

Interdependence of the Stock Markets, Pre and Post Asian Crisis and Economic Recession : How is the Sri Lankan Stock Exchange Affected ?

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Abstract

The objective of this article is to determine whether world stock markets move together or differently under conditions of current economic recession by studying the interdependence among the price indices of six countries (USA, Germany, UK, Japan, Singapore and Sri Lanka). The study covers the most recent period 1990–2010 using daily index data. We employed Vector Autoregressive (VAR) and Vector Error Correction Model (VECM) to identify co-integration and causal link between the price indices. The results imply that under the context of globalization, the stock markets are enhanced their interrelations after the recent economic recession. Especially an emerging market of Sri Lanka is affected by almost all developed markets during the post-economic recession. Possible reasons include this recent trend in Sri Lanka are having overcome some of the bottlenecks for investment in Sri Lanka; inclusive of political instability, monetary and fiscal disciplines last decades; foreigners have revert their attention to Sri Lanka's equity market. The other observed factor is increasing liquidity in Sri Lankan market after the civil conflict in the country. Meanwhile, the leading role of the US market in the world stock market is clearly visible throughout all causality tests and in all time periods.

Key Words : Market Interdependence, Granger Causality, Economic Recession, Capital markets

1 Introduction

In the last three decades, there was a civil conflict in the North-East part of Sri Lanka and this conflict disrupted the Sri Lankan economy, the tourism industry, and destroyed key infrastructure facilities. Not only that but also, it switched government revenues from social projects to military spending. Sri Lanka has become one of the world's fastest growing economies after its civil conflict against the Liberation Tamil Tigers (LTT) ended in 2009. In 2010, Sri Lanka's Gross Domestic Product (GDP) grew by 8 percent after 3.5 percent in 2009. The country's property prices have increased. Further, improvements in peaceful environment, the favorable political atmosphere, and infrastructure projects like ports, highways, and airports are all leading to a gradual return of foreign investment. Continued benefits from the end of the long-running civil conflict in 2009, such

as improved business and tourist confidence plus more land available to agriculture, as well as the global return to growth, under-pinned the strong performance. The overall optimism was reflected in the stock market's doubling. According to the Colombo Stock Exchange (CSE) Annual Report in 2010, the CSE performed as the second best stock exchange in the world.

"The equity market reached unprecedented levels in year 2010, surpassing all records set in the post-war period starting May 2009. The CSE retained its position as the second best performing stock exchange in the world as ranked by Bloomberg News and was also ranked the top performing broad equity market index from among members of the World Federation of Exchanges (WFE)".

(Colombo Stock Exchange, Annual Report 2010: P 17)

Table 1 gives the overall picture of the CSE during the sample period from 1990 to 2010. It summarizes the trend in the Market Capitalization, Number of trades of the equity, annual turnover of the equity, and All Share Index (ASI).

In 2010, the CSE has reported 2210.5 billion Rupees the highest market capitalization which corresponds to approximately 39.5 percent of the GDP of the country. During the period of 1994 to 2010, the market capitalization as a percentage of GDP was range from 7 percent to 39.5 percent. Across this period, there could not be seen any significant pattern among the market capitalization. After the year of 2000, market capitalization was increased considerably.

Since 2001, the ASI continued to be increase except two years. Before the 21st century, ASI recorded mixed performance and in 2010, it reached to the highest level which is corresponds 6,635.90 points. The Colombo stock market was completely liberalized for foreign investors in 1990. Foreign institutions and individuals are permitted to buy and sell shares in a listed company up to 100 percent of the issued capital except in the case of a few companies. In terms of turnover, 60 percent represent by domestic and 40 percent represent by foreign shareholders in 1991. In 2009 domestic turnover was about 70 percent and foreign turnover was 30 percent in the CSE. During the sample period, on average, domestic investors owned 67 percent of the market turnover, while foreign investors' ownership was 33 percent of the market turnover. Foreign turnover peaked at 55 percent in 1996 and bottomed at 18 percent in 2004. Thus, although Sri Lanka is a relatively smaller stock market, foreign investors have played a significant role in terms of turnover in the CSE during the sample period.

The recent fast development in the Sri Lankan economy in more than three decades as the end of a 26-year civil conflict in May 2009 boosted consumer demand, foreign investment and also continue to grow tourism industry. The social indicators, apart from the northeast zone, remain the best in the region, and the country strategic location is inviting investments from both Asian giants, China and India. The Colombo stock market is booming, and tourists are back to enjoy sun, sand, sea, and the island's natural beauty. These recent sound economic development and in-

Table 1 Performance of the Colombo Stock Exchange from 1990–2010

Year	*M. C. (Rs Bn)	Equity Trades (No)	Equity Annual Turnover (Rs Mn)	Domestic (Rs Mn)	Foreign (Rs Mn)	ASI
1990	36.9	48,332	1,563	N A	N A	384.4
1991	81.0	91,571	5,542	3,383	2,159	837.9
1992	66.2	109,930	6,159	4,687	1,472	605.3
1993	124.1	232,337	22,124	14,449	7,675	979.0
1994	143.7	404,367	34,505	20,699	13,806	986.7
1995	106.9	186,274	11,249	5,815	5,434	663.7
1996	104.2	98,130	7,395	3,347	4,048	603.0
1997	129.4	206,109	18,258	10,398	7,860	702.2
1998	116.6	327,380	17,912	11,525	6,387	597.3
1999	112.8	203,298	14,292	8,870	5,422	572.5
2000	88.8	158,576	10,624	7,497	3,128	447.6
2001	124.0	158,627	13,905	11,281	2,624	621.3
2002	162.6	280,681	30,183	23,926	6,256	815.1
2003	262.8	481,269	73,837	59,818	13,839	1,062.1
2004	382.1	645,083	59,052	48,327	10,724	1,506.9
2005	584.0	1,100,451	114,599	89,959	24,640	1,922.2
2006	834.8	952,382	105,154	70,675	34,479	2,722.4
2007	820.7	876,928	104,985	63,616	41,170	2,541.00
2008	488.8	776,244	110,454	50,797	59,657	1,503.00
2009	1092.1	1,266,299	142,463	99,011	43,452	3,385.60
2010	2210.5	3,355,126	570,327	464,733.6	105,593.2	6,635.90

*M C = Market Capitalization

Source : Annual Reports of the Colombo Stock Exchange, The CSE database in 2010

creased foreign investment in the country is the main reason for an empirical investigation of the interdependence of the stock exchanges. The other motivation of this study is to change the coverage of the stock markets and sample period. Thus, employing the latest data and a new approach will be the major contribution to the literature on the interdependence of the stock exchanges. And also, the study is to measure the week day and week end effect will be a new phase to the literature.

Following this introductory section, Section 2 discusses the recent empirical studies in relation to the stock market interdependence. Section 3 explains data, and methodology which is applied for the study. Section 4 presents the empirical results on the long-run and short-run structure of interdependence. Section 5 closes with brief concluding remarks.

2 Literature Review

In the era of increasing globalization, interdependence among the stock exchanges has been widely examined. Early studies have pointed out that the degree of interdependence of share price movements among the market is an insignificant and the major determinants are the domestic factors rather than international. In recent years, the capital inflow and outflow are almost free among the countries. At the same time, transmission of information has become faster than before due to the wider range of technological advancement and internet applications. As a result, higher price movements in the stock markets are experiencing and exhibit a substantial degree of interdependence among stock markets. Eun and Shim (1989) indicated the presence of interdependence among the main stock exchanges of USA, UK, Canada, Germany, France, Australia, Japan, Switzerland and Hong Kong. They employed VAR to the daily closing price data for the period 1980–1985. They pointed out that innovations in the US market were rapidly transmitted to the other markets. However, they did not find evidence that the foreign market can explained the price movements in the US market.

Bracker et al. (1999) examined the stock market co-movements between 9 stock markets over 22 years, and showed that bilateral import dependence, market size, and geographic distance were the important factors. Chung and Ng (1991) found that information of the US market has affected significantly to the return of Tokyo stock exchange on the next day, but they did not find influence from the Tokyo to US market.

Kwan et al. (1995) investigated long-run relationship using co-integration analysis between Australia, Hong Kong, Japan, Singapore, South Korea, Taiwan, UK, USA, and Germany for the period from 1982–1991. They used monthly data and found that these markets were not weak form efficient.

Malliaris and Urrutia (1992) focused on interrelationships between stock markets under condition of the October financial crisis. They employed Granger Causality test to examine the direction of causality. They used daily data for the stock markets of USA, UK, Australia, Hong-Kong, Japan and Singapore for the period May 1987 to March 1988. They did not find interdependence before or after the crisis. Specially, they concluded that the USA was no more the world dominant market.

Cheung and Mak (1992) used weekly data for national stock market indices to examine financial integration, for the period January 1978 to June 1988. They concluded that the US market appeared to exert dominant influence to the most of the Asian pacific stock markets. Further they showed that the Japanese market is found to have a less important influence on the Asian – Pacific emerging markets. Roca (1999) investigated short and long-term price linkages between Asian equity markets over the period December 1974 to December 1995. The results did not find any indication of co-integration between the stock markets.

Kanas (1998) examined relationship between US and major six stock exchanges in Europe for

the period January 1983 to 1996. The study used monthly time series data and found that there was no co-integration among the indices. Glezakos et al. (2007) investigated the interdependence between major world financial markets from 2000–2006. In the analysis, they paid their special attention to the Athens stock exchange. Their sample was included 10 countries; the strongest financial market USA, the leader in the Asian region Japan, the strongest markets in the Europe (UK, Germany, and France), Italy, Spain, Holland, Belgium, and Greece. They employed VAR methodology to test short and long-run relationship between stock exchanges. The results showed that the USA market is the dominance market in the world, while influence of the Germany and UK also substantial on all other markets of the sample. Furthermore, they confirmed that Greek capital market is Granger caused by the markets of Germany, Belgium, USA and Italy.

Worthington et al. (2003) studied price linkages between nine Asian stock markets for the period 1988–2000. Total sample period was divided into three sub periods based on Tai currency crisis. They found evidence of price linkages between the equity markets before and after the Tai currency crisis. Further, they concluded that the most influential market in the pre crisis period became less influential in the post-crisis period.

Gklezakou and Mylonakis (2009) studied interdependence between the developing stock markets of the South Eastern Europe, for the period 2000–2009 before and during the current economic crisis. They employed Granger causality test to analyze the daily closing price data for the seven countries. Their finding indicate that the interdependence of the stock exchanges were strong during the current economic crisis. Further, they found that the developed stock markets are influenced to the developing markets at the greater extent. Furthermore, they identified that the Athens stock exchange plays an important role in the sample, since it affects most of the emerging stock markets. Gklezakou and Mylonakis (2010) examined the interdependence among ten markets using daily closing price data from 2000 to 2009. The sample includes the USA, Belgium, France, Germany, Greece, Italy, the Netherlands, Spain, the United Kingdom and Japan. The empirical findings indicated that the recent economic recession leads to enhance their correlation, and tightened their existing relations. Moreover, they found that while the direction of influence seems to be increased during the crisis, the leading role of the USA and Germany were confirmed.

Lu et al. (2011) examined the interdependence of stock market between India and its neighboring countries (Sri Lanka and Nepal) from 2000 to 2008. They found that there is a causality relation from India to Sri Lanka under the increasing of liquidity in the Colombo stock market in recent years. Elyasiani et al. (1998) examines the interdependence and dynamic relation between the emerging market of Sri Lanka and its major trading partners. They employed VAR technique for daily data from 1 January 1989 to 10 June 1994. The sample was consisted the following countries; USA, Japan, India, Hong Kong, South Korea, Taiwan, Singapore and Sri Lanka. They did not detect any causal relationship between Sri Lanka and its trading partners and also indi-

cated that dynamic responses to external shocks were very low. Therefore, they concluded that there was no significant interdependence between Sri Lanka and other equity markets. Further, they pointed out that possible reason for this weak relationship as small market capitalization, lack of liquidity, high concentration in blue chip companies, and investment barriers on Sri Lankan investors.

Our study differs from the other existing studies on interdependence relation between Sri Lanka and other countries in few ways. We carry out a comprehensive study with the long sample period. Therefore, the number of observation included in the study is 5400 per country. We use week day data (Monday to Thursday data for USA and Tuesday to Friday data for other countries) for the analysis. It is because of the value of correlation coefficient. As we expected the correlation coefficient of the week end (Friday data for USA and Monday data for other countries) is smaller than week day's coefficients. The other aspect is that in recent years the liquidity in the Sri Lankan market is increased substantially. Further, having overcome some of the bottlenecks for investment in Sri Lanka; inclusive of political instability, monetary and fiscal disciplines last decades; foreigners have revert their attention to Sri Lanka's equity market. These benefits are experiencing after the end of the civil conflict in Sri Lanka. The capital market started to boom and market capitalization also increased. The prevailing literature related to the financial market interdependence indicated that almost developed markets are closely related and the emerging markets are less integrated. This implies that the developed markets have fewer opportunities for portfolio diversification. In this context also, it is important to identify the interdependence of Sri Lanka with other developed markets in the world.

3 Data and Methodology

3.1 Data

The data employed in the study is composed of daily closing stock price indices over the period from January 2, 1990 to September 9, 2010 for six countries; namely USA, Germany, UK, Japan, Singapore, and Sri Lanka. These data were collected from the Datastream. The sample consists of 5398 observations per country. All stock price indices are expressed in local currencies. Table 2 shows the general stock price indices of the countries which make up the sample of this study.

The sample was chosen based on following characteristics.

- The USA is the strongest developed financial market worldwide
- England, and Germany are the strongest European markets
- The Japanese market is the leader in the Asian region
- The Singapore is a developed market in the Asian region
- Sri Lanka is an emerging market in the Asian region

The sample was divided into three sub-groups starting from 2/01/1990 to 30/6/1997, from 1/07/1997 to 31/08/2007 and from 1/09/2007 to 9/09/2010. This categorization is based on the

Table 2 Stock Exchanges and Stock Market Indices

Country	Stock Index	Symbol
Sri Lanka	All Share Index	ASI
USA	Dow Jones Composites	DJ
Germany	Deutscher Aktien Index	DAX-30
United Kingdom	Financial Times Index	FTSE-100
Japan	Nihon Keizai Shimbin Inc Index	Nikkei-225
Singapore	Straits Times Index	Straits-Time

Asian currency crisis and current economic recession. The study addresses the impact of these crises in order to study the stock markets' interdependence under different market conditions. Three sub-groups represent the pre Asian currency crisis (1990-1997), post-Asian crisis and pre-current economic recession (1997-2007), and post-economic recession (2007-2010), respectively.

3.2 Methodology

The daily returns of the indices are computed as follows.

$$R_t = \log P_t - \log P_{t-1}$$

Where R_t is the daily return at time t . P_{t-1} and P_t are daily closing prices of the indices at two successive days, $t-1$ and t , respectively. According to the framework of the present study, the following methodologies were employed to achieve the objective of the study, which is the relationship between stock markets of Sri Lanka and other major world stock markets.

3.2.1 Correlation between the Stock Indices

Returns of the daily indices are used to calculate correlation coefficient among the stock markets. The correlation matrix shows that correlation coefficients for pairs of stock price indices. It is estimated for three sub samples which are described as above ; the Asian currency crisis and current economic recession.

The trading hours among the different stock exchanges do not coincide ; therefore during the examination of the results we paid our attention to the differences among the daily operations of different stock exchanges. For example, the Tokyo stock exchange and Singapore stock exchange open before the opening of the CSE. On the other hand New York Stock Exchange (NYSE) and European markets open after the CSE. So the innovations in the Japan and Singapore markets may be passed on to the CSE within the same day. On the contrary, the shocks of the stock exchanges of USA and Europe exert influence on the CSE next day.

3.2.2 Testing for Stationary

We applied the Augmented Dickey-Fuller (ADF) Test to test the stationary of the data. It is noted that a variable is considered to be stationary when the mean and the variance of the series

do not depend on time. The ADF unit root test is widely used to test the stationary properties of the time series data. It shows whether an individual series is stationary by running OLS regression. According to the ADF test, the null hypothesis is that the series has a unit root and if the ADF t-statistic is smaller than the reported critical values, it indicates that we cannot reject the null hypothesis of non-stationary.

3.2.3 Examination of Co-integration and Causality

The correlation coefficient is a preliminary indication of the relationship between each pair of share price movements in stock exchanges, before and after the Asian currency crisis and current economic crisis. It does not basically indicate long-run or short-run relationship in any meaningful sense.

Co-integration indicates the long-term common stochastic trend between non-stationary time series data. If non-stationary series x and y are both integrated of same order and there is a linear combination of them that is stationary, they are called co-integrated series. However, co-integration does not involve high correlation; two series can be co-integrated and but they may have very low correlations. Co-integration tests allow us to determine whether stock market indices of different national markets move together over the long run, while providing for the possibility of short-run deviations.

Meanwhile, systematic investigation of causal relationship became possible after developing an analytical framework by Granger (1969) and Sims (1972). More specifically, it is pointed out that X Granger-causes Y , if X gives statistically strong information in forecasting the future values of Y . The existence of causality implies the direction of effect from one country to another. We examined pair wise Granger causality relationships; hence we used the bi-variate Granger causality test for returns of the each stock exchange in our sample. The lag length was determined based on Akaike Information Criteria (AIC) in VAR model and VECM for the six stock index price series. F-statistic is used to determine the significance of each of the indices in the test.

4 Preliminary Analysis and Empirical Results

4.1 Preliminary Analysis

During the sample period under investigation of stock market interdependence, five out of six stock markets (see Table 3) showed positive returns and especially in Japan the average return of the index indicates negative value during the sample period. The highest return came from the Sri Lankan market the lowest from Japan. During the sample period USA reported the highest volatility and UK the lowest, while the Singapore Stock Exchange indicates moderate levels of risk and return. The stock returns for Germany, UK, Japan and Singapore are skewed to the left while those for Sri Lanka and USA are skewed to the right. The negative skewness shows that large negative returns tend to occur more often than positive ones. The coefficients of kurtosis are

Table 3 Characteristics of the Stock market Indices from 1990–2010

	Sri Lanka	Germany	USA	UK	Japan	Singapore
Mean	0.00065	0.00025	0.00023	0.00015	−0.00027	0.00013
Median	0.00000	0.00033	0.00013	0.00000	0.00000	0.00000
Maximum	0.30535	0.10798	1.44940	0.09384	0.13235	0.12874
Minimum	−0.29677	−0.09871	−1.40799	−0.09265	−0.12111	−0.09216
Std. Dev.	0.01280	0.01434	0.02954	0.01131	0.01530	0.01305
Skewness	0.44630	−0.08306	1.79173	−0.08940	−0.02411	−0.04603
Kurtosis	132.95	8.09	2030.60	9.64	8.62	11.19
Jarque-Bera	3798314	5844.13	9.25E + 08	9912.735	7116.982	15080.24
Probability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

almost all larger than 3 indicating that the tails of the distribution are all fatter than those of the normal distribution. The Jarque-Bera statistic measures normality assumption and the result indicate that the sample stock returns are not normally distributed.

Tables 4, 5 and 6 show the correlation coefficients of daily returns among the six indices. The values in Tables 4, 5 and 6 indicate the correlation coefficients for the pre- and post-Asian financial crisis and after current economic recession. In general, the markets under examination points out a relatively low interdependence for the whole sample period 1990–2010. More specially, during the current economic recession the interdependence between stock Exchanges became stronger than before the recession. Table 6 indicates that the Japanese market is quite highly affected by the USA market than the others. Further, it is evident from Tables that the correlation coefficients of daily returns in Sri Lanka are immaterial in magnitude and implies that relatively low level of interdependence. Overall, the information and innovations of the other markets do not seem to have an impact on Sri Lanka before the current economic recession.

We calculated correlation coefficient based on week days and week end for the sample. As we expected, the correlation coefficients for week end data are smaller than week day's correlation coefficients. It is noteworthy that the application of week day's data for the analysis and the results are reported in Table 6. We ignored the week end correlation calculation and the results also do not report here.

However, examination of correlation coefficient does not indicate a strong basis for studies of interdependence. It considers as a preliminary technique to identify the interrelationships among the stock exchanges. Apart from the above weak point, it does not provide insight into the dynamic behavior of stock market relation and direction of the influence. The examination of the direction of the influence can be analyzed by Granger Causality test, which is used only stationary time series data.

Table 4 Correlation Coefficient of Returns of the Stock Indices from Sri Lanka to other Markets Periods between t and $t+1$

Periods	DJ	Nikkei-225	Straits-Time	DAX-30	FTSE-100
1990-2010	-0.001	0.021	0.016	0.028	0.037
1990 Jan-97 June	-0.030	0.008	-0.043	-0.006	-0.028
1997 July-2007 Aug	-0.013	0.019	0.028	-0.003	0.011
2007 Sep-2010 Sep	0.035	0.037	0.040	0.112	0.116

Table 5 Correlation Coefficient of Returns of the Stock Indices from Others to Sri Lanka markets Periods between t and $t-1$

Stock Exchange	1990-97 June	1997 July-2007 Aug	2007 Sep-2010 Sep	1990-2010
USA	0.015	0.052	0.289	0.057
Japan	-0.049	0.042	0.080	0.028
Singapore	-0.028	0.079	0.089	0.059
Germany	-0.006	0.034	0.077	0.043
UK	-0.029	0.032	0.069	0.041

Table 6 Correlation Coefficient of Returns of the Stock Indices from USA to other markets Period between t and $t-1$

	ASI	Nikkei-225	Straits-Time	DAX-30	FTSE-100
1990-2010	0.068	0.432	0.394	-0.003	0.388
1990-97 June	0.004	0.268	0.384	0.423	0.326
1997 July-2007 Aug	0.057	0.382	0.371	0.287	0.352
2007 Sep-2010 Sep	0.123	0.640	0.456	0.037	0.465

4.2 Empirical Results

ADF test is applied to the data to identify stationary properties of the indices. To test for this property, the ADF test is conducted on the level and first-differenced stock index series for the whole sample period as well as sub sample periods. The lag order for the ADF test was automatically selected by Schwarz Information Criterion (SIC). The results of the tests conducted on the stock indices levels and first-differences are summarized in Tables 7, and 8 (See Figure 1 and 2 also). The ADF test statistics indicated that for each series in level there is no sufficient evidence to reject the null hypothesis of unit root at 1 percent level. The first-differenced series reject the null hypothesis of unit root, indicating that they are stationary for all periods. Consequently, all five series are integrated I(1). All series are strongly mean reverting in their first difference.

In the following section, we employed Johansen co-integration analysis followed by error cor-

Table 7 Results of the ADF Test on the Levels and First Differences of the Price Indices

Index	1990 Jan-2010 Sep				1990 Jan-1997 June			
	Prob. (Level)	Conclusion	Prob.	Conclusion	Prob. (Level)	Conclusion	Prob.	Conclusion
ASI	1.0000	U. R.	0.0000	Not U. R.	0.6530	U. R.	0.0000	Not U. R.
DAX-30	0.6121	U. R	0.0000	Not U. R.	0.9980	U. R	0.0000	Not U. R
DJ	0.6537	U. R	0.0000	Not U. R	0.9651	U. R	0.0000	Not U. R
FTSE-100	0.4648	U. R	0.0000	Not U. R	0.4337	U. R	0.0000	Not U. R
Nikkei-225	0.0634	U. R	0.0000	Not U. R	0.0621	U. R	0.0000	Not U. R
Straits Time	0.5866	U. R	0.0000	Not U. R	0.7356	U. R	0.0000	Not U. R

Notes : Hypotheses H 0 : unit root (U. R), H 1 : no unit root (stationary- Not U. R) at 1% significance level. The lag order for the ADF test was automatically selected by SIC.

Table 8 Results of the ADF Test on the Levels and First Differences of the Price Indices

Index	1997 July-2007 Aug				2007 Sep-2010 Sep			
	Prob. (Level)	Conclusion	Prob.	Conclusion	Prob. (Level)	Conclusion	Prob.	Conclusion
ASI	0.5809	U. R.	0.0000	Not U. R.	1.0000	U. R.	0.0000	Not U. R.
DAX-30	0.9400	U. R	0.0000	Not U. R	0.8739	U. R	0.0000	Not U. R
DJ	0.7931	U. R	0.0000	Not U. R	0.7668	U. R	0.0000	Not U. R
FTSE-100	0.8354	U. R	0.0000	Not U. R	0.8047	U. R	0.0000	Not U. R
Nikkei-225	0.7336	U. R	0.0000	Not U. R	0.6648	U. R	0.0000	Not U. R
Straits Time	0.8663	U. R	0.0000	Not U. R	0.9513	U. R	0.0000	Not U. R

Notes : Hypotheses H 0 : unit root (U. R), H 1 : no unit root (stationary- Not U. R) at 1% significance level. The lag order for the ADF test was automatically selected by SIC.

rection modeling and finally, if appropriate, Granger tests for short run causality.

Since all stock indices are I(1) in level, the Johansen co-integration test is conducted. According to Johansen (1988) and Johansen and Jusellus (1990), there are two types of test for co-integrating vectors, namely (i) the trace test statistic, (ii) the maximum eigenvalue test statistic. Both tests identify several equilibrium relationships governing the joint evolution of all the variables. Using the trace statistic and the maximum eigenvalue statistic, the sequential procedure is done to find the number of co-integrating relations. Tables 9 and 10 provide the evidence from both the trace and the maximum eigenvalue test. We found co-integration relations only for the periods from 1990-1997 and from 1997-2007. From Table 9, The trace statistic and maximum eigenvalue statistic for 1990-1997, indicate that there is a one co-integration vector that is the stock price indices of six markets share long run equilibrium in the pre-Asian financial crisis period.

From Table 10, the trace statistic indicates that there are two co-integration relations at 1 percent level in between 1997-2007. The maximum eigenvalue statistic also shows that there is a one co-integration vector. Meanwhile, this result indicates that the Asian financial crisis had an

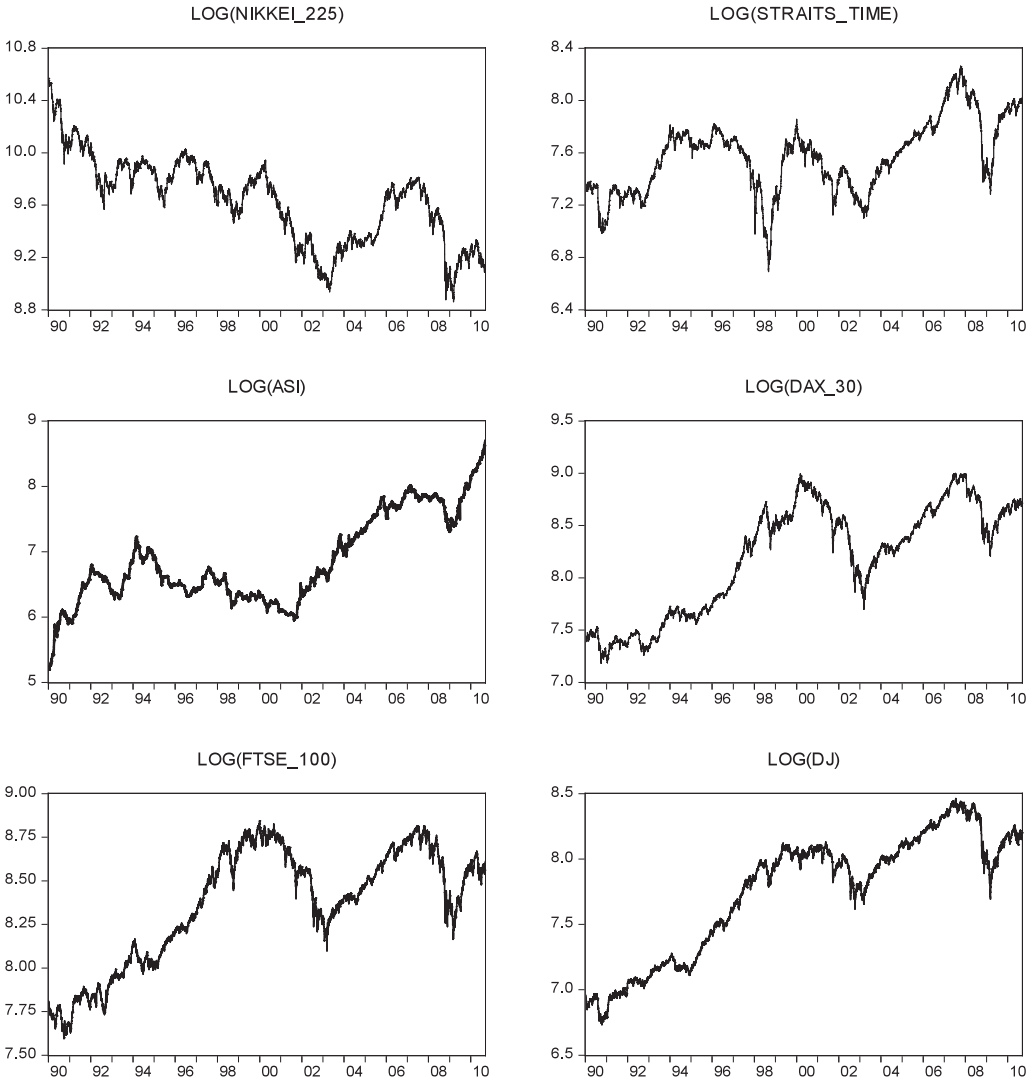


Figure 1 Stock Market Indices from 1990-2010

impact on stock market relations by increasing the number of co-integrating relations within this period. Therefore, this indicates the presence of long-run equilibrium relations between the USA, UK, Germany, Japan, Singapore and Sri Lankan stock markets. In other words, by and large all the stock indices are moving together in the long-run.

Tables 9 and 10 above show the results from the co-integration analysis in the preferred VAR-model for the different countries. We can see that the results are quite mixed. Somewhat surprisingly, there does not seem to be a co-integrating relationship between the period 1990-2010 and 2007-2010. This means we can carry on with the causality analysis in a VAR-setting using the first differences of indices; there is no information on a long-run relationship between the level vari-

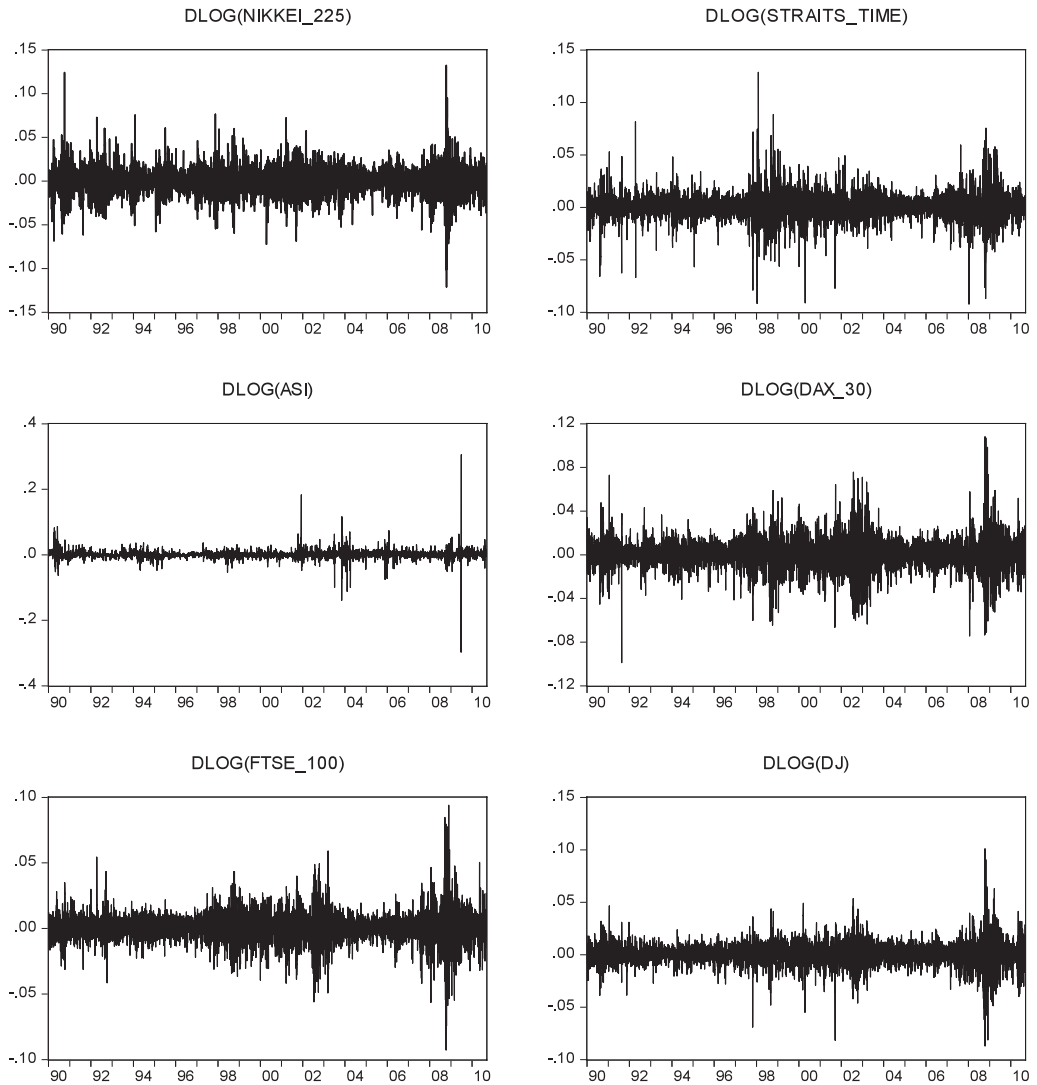


Figure 2 First Difference of the Indices from 1990-2010

ables that is neglected by doing so. For the period 1990-1997 and 1997-2007 there is an evidence of co-integration between the stock indices. If variables are non-stationary in level and are co-integrated, the adequate method to capture short run dynamics is VECM. We employed VECM to the data to identify causal link between the periods of 1990-1997 and 1997-2007. Results are summarized in Tables 11, 12, 13 and 14 with F statistics or Chi-sq statistic in first row and probability in second row.

Tables 12 and 13 present results from the VECR for the period 1990-1997 and 1997-2007, and Tables 11 and 14 the VAR in first-differences for the period 1990-2010 and 2007-2010, respectively.

Table 9 Co-integration Test Results (Trace and Eigenvalue Statistic) 1990-1997

Hypothesized No. of CE(s)	Trace Statistic	Critical Value	Prob.**	Max-Eigen Statistic	Critical Value	Prob.**
None	135.3003*	117.7082	0.0024	58.46715*	44.4972	0.0009
At most 1	76.83318	88.8038	0.2663	25.70016	38.33101	0.6212
At most 2	51.13302	63.8761	0.3648	20.5463	32.11832	0.6086
At most 3	30.58672	42.91525	0.4678	14.74129	25.82321	0.6576
At most 4	15.84543	25.87211	0.505	9.354365	19.38704	0.6876
At most 5	6.491067	12.51798	0.4006	6.491067	12.51798	0.4006

Notes: Co-integration Test are computed using regressions with an Intercept, Trend

*denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) *p*-values

Table 10 Co-integration Test Results (Trace and Eigenvalue Statistic) 1997-2007

Hypothesized No. of CE(s)	Trace Statistic	Critical Value	Prob.**	Max-Eigen Statistic	Critical Value	Prob.**
None	144.5782*	117.7082	0.0004	49.14683*	44.4972	0.0146
At most 1	95.43141*	88.8038	0.0153	38.2346	38.33101	0.0513
At most 2	57.19681	63.8761	0.1604	25.18358	32.11832	0.2758
At most 3	32.01323	42.91525	0.3877	15.38223	25.82321	0.6001
At most 4	16.631	25.87211	0.4429	9.934859	19.38704	0.6258
At most 5	6.696137	12.51798	0.3773	6.696137	12.51798	0.3773

Notes: Co-integration Test are computed using regressions with an Intercept, Trend

*denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) *p*-values

Table 11 indicates that Granger causality test results under VAR model for whole sample period. Among the six markets, twenty two significant causal relationships are found at the 5 percent level or less than that. Not surprisingly, the three leading markets Germany, UK, and USA have a strong degree of causal relationship which also affects emerging market of Sri Lanka. Tables 12 and 13 show that an interestingly none of the stock markets under examination have a significant causal linear relationship with the CSE. This applies to both time periods, 1990-1997 and 1997-2007. In fact, the Sri Lankan stock market acts completely through its internal dynamics during this period. This result is consistent with the study by Elyasiani et al. (1998) who considered the period 1989-1994. This lack of interdependency in the Sri Lankan stock market implies that additional profit opportunities and diversification benefits to global investors.

It is evident that the NYSE is again one of the most influential markets in the sample, influencing Japan, Germany, UK and Singapore. The least influential markets in the pre-Asian crises period include Sri Lanka, Singapore and Germany. One important change in the post-Asian crisis

Table 11 Granger Causality Test Results (VAR Model)

1990–2010							
Market	JAN	SIN	SRI	GER	UK	USA	Causes
JAN	—	3.02621	0.44515	2.58706	3.20652	4.74233	4
		0.0167	0.776	0.0351	0.0122	0.0008	
SIN	13.1075	—	4.51279	1.22353	0.54917	2.38117	3
	1.00E–10		0.0012	0.2985	0.6996	0.0494	
SRI	1.09933	0.76677	—	2.11032	2.22648	1.88265	0
	0.355	0.5467		0.0773	0.0636	0.1105	
GER	125.872	43.5086	4.04201	—	3.55383	4.12532	5
	7.00E–103	5.00E–36	0.0028		0.0067	0.0024	
UK	106.288	43.1261	4.25047	5.91437	—	7.11272	5
	3.00E–87	1.00E–35	0.002	0.0001		1.00E–05	
USA	218.219	148.215	7.62549	82.6079	142.614	—	5
	8.00E–174	2.00E–120	4.00E–06	4.00E–68	5.00E–116		
Caused	4	4	4	3	3	4	22

Table 12 Granger Causality Test Results (VEC Model)

1990–1997							
Market	JAN	SIN	SRI	GER	UK	USA	Causes
JAN	—	8.783527	1.970848	19.72777	19.14004	2.06346	3
		0.0124	0.3733	0.0001	0.0001	0.3564	
SIN	3.073116	—	0.507718	1.991175	3.602125	9.318044	1
	0.2151		0.7758	0.3695	0.1651	0.0095	
SRI	1.450421	3.031704	—	0.327434	1.476068	0.190308	0
	0.4842	0.2196		0.8490	0.4781	0.9092	
GER	4.611001	2.757535	1.170101	—	3.80344	6.334537	1
	0.0997	0.2519	0.5571		0.1493	0.0421	
UK	5.674686	14.04478	1.784368	24.01347	—	2.311528	2
	0.0586	0.0009	0.4098	0.0000		0.3148	
USA	68.41428	146.9214	2.900909	240.8124	112.4746	—	4
	0.0000	0.0000	0.2345	0.0000	0.0000		
Caused	1	3	0	3	2	2	11

Table 13 Granger Causality Test Results (VEC Model)

1997-2007							
Market	JAN	SIN	SRI	GER	UK	USA	Causes
JAN	—	15.90602	0.602745	1.877072	8.418659	4.430524	2
		0.0004	0.7398	0.3912	0.0149	0.1091	
SIN	1.322785	—	0.861452	2.347247	3.648066	3.162057	0
	0.5161		0.6500	0.3092	0.1614	0.2058	
SRI	2.526199	3.337439	—	0.284892	0.948096	2.571883	0
	0.2828	0.1885		0.8672	0.6225	0.2764	
GER	30.8956	2.435842	0.773186	—	1.349322	2.067283	1
	0.0000	0.2958	0.6794		0.5093	0.3557	
UK	7.91706	3.279646	0.756375	2.187371	—	0.774354	1
	0.0191	0.194	0.6851	0.3350		0.6790	
USA	142.9397	181.8169	5.871287	132.9038	252.4891	—	4
	0.0000	0.0000	0.0551	0.0000	0.0000		
Caused	3	2	0	1	2	0	8

Table 14 Granger Causality Test Results (VAR Model)

2007-2010							
Market	JAN	SIN	SRI	GER	UK	USA	Causes
JAN	—	0.83131	3.80354	1.65764	0.59255	5.20390	2
		0.4768	0.01	0.1747	0.62	0.0015	
SIN	18.1166	—	6.23165	0.73898	3.46505	2.13243	3
	2.00E-11		0.0003	0.529	0.0159	0.0947	
SRI	0.63723	0.78905	—	2.30413	0.56155	1.06659	0
	0.5912	0.5002		0.0756	0.6405	0.3625	
GER	78.5093	17.0516	2.90727	—	1.81493	2.15121	3
	2.00E-44	1.00E-10	0.0339		0.1429	0.0924	
UK	55.5787	13.6695	3.43502	1.06689	—	2.22661	3
	1.00E-32	1.00E-08	0.0166	0.3624		0.0837	
USA	135.283	45.2222	5.72815	24.5341	46.5691	—	5
	2.00E-70	6.00E-27	0.0007	4.00E-15	1.00E-27		
Caused	4	3	5	1	2	1	16

period (1997-2007) is that the number of causal links has fallen from eleven to eight. The relative influence of the Singapore, Japan and UK has declined substantially in the post-Asian crises period. In the pre-Asian crisis period, Japan, Germany, UK and Singapore account for seven of the eleven significant causal relationships. In the post-Asian crisis period these markets account for far fewer significant causal relationships.

The leading role of the US market in the world stock market is clearly visible throughout all causality tests and in all time periods. The least influential markets in the post-current economic recession are Sri Lanka and Japan. One of the most important points is that in the post-economic recession period, the number of causal relations increased from eight to sixteen. With reference to the Sri Lankan capital market, we could say that it is Granger caused by all markets in the sample in recent years. One of the most interesting finding is that the Sri Lankan stock market started to increase Granger caused in the post-economic recession period as compared to the pre-Asian crisis period.

The study examines the short-term interactions of the stock indices via impulse response functions. In economics, impulse response function points out that how the economy reacts over time to exogenous impulses, which usually call 'shocks', and are often modeled in the context of a VAR. For example, a change in the particular market will not only affect on that market, but it will transmit information to other markets, even with a time lag. Table 15 shows the result of impulse response of the six stock indices with respect to one standard deviation price shock during the post-economic recession (see Figure 3).

Table 15 indicates that the dynamic response of Sri Lanka to itself is greater on first day than

Table 15 Impulse Response of the Sri Lankan Market to One Standard Error Innovations in Each of the Markets from 1/9/2007 to 9/9/2010

2007-2010						
Response of SRI LANKA						
Period	Japan	Singapore	Sri Lanka	Germany	U K	USA
1	0.0007	0.0012	0.0177	0.0000	0.0000	0.0000
2	0.0015	0.0021	0.0126	0.0009	0.0005	0.0006
3	0.0010	0.0026	0.0137	0.0006	0.0003	0.0007
4	0.0008	0.0030	0.0132	0.0003	0.0004	0.0003
5	0.0007	0.0034	0.0132	0.0002	0.0004	0.0002
6	0.0005	0.0038	0.0131	0.0000	0.0004	0.0000
7	0.0003	0.0042	0.0130	-0.0002	0.0004	-0.0001
8	0.0002	0.0045	0.0129	-0.0004	0.0004	-0.0003
9	0.0001	0.0048	0.0128	-0.0005	0.0005	-0.0004
10	0.0000	0.0051	0.0127	-0.0007	0.0005	-0.0006

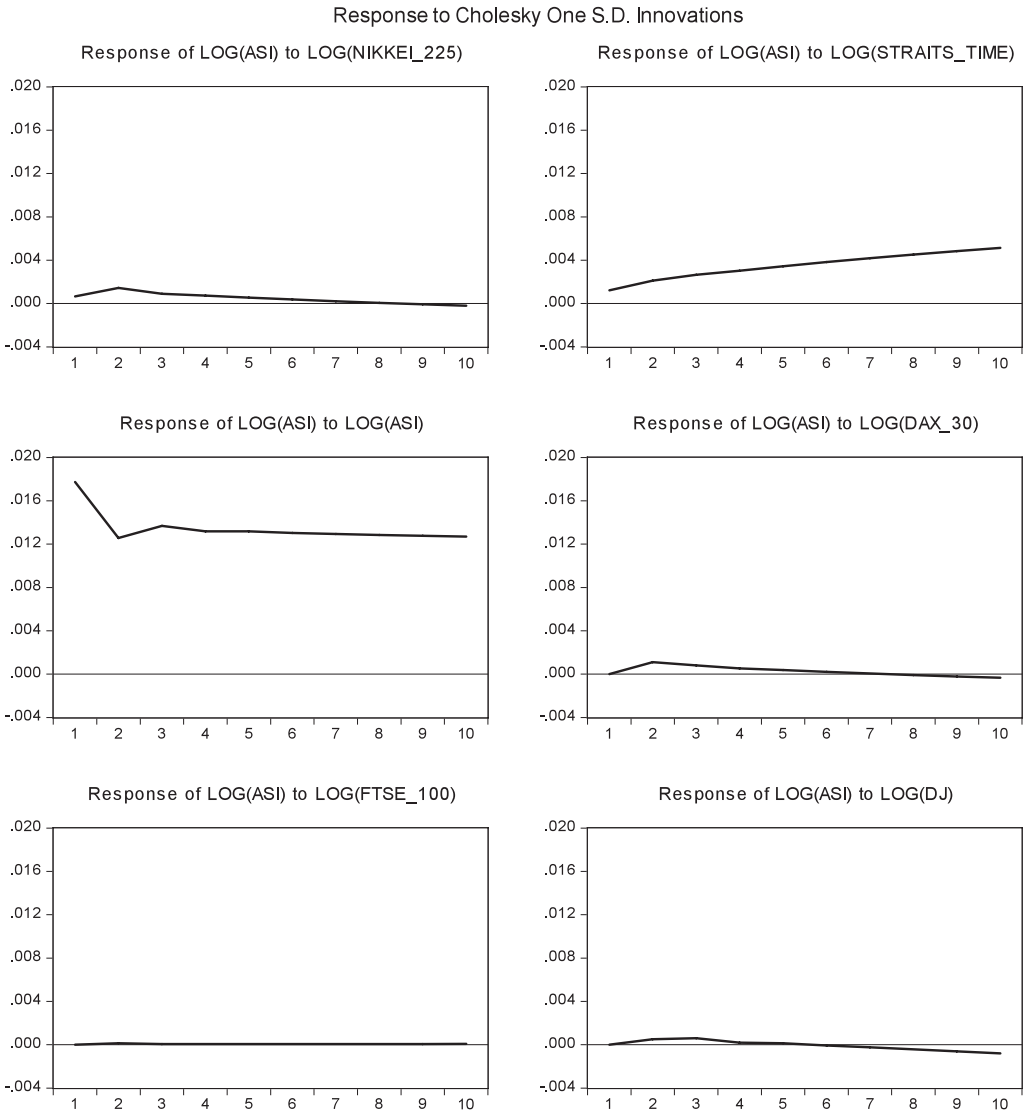


Figure 3 Impulse Response of Sri Lanka from other Stock Exchanges from 2007-2010

the other days while shocks from Japan and Singapore are 0.0007 and 0.0012, respectively. However, USA, UK and Germany stock exchanges have no effect on Sri Lanka on first day. It is because of the differences in opening and closing time of the stock markets. Sri Lanka response to a shock of one standard deviation on second day from Germany is 0.0009, from USA is 0.0006, from UK is 0.0005, from Japan is 0.0015, and from Singapore is 0.0021. However, the shocks die out after six days and effect of the shock is hardly noticeable thereafter in USA and Germany. Particularly, it can be ascertained that the response of Sri Lanka to a one standard deviation innovation in Singapore, Japan and UK is positive till ten days. Investigating the interdependency of the Sri Lankan market with the others we observe that any events occurring in them cause only

small and statistically insignificant reactions in the Sri Lankan stock exchange.

5 Conclusion

This paper examines price relationships among six stock exchanges for the period 1990–2010 using the VAR model and VECM. Except Sri Lanka, all other five markets are developed and leading markets in the world. The empirical results are reported based on three categories, namely ; pre-Asian currency crisis, post-Asian crisis and pre-current economic recession, and post-economic recession, respectively.

First, the ADF test is applied to the data to identify stationary properties of the indices. To test for this property, it is conducted on the level and first-differenced stock index series. The ADF test statistic indicated that for each series in level there is no sufficient evidence to reject the null hypothesis of unit root at 1 percent level. The first-differenced series reject the null hypothesis of unit root, indicating that they are stationary for all periods. Consequently, all five series are integrated I(1). Next, we employed Johansen co-integration analysis followed by error correction modeling and finally, we applied Granger tests for short run causality. We found co-integration relations only for the periods from 1990–1997 and from 1997–2007. We can see that the results are quite mixed. Somewhat surprisingly, there does not seem to be a co-integrating relationship between the period 1990–2010 and 2007–2010. Therefore, we employed VECM to the data to identify causal link between the periods of 1990–1997 and 1997–2007. Not surprisingly, the three leading markets Germany, UK, and USA have a strong degree of causal relationship which also affects emerging market of Sri Lanka for the whole sample period. Meanwhile, it is evident that the NYSE is again one of the most influential markets in the sample, influencing Japan, Germany, UK and Singapore. The leading role of the US market in the world stock market is clearly visible throughout all causality tests and in all time periods. The least influential markets in the post-current economic recession are Sri Lanka and Japan. One of the most important points is that post-economic recession period number of causal relations increased from eight to sixteen. With reference to the Sri Lankan capital market, we could say that it is Granger caused by all markets in the sample in recent years. One of the most interesting finding is that the Sri Lankan stock market started to increase Granger caused in the post-economic recession period as compared to the pre-Asian crisis period.

The main implication of this results is that under the context of globalization, the stock markets are enhanced their interrelations after the recent economic recession. Especially an emerging market of Sri Lanka is affected by almost all developed markets during the post-economic recession. Possible reasons include this trend in Sri Lanka are trade and foreign investment interaction, increasing liquidity in the CSE after the civil conflict in the country, universal process of microeconomic reforms flowing from the economic crises themselves.

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