The F statistics for the U.S., European, and Australasian stock markets are all significant at the 10% level in this test. It indicates that the past returns of the U.S., European, and Australasian stock markets all have some predictive power of the future returns of the Latin American stock markets. The p value statistics imply that the Australasian stock returns have more predictive power compared with the European and U.S. stock returns.

Table 5: Granger Causality Tests

Stock Market	F Statistic	P Value
Panel A: Dependent Variable: United States[1]		
Latin America	2.5733*	0.0568
Europe	0.9711	0.4085
Australasia	0.7050	0.5507
Panel B: Dependent Variable: Latin America[2]		
United States	2.2918*	0.0812
Europe	2.4823*	0.0638
Australasia	2.5689*	0.0571
Panel C: Dependent Variable: Europe[3]		
United States	7.1241***	0.0002
Latin America	3.3328**	0.0216
Australasia	1.1540	0.3299
Panel D: Dependent Variable: Australasia[4]		
United States	6.0014***	0.0007
Latin America	1.4554	0.2300
Europe	2.0611	0.1085

*This table presents the Granger-causality regression results. ***, **, and * indicate the significance of the F statistic for the explanatory variables at the 1, 5, and 10 percent levels, respectively. [1] Centered R^2 = 0.969 [2] Centered R^2 = 0.973 [3] Centered R^2 = 0.974 [4] Centered R^2 = 0.985*

The European stock markets are the dependent variable in Panel C. The F statistic for the Australasian stock markets is not statistically significant in this test. However, the F statistics for the U.S. stock market is significant at the 1% level and the F statistic for the Latin American stock markets is significant at the 5% level. These results indicate that the U.S. and Latin American stock returns lead the European stock markets (i.e., the past returns of the U.S. and Latin American stock markets can predict the future returns of the European stock markets).

The Australasian stock markets are the dependent variable in Panel D. The Latin American and European stock markets are not statistically significant at the conventional levels in this test. However, the F-value test statistic for the U.S. stock market indicates that U.S. stock market has a strong lead over the Australasian stock market (the past returns of the U.S. stock market can predict the future returns of the Australasian stock markets with a high degree of accuracy).

CONCLUDING COMMENTS

The 2008 crash was the most important global stock market crash in world history since the Great Depression. Previous empirical studies demonstrate that events of global importance can change the correlation patterns of global stock markets. In this paper, we study the linkages between global stock markets after the 2008 stock market crash with the time-varying correlation analysis, principal components analysis, and Granger-causality statistical techniques. Global portfolio diversification is recommended because of low correlation between global stock markets. Our time-varying correlation analysis results indicate that the correlation between global stock markets has increased and the benefit of global portfolio diversification has decreased considerably after the 2008 stock market crash.

The principal components analysis (PCA) technique can group global stock markets in terms of the similarities in their contemporaneous co-movements. Global investors can maximize the portfolio diversification benefit by investing in stock markets with high factor loadings in different principal components. Our PCA results indicate that all Asian stock markets, except the Japanese stock market, were lumped together in one principal component and the stock markets in the rest of the world were lumped together in another principal component during the October 8, 2007-July 26, 2010 period. This implies that there were relatively limited global portfolio diversification opportunities available for investors during this period. Investors could benefit from global portfolio diversification by investing in a stock market with high factor loading in the first principal component and in another stock market with a high factor loading in the second principal component.

Close lead/lag linkages between global stock markets imply limited portfolio diversification benefits to global investors. Our Granger-causality test results indicate that the U.S. stock market has substantial influence on the European and Australasian stock markets after the 2008 stock market crash. U.S. stock returns lead European and Australasian stock returns with a high level of statistical significance (i.e., the past returns of the U.S. stock market can predict the future returns of the European and Australasian stock markets with a high degree of accuracy) after the crash. There is also close lead/lag linkages between the U.S stock market and the Latin American stock markets. These results indicate that there are limited global portfolio diversification opportunities for U.S. Global investors after the 2008 global stock market crash.

This paper focuses on the contemporaneous co-movements and time-series lead/lag linkages between the world's stock markets only during the October 8, 2007-July 26, 2010 period. Future research investigating the changes in the long-term correlation and lead/lag linkage patterns of global stock markets can provide valuable information. Such a study can help determine if world financial crises are causing permanent structural breaks in the global stock market relationships.

In this paper, we use the time-varying correlation analysis, principal components analysis, and Granger-causality techniques to study the co-movements of the world's stock markets during and after the 2008 crash. An interesting field of study in finance is the long-term integration of the world's stock markets. The co-integration analysis technique is generally used for this purpose to study the co-integration of pairs of stock markets. A future study focusing on the long-term co-integration of the U.S., Latin America, European, and Australasian stock markets can provide valuable insights to investors in terms of long-term global portfolio diversification prospects.

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