AN ANALYSIS OF IMPACT OF GLOBAL RECESSION ON BSE SENSEX – DOES STOCK MARKET INTERDEPENDENCE PLAY A PIVOTAL ROLE?

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Abstract: In 2008, an economic recession was suggested by several important indicators of economic downturn. These included high oil prices, which led to both the drastic high food prices and global inflation; a substantial credit crisis leading to the drastic bankruptcy, diverse nations around the world; increased unemployment; and signs of contemporaneous economic downturns of the world, a global recession. This paper attempts to re-establish subtle nuances between interdependencies amongst the stock markets and its impact during recession? Given interdependency a major area of concern author attempt to examine the intensity, nature and direction that can possibly drag the emerging stock markets like India? Research question emanates include- Will this crisis or shock cause a permanent variation in interdependency, or remain constant? Methodology employed includes Augmented Dickey-Fuller test, VAR model for testing stationary and measuring magnitude of association ,Further analysis is worked -out by Granger causality and co integration test for assessing short run and long run dynamics.

Key words: Granger causality, co integration, VAR, stationary, interdependency JEL Classification: G1, G2

Introduction: The global market melt down has shaken all of us. The crux of this issue is attributed to significant mis-pricing of risks in the financial system. The impact was compounded by relatively easy monetary policies at major financial centers and globalization of liquidity flows, possibly without adequate safeguards. Complex and structured derivatives and inadequacy of majority of stakeholders in understanding this innovation also played their part. The crises first emerged as a liquidity crisis whose first symptoms appeared at the beginning of August 2007 when serious disruptions surfaced in the inter-bank market. The issues of emerging financial market integration have recently attracted the attention of investors and academics. The liberalization of capital flows facilitated by recent developments in trading machinery and improved transmission of news has resulted to increased integration between international financial markets. The spillover or contagion effect across financial assets has been the spotlight of much interest from financial market regulators in recent years. Although some researcher suggested that financial market integration among countries can be weak as development of these markets are predominantly guided by domestic forces but the fact is that the stock markets become highly interdependent with free international capital flows.. Last time when recession hit USA in 2000-2001 Dow Jones Industrial Index (DJIA) went down to 22.7%, SENSEX fell by 14.6% showing a strong sign of co movement. But strength of the Indian economy, market capitalization and structure of capital market has changed by 2008. The current global economic downturn has caused significant fall in the growth rate of major stock markets across the world. Given this interdependency a major area of concern is to what extent that can drag along the emerging stock markets like India? How much the phenomenon of volatility spillover contributes to the co-movement of the stock market? Will this crisis or shock cause a permanent increase or decrease in interdependency, or it remains constant? How much of the recessionary impact has trickle down to domestic economy through stock markets?

Literature Review

Several studies, such as (Kyle, 1985) have pointed out that much of the information would be revealed in the volatility of stock prices, rather than the price itself.

There are several reasons to analyze the cross-border volatility spillovers. In addition to various domestic factors, volatility of major foreign trading partners is one of the important determinants of stock return volatility in a domestic market

Early research focused exclusively on the spillover of. the return among the major stock exchanges (Eun & Shim, 1989, Joen & Furstenberg, 1990 and Cumby, 1990 etc.). But, studying the stock market co-movements is a combined study of information spillover both in terms of returns as well as the volatility of returns. Volatility linkages, i.e. inter-market linkages of stock price is the another significant aspect of international stock market integration.

Regional economic integration can take place among the markets within the same region because of so many factors, such as economic ties among the countries, lower geographical distance, foreign investments, contagion effect etc.

Masih and Masih (2001) examined the markets of USA, Britain, Japan, Germany, South Korea

Singapore, Hong-Kong, Taiwan and Australia in their study on the interdependency of world stock markets. The period of study was from 1992 to 1994. The method involved was co-integration test. The study provided two specific results. The first was that there was inevitable interdependency among the Asian stock markets and the developed countries of the OECD. The second conclusion of the study was that the markets of the USA and Britain exert a dominant role both in the long-run and the short – run.

The investigation by Kim, Yoon and Viney (2001) of the markets of Hong-Kong, Korea and Thailand during the period of 1997-1998 established the existence of co-integration markets. The study confirmed that the Hong-Kong stock market played a dominant role. The method used for the study was Multivariate VAR-EGARCH MODEL

In the paper of Deb, Vuyyri and Roy, monthly volatility of market indices (Sensex & S&PCNX-Nifty) of Indian capital markets has been modeled using eight different univariate models. They found GARCH (1, 1) model to be the over all superior model based on most of the symmetric loss functions though ARCH (9) has been found to be better than the other models for investors who are more concerned about under predictions than over predictions.

Mukherjee, Dr. Kedarnath and Mishra, Dr. R. K. (2008) in their study found that Hong Kong, Korea, Singapore and Thailand are found to be the four Asian markets from where there is a significant flow of information in India. Similarly, among others, stock markets in Pakistan and Sri Lanka are found to be strongly influenced by movements in Indian market. Though most of the information gets transmitted among the markets without much delay, some amount of information still remains and can successfully transmit as soon as the market opens in the next day.

The theory of stock market integration and recession: Explanation of interdependence of stock market can be broadly classified in three categories, firstly; contagion effect, secondly; economic integration and finally stock market characteristic (Pretorious,)

Contagion: Contagion is the co-movement of asset markets of different countries not caused by a common movement of fundamentals (Wolf,1998). Contagion is measured in terms of the residuals from the co-movement that is not caused by any economic fundamentals. Informational factor responsible for this contagion can be explained in terms of Keynesian 'Beauty Contest' where each judge votes according to the way he thinks the other judges may do. So an international investor will sell off his investment if he thinks that other investors may do the same in that specific asset class. Because of this herd behavior of the investors stock markets show similar upturn and downturn. This contagion effect can drag along other stock markets without any fundamental economic reason. Institutional factors responsible for such co-movement can be the case of forced redemption and two stage investment strategies (olf, 1998)

Economic Integration: Co-movement of stock market of different countries can be explained in terms of their degree of macroeconomic integration. In an open economic system a significant contributor to this integration is degree of bilateral trade. If country a is the principal importer of any specific product class from B, then reduction in import demand of A because of its domestic reasons will exerts substantial pressure on the stock market of country B. For example India being the principal exporter of IT enabled services to USA, suffered a huge shock in post 9/11 period because of a sudden reduction in import demand. This results in similar downturn of equity prices of IT industries in both the countries.

Integration can also take place through macroeconomic variables like interest rate, inflation, wage structure or labor movement between countries. As these variables influence stock market returns, so correlation between them will also influence the correlation between their stock markets.

Stock Market Characteristics: Apart from the reasons discussed above, stock market characteristics like size, volatility and industrial similarity may also dictate the level of integration.

Size play apivotal role in stock market integration. Liquidity, information and transaction costs vary from market to market depending on their size. So large size differential between stock markets results in larger difference in above factors which in turn induces less co-movement amongst them.

Existence of risk return trade off also causes stock market integration. As return from any stock market is the function of its volatility, so similar volatility in some stock market because of any external shocks results in similar trend of returns.

Industrial similarity as the reason for stock market correlation (Wolf, 1998;Roll,1992) got substantial attention in different literatures. Domination of same industrial sectors in different region suffering from shock results in co-movement of their stock markets. Demand bottlenecks of any particular category of industrial product are expected to results in similar equity price movement associated with that product in different countries.

Scope of study:

In the given period while BSE touched its lowest ever

figure, before attains its recovery, author attempted to assess the following key parameters of the study.
To examine the correlation of the stock market returns during the period.
To estimate the impact of downturn of stock markets of major countries namely USA,UK, Japan etc on BSE.
To analyze short run and long run relationship among these stock markets during a recessionary period.To assess the contribution of shocks from other stock markets on BSE through Variance Decomposition
To relate economic fundamentals with stock market co-movement.
5.Modeling ; 5.1 Data
Daily indices of five major countries USA (Dow Jones), Japan (Nikkei), UK (S&P500), Hong kong (Hanseng) and Singapore(STI) along with BSE sensex are considered for analysis. These countries are chosen because of their relative importance depending on their trade relation with India. The following reasons can be attributed for their selection. USA, the largest financial market in the world also with highest Market capitalization. UK is one of the strongest European markets. Japan other than being a strong market, play the most significant role in Asian Economy. China and specifically Singapore have been chosen for their growing trade relation with India Closing value of each of the above stock market for the period 1st april,2008 to 30th June,2009 are collected from 'historical prices' of Yahoo Finance which accounts for 296 daily prices. Above period is chosen because during mid of the period Sensex touches its bottom before reviving so both contraction and revival phase of recessionary cycle can be taken into account.
5.2 Methodology and Empirical framework
Following methodology is employed for the purpose of quantitative analysis and conclusion Summary statistics of the return series employed to understand the return and volatility Correlation matrix of actual indices/prices as well as return series to examine the degree of interdependency amongst them.
Augmented Dickey-Fuller test to check the stationary status. Akaike criterion (AIC) for selecting optimum lags for the purpose of running Vector Auto regression.
VAR model for implementing Variance Decomposition of the return series. Engel Granger Co integration tests for cross checking long run relationships among the stock markets under investigation.

6. Estimation and Analysis of Empirical Results

Table:1 Summary Statistics, using the observations (08/04/01 - 09/06/17)

Variable	Mean	Median	Minimum	Maximum	Std. Dev.	C.V.	Skewness	Ex. kurtosis
d_BSE	-3.77593	-2.94000	-1070.63	2110.79	335.373	88.8187	0.760220	4.60179
d_Dow Jones	-12.9710	-6.89000	-777.680	936.420	219.174	16.8973	0.0645666	2.49441
d_Nekkei	-10.3560	-4.64500	-1089.02	1171.14	258.318	24.9437	-0.227347	2.85158
d_S&P 500	-1.42583	0.595000	-106.850	104.130	25.3349	17.7685	-0.192745	2.56852
d_Hanseng	-14.4881	0.000000	-1602.54	1695.27	466.939	32.2291	0.208877	1.41738
d_stisingapur	-2.25759	-2.79500	-154.380	139.860	44.9284	19.9010	0.0998211	1.03936

From the summary statistics, during the period under consideration all stock markets showed negative returns. BSE Sensex showed fourth highest negative returns after NIKKEI , DOW JONES and HANSENG which proves the recessionary impact on developed market like Dow Jones and Nikkei were more severe compared to that of BSE. But interestingly BSE stock market suffered from the highest volatility, which can be confirmed from the value of standard deviation and coefficient of variation of the return series.

(Missing values were skipped) 5% critical value (two-tailed) = 0.1102 for n = 317

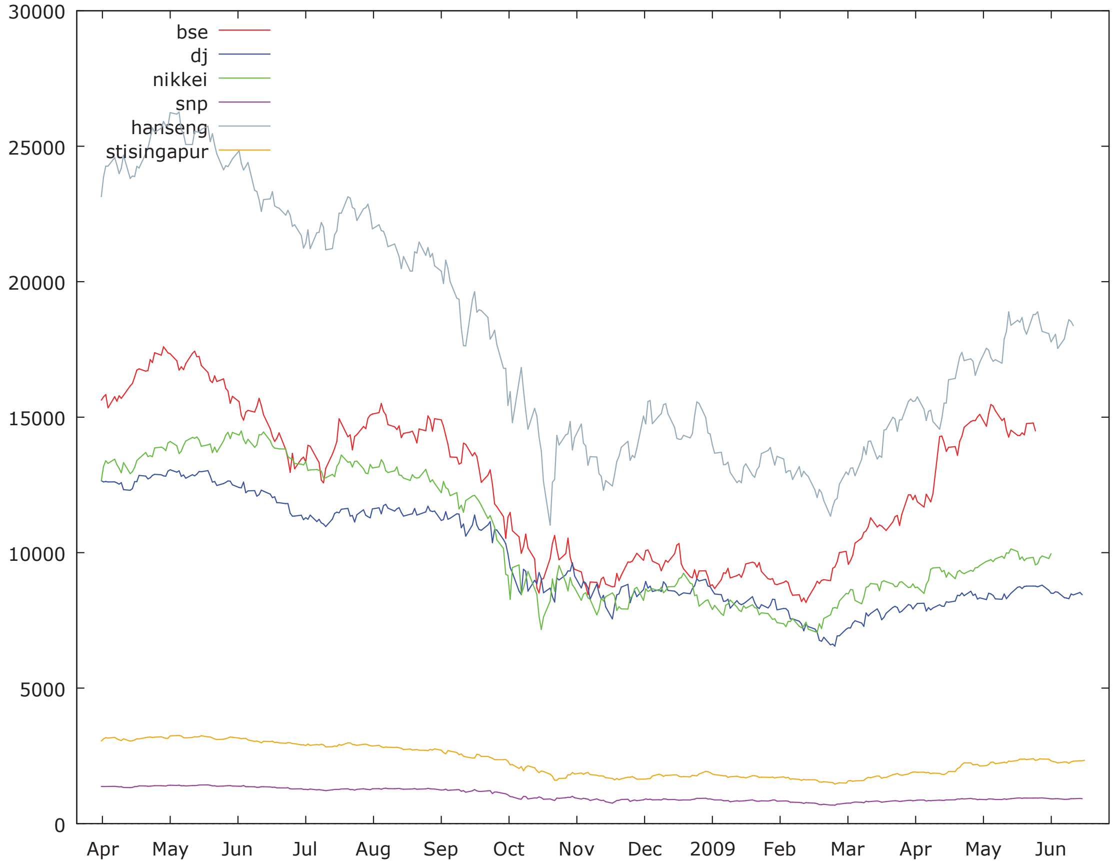
Table:2 Correlation coefficients, using the observations 08/04/01– 09/06/17

BSE	Dj	Nikkei	S&P500	Hanseng	Stisingapur	
1.0000	0.8022	0.8748	0.8212	0.9093	0.8891	bse
	1.0000	0.9499	0.9962	0.9375	0.9481	dj
		1.0000	0.9653	0.9653	0.9695	nikkei
			1.0000	0.9487	0.9628	S&P 500
				1.0000	0.9832	Hanseng
					1.0000	Stisingapur

(Missing values were skipped), 5% critical value (two-tailed) = 0.1102 for n = 317

Table:3 Correlation coefficients, using the observations 08/04/01 - 09/06/17						
d_bse	d_dj	d_nikkei	d_s&p500	d_hanseng	d_stisingapur	
1.0000	0.0843	0.0836	0.0786	-0.0584	0.0363	d_bse
	1.0000	-0.0604	0.9887	0.1206	0.0622	d_dj
		1.0000	-0.0650	-0.0570	0.0281	d_nikkei
			1.0000	0.1294	0.0700	d_snp
				1.0000	0.0708	d_hanseng
					1.0000	d_stisingapur

Table-2 shows correlation of actual prices where as table-3 depicts the return correlations among the various indices. Correlation of the actual indices showed a very high degree of association. But return correlations are not as strong as that of indices. Table-3 showed that BSE was having high correlations with Dow Jones and Nikkei but it constitutes only about 8% to 8.5% of the movement of the return series. Although return may not be significantly correlated but indices of the countries under consideration showed similar co movement which can be confirmed from the following graph. Explanation could be that these countries suffered from symmetric shocks of the recession. Also during that period international investor showed strong herd behavior.



The BSE Sensex trend lines show similar pattern of movements that of all other major stock markets of the world taken into consideration. This co movement to some extent proves the fact that BSE is integrated with those stock markets. Especially the curves show that July.2008 and Mid October, 2008 crash of BSE, Nikkei, Hanseng and Dow Jones share the same pattern. The entire effort was exercised to address the direction of causality. Also it is immensely important to decompose the impact and calculation of contribution of shock of each other stock markets on BSE

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In	Lag length	ADF Statistics	p-value	Deterministic term
BSE	0	-0.439034	0.9857	constant and trend
DJ	0	-1.841	0.6824	constant and trend
Nikkei	0	-1.09492	0.9271	constant and trend
SNP	0	-1.51412	0.823	constant and trend
Hanseng	0	-0.64511	0.9753	constant and trend
STI	0	-0.0355935	0.9957	constant and trend

The results of Augmented Dickey Fuller test show that the actual time series of indices are non-stationary.

In(first difference)	Lag length	ADF Statistics	p-value	Deterministic term
BSE	0	-16.1923	0.0000	constant and trend
DJ	0	-20.7389	0.0000	constant and trend
Nikkei	0	-18.9994	0.0000	constant and trend
SNP	0	-20.8079	0.0000	constant and trend
Hanseng	0	-18.502	0.0000	constant and trend
STI	0	-17.9622	0.0000	constant and trend

First difference of the indices series are stationary as all the p-value are extremely closed to zero, that is the series are co integrated of order one I(1) or they contain one unit root.

Vector Auto Regression: As the study include several time series, researcher need to take into account the interdependence between them. So Vector auto regressive approach (VAR) is utilized which is a multiple time series generalization of the AR model. Estimation of a VAR(P) model require determination of optimum lag(P). To assign the optimum number of lag Akaike Information Criteria (AIC) is being utilized which determine that lag length should be 3 (Table-4).

Table: 4

VAR system, maximum lag order 6:

The asterisks below indicate the best (that is, minimized) values

of the respective information criteria,

AIC = Akaike criterion,

BIC = Schwartz Bayesian criterion and

HQC = Hannan-Quinn criterion

lags	loglik	p(LR)	AIC	BIC	HQC
1	-10672.39785	72.887060	73.413286*	73.097798	
2	-10575.85394	0.00000	72.475197	73.452473	72.866567
3	-10512.32240	0.00000	72.287907*	73.716234	72.859909*
4	-10487.79683	0.07211	72.365965	74.245342	73.118599
5	-10462.19081	0.04797	72.436672	74.767100	73.369938
6	-10433.20088	0.01156	72.484360	75.265838	73.598258

VAR (P) where P=3 is estimated to establish the relationship amongst the return series of the stock markets under consideration (Appendix-1).Null hypothesis being

Ho: There exists no association amongst the return series.

H1: There exists association.

The results in case of BSE as dependent variable reject the null hypothesis at 5 % level of significance which can be confirmed from the fact that p-values except that of hanseng with lag order 1 are greater than 0.05.So other than hanseng there exits association amongst the return series of these stock markets.

VAR estimate of Dow Jones as dependent variable also show that autoregressive coefficient of BSE as independent variable is significant thus null hypothesis is rejected.

Interestingly NIKKEI return series is not dependent or influenced by BSE so null hypothesis is accepted at

5% level of significance both for lag order1 and 2.
Variance decomposition of BSE: Given the fact that VAR shows association of the return series of the stock indices, variance decomposition technique has been incorporated to measure the shock impact. Variance decomposition of the return series of stock indices of BSE try to capture the magnitude of response to a unit shock due to other variable. Once a shock is introduced through the error term variance decomposition measure the contribution of the other variables to the total volatility. Taking seven period variance decomposition a unit shock to BSE can cause a very insignificant around 0.5% to 0.8% variation to other stock market like Dow Jones and NIKKEI.
But variance decomposition of Dow Jones shows that it is responsible for 5.04% variation of return series of BSE. Also Variance decomposition of NIKKEI accounts for as high as 13.79% variation of BSE sensex. This can be treated as a proxy measure of direction of causality of association. Thus During the recessionary period major stock markets like Dow Jones and Nikkei exerts significant pressure on BSE and responsible for sizable variation in return of BSE.

Decomposition of variance for d_bse					
Period	std. error	d_bse	d_dj	d_snp	d_nikkei
1	324.542	100.0000	0.0000	0.0000	0.0000
2	329.532	97.6639	0.1365	0.3814	0.4952
3	331.331	96.7808	0.3899	0.3781	0.5069
4	334.082	95.2050	0.4625	0.3769	0.8372
5	334.413	95.0180	0.5217	0.3764	0.8427
6	334.815	94.8346	0.5406	0.4706	0.8453
7	335.058	94.7350	0.5764	0.4703	0.8822
Decomposition of variance for d_bse (continued)					
	d_hanseng	d_stisingapur			
1	0.0000	0.0000			
2	1.3230	0.0001			
3	1.5022	0.4420			
4	2.6813	0.4371			
5	2.8043	0.4369			
6	2.8729	0.4360			
7	2.8991	0.4370			

Co integration tests: Although we have used Akaike criteria for selecting optimum lag for VAR model but it lack any specific methodology for determining lag structure. In this analysis 3 lags are considered for each variable and there are 6 variables. Thus each equation have 18 parameters to be estimated also the system has 108 parameters to estimate. This over optimization is also considered to be a major limitation of VAR models. So along with this unrestricted VAR, Co integration tests are utilized to detect more accurately the existence of integration of the stock markets under consideration. Engle Granger co integration test are utilized to address the issue of long run relations of the stock markets. Engle Granger co integration procedure is implemented for the pairs of return series of stock indices one of the series in those pairs being BSE Sensex.
The results (Appendix-2) of pair wise co integration between BSE and all other stock market under consideration showed that the unit-root hypothesis is rejected for the residuals (what) from the co integrating regression which is an evidence of existence of co integrating relationship among the pairs of stock markets.
Conclusions: The study shows interdependence of stock market plays a pivotal role in co-movement of stock markets in the time of recession. World growth is projected to slow from 5 percent in 2007 to 3.75 percent in 2008 and to just over 2 percent in 2009, with the downturn led by advanced economies. Weakening global demand is depressing commodity prices more specifically variance decomposition of major stock market return proves that they contribute significantly to the volatility of BSE sensex. For example Asian giant NIKKEI contribute more than 13% of movement of BSE indices. Empirical findings also confirmed the existence of long run relationships between BSE and other major indices

taken into consideration. Co integrating relationship gave an indication that the impact of recession on BSE may not be static or short lived as influence of global downturn is going to stay in the long run.

Further research can be taken towards the direction of causality of this integration. Also economic fundamentals can be incorporated to find the impact on domestic economy because of these recessionary co-movements of stock markets.

Appendix-1:

VAR system, lag order 3
OLS estimates, observations 08/04/07-09/05/26 (T = 297)
Log-likelihood = -10618.5
Determinant of covariance matrix = 4.5645923e+023
AIC = 72.2727
BIC = 73.6905
HQC = 72.8403
Portmanteau test: LB (48) = 1840.5, df = 1620 [0.0001]
Equation 1: d_bse

	Coefficient	*Std. Error*	*t-ratio*	*p-value*
const	-1.72897	19.731	-0.0876	0.93024
d_bse_1	0.0585506	0.0605024	0.9677	0.33402
d_bse_2	-0.0361075	0.0624295	-0.5784	0.56348
d_bse_3	-0.00860656	0.0658627	-0.1307	0.89613
d_dj_1	-0.799673	0.611129	-1.3085	0.19178
d_dj_2	-0.154298	0.607487	-0.2540	0.79969
d_dj_3	0.777292	0.600431	1.2946	0.19655
d_nikkei_1	0.0759228	0.0848198	0.8951	0.37150
d_nikkei_2	0.0465171	0.082507	0.5638	0.57335
d_nikkei_3	0.0312021	0.0824381	0.3785	0.70535
d_snp_1	7.81922	5.29061	1.4779	0.14055
d_snp_2	0.867456	5.30784	0.1634	0.87030
d_snp_3	-5.95933	5.25961	-1.1330	0.25818
d_hanseng_1	-0.0929319	0.0458756	-2.0257	0.04375
d_hanseng_2	0.0123919	0.0481188	0.2575	0.79696
d_hanseng_3	0.0897607	0.0496155	1.8091	0.07151
d_stisingapur_1	-0.0110002	0.512537	-0.0215	0.98289
d_stisingapur_2	-0.736503	0.476594	-1.5453	0.12340
d_stisingapur_3	-0.256892	0.4399	-0.5840	0.55971

Mean dependent var	-2.859529	S.D. dependent var	335.7643
Sum squared resid	31282212	S.E. of regression	335.4489
R-squared	0.062575	Adjusted R-squared	0.001878
F(18, 278)	1.030939	P-value(F)	0.424801
rho	0.018637	Durbin-Watson	1.956442

F-tests of zero restrictions:	
All lags of d_bse	F(3, 278) = 0.4249 [0.7353]
All lags of d_dj	F(3, 278) = 1.1757 [0.3193]
All lags of d_nikkei	F(3, 278) = 0.35831 [0.7832]
All lags of d_snp	F(3, 278) = 1.1971 [0.3112]
All lags of d_hanseng	F(3, 278) = 2.3813 [0.0698]
All lags of d_stisingapur	F(3, 278) = 0.92182 [0.4307]
All vars, lag 3	F(6, 278) = 1.0267 [0.4081]

Equation 2: d_dj

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	-11.4256	11.1572	-1.0241	0.30670	
d_bse_1	0.0453223	0.034212	1.3247	0.18634	
d_bse_2	0.0512146	0.0353017	1.4508	0.14797	
d_bse_3	-0.00905063	0.0372431	-0.2430	0.80817	
d_dj_1	0.380892	0.345572	1.1022	0.27133	
d_dj_2	0.188749	0.343513	0.5495	0.58313	
d_dj_3	0.639477	0.339523	1.8835	0.06068	*
d_nikkei_1	0.0610999	0.0479626	1.2739	0.20376	
d_nikkei_2	0.0969613	0.0466549	2.0783	0.03860	**
d_nikkei_3	0.0680765	0.0466159	1.4604	0.14532	
d_snp_1	-6.50018	2.99165	-2.1728	0.03064	**
d_snp_2	-4.02925	3.0014	-1.3425	0.18054	
d_snp_3	-5.16639	2.97413	-1.7371	0.08347	*
d_hanseng_1	0.120819	0.0259411	4.6574	<0.00001	***
d_hanseng_2	0.18605	0.0272095	6.8377	<0.00001	***
d_hanseng_3	0.0521623	0.0280558	1.8592	0.06405	*
d_stisingapur_1	-0.389088	0.289822	-1.3425	0.18053	
d_stisingapur_2	-0.219146	0.269497	-0.8132	0.41682	
d_stisingapur_3	0.185543	0.248748	0.7459	0.45635	

Mean dependent var	-12.95071		S.D. dependent var	220.2672
Sum squared resid	10002522		S.E. of regression	189.6847
R-squared	0.303505		Adjusted R-squared	0.258408
F(18, 278)	6.730080		P-value(F)	5.39e-14
Rho	-0.013861		Durbin-Watson	2.026376

F-tests of zero restrictions:	
All lags of d_bse	F(3, 278) = 1.382 [0.2485]
All lags of d_dj	F(3, 278) = 1.6559 [0.1768]
All lags of d_nikkei	F(3, 278) = 2.2098 [0.0872]
All lags of d_snp	F(3, 278) = 3.0457 [0.0292]
All lags of d_hanseng	F(3, 278) = 20.578 [0.0000]
All lags of d_stisingapur	F(3, 278) = 0.85532 [0.4648]
All vars, lag 3	F(6, 278) = 1.632 [0.1382]

Equation 3: d_nikkei

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	-19.2157	13.8682	-1.3856	0.16698	
d_bse_1	0.162291	0.042525	3.8164	0.00017	***
d_bse_2	0.282968	0.0438794	6.4488	<0.00001	***
d_bse_3	0.119038	0.0462925	2.5714	0.01065	**
d_dj_1	-0.515102	0.429541	-1.1992	0.23147	
d_dj_2	-0.296661	0.426981	-0.6948	0.48777	
d_dj_3	-0.548307	0.422021	-1.2992	0.19494	
d_nikkei_1	-0.233003	0.0596167	-3.9083	0.00012	***
d_nikkei_2	-0.087151	0.0579912	-1.5028	0.13402	
d_nikkei_3	-0.096875	0.0579427	-1.6719	0.09567	*
d_snp_1	4.46122	3.71858	1.1997	0.23127	

d_snp_2	1.02874	3.73069	0.2757	0.78295	
d_snp_3	3.80746	3.69679	1.0299	0.30394	
d_hanseng_1	-0.0223914	0.0322443	-0.6944	0.48799	
d_hanseng_2	0.0190686	0.033821	0.5638	0.57334	
d_hanseng_3	0.0334374	0.0348729	0.9588	0.33847	
d_stisingapur_1	0.532702	0.360244	1.4787	0.14035	
d_stisingapur_2	-0.237036	0.334981	-0.7076	0.47978	
d_stisingapur_3	-0.380785	0.30919	-1.2316	0.21916	

Mean dependent var	-12.60475	S.D. dependent var	257.3453
Sum squared resid	15453957	S.E. of regression	235.7748
R-squared	0.211657	Adjusted R-squared	0.160613
F(18, 278)	4.146570	P-value(F)	9.94e-08
rho	-0.006707	Durbin-Watson	2.001527

F-tests of zero restrictions:	
All lags of d_bse	F(3, 278) = 20.373 [0.0000]
All lags of d_dj	F(3, 278) = 1.1773 [0.3187]
All lags of d_nikkei	F(3, 278) = 6.0518 [0.0005]
All lags of d_snp	F(3, 278) = 0.82871 [0.4790]
All lags of d_hanseng	F(3, 278) = 0.5301 [0.6620]
All lags of d_stisingapur	F(3, 278) = 1.4566 [0.2267]
All vars, lag 3	F(6, 278) = 2.2055 [0.0427]

Equation 4: d_snp

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	-1.2218	1.29246	-0.9453	0.34531	
d_bse_1	0.00366281	0.00396315	0.9242	0.35617	
d_bse_2	0.00547548	0.00408938	1.3390	0.18168	
d_bse_3	-0.00170199	0.00431427	-0.3945	0.69351	
d_dj_1	0.0465916	0.0400314	1.1639	0.24547	
d_dj_2	0.0265705	0.0397928	0.6677	0.50486	
d_dj_3	0.0596301	0.0393306	1.5161	0.13062	
d_nikkei_1	0.00746667	0.00555603	1.3439	0.18008	
d_nikkei_2	0.0106238	0.00540454	1.9657	0.05033	*
d_nikkei_3	0.00764751	0.00540002	1.4162	0.15784	
d_snp_1	-0.770824	0.346556	-2.2242	0.02694	**
d_snp_2	-0.504435	0.347685	-1.4508	0.14795	
d_snp_3	-0.488874	0.344525	-1.4190	0.15703	
d_hanseng_1	0.0149752	0.00300503	4.9834	<0.00001	***
d_hanseng_2	0.0212844	0.00315197	6.7527	<0.00001	***
d_hanseng_3	0.00635596	0.00325001	1.9557	0.05151	*
d_stisingapur_1	-0.0421114	0.0335732	-1.2543	0.21078	
d_stisingapur_2	-0.0124176	0.0312188	-0.3978	0.69111	
d_stisingapur_3	0.0292257	0.0288152	1.0142	0.31135	

Mean dependent var	-1.440976	S.D. dependent var	25.46171
Sum squared resid	134224.7	S.E. of regression	21.97323
R-squared	0.300536	Adjusted R-squared	0.255246
F(18, 278)	6.635941	P-value(F)	9.02e-14
rho	-0.014803	Durbin-Watson	2.028383

F-tests of zero restrictions:	
All lags of d_bse	F(3, 278) = 1.0029 [0.3920]
All lags of d_dj	F(3, 278) = 1.338 [0.2623]
All lags of d_nikkei	F(3, 278) = 2.0947 [0.1011]
All lags of d_snp	F(3, 278) = 2.8985 [0.0355]
All lags of d_hanseng	F(3, 278) = 21.171 [0.0000]
All lags of d_stisingapur	F(3, 278) = 0.81717 [0.4853]
All vars, lag 3	F(6, 278) = 1.5226 [0.1706]

Equation 5: d_hanseng

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	-6.23188	25.2955	-0.2464	0.80558	
d_bse_1	0.0564459	0.0775653	0.7277	0.46740	
d_bse_2	0.144404	0.0800358	1.8042	0.07228	*
d_bse_3	0.172449	0.0844373	2.0423	0.04206	**
d_dj_1	0.107235	0.783479	0.1369	0.89123	
d_dj_2	-0.590557	0.77881	-0.7583	0.44893	
d_dj_3	1.52623	0.769764	1.9827	0.04838	**
d_nikkei_1	0.421523	0.108741	3.8764	0.00013	***
d_nikkei_2	0.352473	0.105776	3.3323	0.00098	***
d_nikkei_3	0.32339	0.105687	3.0599	0.00243	***
d_snp_1	-0.631329	6.78266	-0.0931	0.92591	
d_snp_2	5.92498	6.80475	0.8707	0.38466	
d_snp_3	-12.5326	6.74292	-1.8586	0.06414	*
d_hanseng_1	-0.133345	0.0588134	-2.2672	0.02414	**
d_hanseng_2	0.0116062	0.0616892	0.1881	0.85090	
d_hanseng_3	-0.0465126	0.063608	-0.7312	0.46525	
d_stisingapur_1	-0.724012	0.657083	-1.1019	0.27148	
d_stisingapur_2	-0.090293	0.611003	-0.1478	0.88262	
d_stisingapur_3	0.0936846	0.56396	0.1661	0.86818	

Mean dependent var	-18.42963		S.D. dependent var	466.6574
Sum squared resid	51414595		S.E. of regression	430.0518
R-squared	0.202376		Adjusted R-squared	0.150731
F(18, 278)	3.918614		P-value(F)	3.59e-07
rho	-0.021067		Durbin-Watson	2.041385

F-tests of zero restrictions:	
All lags of d_bse	F(3, 278) = 2.4793 [0.0615]
All lags of d_dj	F(3, 278) = 1.5029 [0.2140]
All lags of d_nikkei	F(3, 278) = 9.7921 [0.0000]
All lags of d_snp	F(3, 278) = 1.4283 [0.2347]
All lags of d_hanseng	F(3, 278) = 2.0856 [0.1023]
All lags of d_stisingapur	F(3, 278) = 0.40756 [0.7477]
All vars, lag 3	F(6, 278) = 3.4763 [0.0025]

Equation 6: d_stisingapur

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	-0.47069	2.08959	-0.2253	0.82195	
d_bse_1	-.00463678	0.00640745	-0.7237	0.46989	
d_bse_2	0.00385854	0.00661153	0.5836	0.55996	
d_bse_3	0.00275385	0.00697513	0.3948	0.69329	
d_dj_1	0.08258	0.0647211	1.2759	0.20304	
d_dj_2	-0.0550478	0.0643353	-0.8556	0.39293	
d_dj_3	-.000131015	0.0635881	-0.0021	0.99836	
d_nikkei_1	0.00669278	0.00898276	0.7451	0.45686	
d_nikkei_2	0.0229608	0.00873783	2.6278	0.00907	***
d_nikkei_3	-0.020399	0.00873052	-2.3365	0.02018	**
d_snp_1	-0.169354	0.560297	-0.3023	0.76268	
d_snp_2	0.964855	0.562122	1.7165	0.08719	*
d_snp_3	0.303098	0.557014	0.5441	0.58678	
d_hanseng_1	0.0098787	0.00485841	2.0333	0.04297	**
d_hanseng_2	0.0260583	0.00509597	5.1135	<0.00001	***
d_hanseng_3	0.0313635	0.00525448	5.9689	<0.00001	***
d_stisingapur_1	-0.268348	0.0542798	-4.9438	<0.00001	***
d_stisingapur_2	-0.0417713	0.0504732	-0.8276	0.40861	
d_stisingapur_3	-0.0860231	0.0465872	-1.8465	0.06588	*

Mean dependent var	-2.767205		S.D. dependent var	45.46246
Sum squared resid	350850.9		S.E. of regression	35.52539
R-squared	0.426511		Adjusted R-squared	0.389379
F(18, 278)	11.48623		P-value(F)	1.44e-24
rho	-0.009663		Durbin-Watson	2.012352

F-tests of zero restrictions:	
All lags of d_bse	F(3,278) = 0.3406 [0.7960]
All lags of d_dj	F(3,278) = 0.79182 [0.4993]
All lags of d_nikkei	F(3,278) = 4.845 [0.0027]
All lags of d_snp	F(3,278) = 1.109 [0.3458]
All lags of d_hanseng	F(3,278) = 18.316 [0.0000]
All lags of d_stisingapur	F(3,278) = 9.8366 [0.0000]
All vars	lag 3 F(6,278) = 11.098 [0.0000]

Appendix-2:
For the system as a whole
Null hypothesis: the longest lag is 2
Alternative hypothesis: the longest lag is 3
Likelihood ratio test: Chi-square(36) = 126.107 [0.0000]

Step 1: testing for a unit root in d_bse
Augmented Dickey-Fuller test for d_bse
including 3 lags of (1-L)d_bse
sample size 296
unit-root null hypothesis: a = 1
test with constant
model: (1-L)y = bo + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff.for e: 0.002
lagged differences: F(3, 291) = 0.498 [0.6838]
estimated value of (a - 1): -1.00705
test statistic: tau_c(1) = -8.81749
asymptotic p-value 1.747e-015

Step 2: testing for a unit root in d_dj
Augmented Dickey-Fuller test for d_dj
including 3 lags of (1-L)d_dj
sample size 296
unit-root null hypothesis: a = 1
test with constant
model: (1-L)y = bo + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff.for e: -0.000
lagged differences: F(3, 291) = 4.524 [0.0041]
estimated value of (a - 1): -1.29605

test statistic: tau_c(1) = -9.26544
asymptotic p-value 7.109e-017

Step 3: cointegrating regression

Cointegrating regression -
OLS, using observations 08/04/02-09/05/26 (T = 300)
Dependent variable: d_bse

Coefficient	std. error	t-ratio	p-value	
const	-2.10372	19.3602	-0.1087	0.9135
d_dj	0.128919	0.0883250	1.460	0.1455

Mean dependent var	-3.775933	S.D. dependent var	335.3733
Sum squared resid	33391389	S.E. of regression	334.7412
R-squared	0.007098	Adjusted R-squared	0.003766
Log-likelihood	-2168.685	Akaike criterion	4341.371
Schwarz criterion	4348.779	Hannan-Quinn	4344.335
rho	0.062207	Durbin-Watson	1.872866

Step 4: testing for a unit root in uhat
Augmented Dickey-Fuller test for what
including 3 lags of (1-L)uhat
sample size 296
unit-root null hypothesis: a = 1
model: (1-L)y = bo + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff.for e: 0.002
lagged differences: F(3, 292) = 0.614 [0.6062]
estimated value of (a - 1): -1.0296
test statistic: tau_c(2) = -8.94109
asymptotic p-value 7.941e-015
There is evidence for a cointegrating relationship if:
(a) The unit-root hypothesis is not rejected for the individual variables.
(b) The unit-root hypothesis is rejected for the residuals (uhat) from the cointegrating regression.

Step 1: testing for a unit root in d_bse
Augmented Dickey-Fuller test for d_bse
including 3 lags of (1-L)d_bse
sample size 296
unit-root null hypothesis: a = 1
test with constant
model: (1-L)y = bo + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff.for e: 0.002
lagged differences: F(3, 291) = 0.498 [0.6838]
estimated value of (a - 1): -1.00705
test statistic: tau_c(1) = -8.81749
asymptotic p-value 1.747e-015

Step 2: testing for a unit root in d_nikkei
Augmented Dickey-Fuller test for d_nikkei
including 3 lags of (1-L)d_nikkei
sample size 296
unit-root null hypothesis: a = 1
test with constant
model: (1-L)y = bo + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff.for e: 0.003
lagged differences: F(3, 291) = 0.473 [0.7011]
estimated value of (a - 1): -1.15735
test statistic: tau_c(1) = -9.09202
asymptotic p-value 2.474e-016

Step 3: cointegrating regression
Cointegrating regression -
OLS, using observations 08/04/02-09/05/26 (T = 300)
Dependent variable: d_bse

coefficient	std. error	t-ratio	p-value	
const	-2.65238	19.3430	-0.1371	0.8910
d_nikkei	0.108492	0.0749453	1.448	0.1488

Mean dependent var	3.775933	S.D. dependent var	335.3733
Sum squared resid	33395266	S.E. of regression	334.7606
R-squared	0.006983	Adjusted R-squared	0.003651
Log-likelihood	- 2168.703	Akaike criterion	4341.406
Schwarz criterion	4348.813	Hannan-Quinn	4344.370
rh	0.047025	Durbin-Watson	1.903986

Step 4: testing for a unit root in uhat
Augmented Dickey-Fuller test for uhat
including 3 lags of (1-L)uhat
sample size 296
unit-root null hypothesis: a = 1
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff.for e: 0.002
lagged differences: F(3, 292) = 0.840 [0.4728]
estimated value of (a - 1): -1.05403
test statistic: tau_c(2) = -8.98887
asymptotic p-value 5.639e-015

There is evidence for a co integrating relationship if:
(a) The unit-root hypothesis is not rejected for the individual variables.
(b) The unit-root hypothesis is rejected for the residuals (uhat) from the
co integrating regression.

Step 1: testing for a unit root in d_bse
Augmented Dickey-Fuller test for d_bse
including 3 lags of (1-L)d_bse
sample size 296
unit-root null hypothesis: a = 1
test with constant
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff.for e: 0.002
lagged differences: F(3, 291) = 0.498 [0.6838]
estimated value of (a - 1): -1.00705
test statistic: tau_c(1) = -8.81749
asymptotic p-value 1.747e-015

Step 2: testing for a unit root in d_snp
Augmented Dickey-Fuller test for d_snp
including 3 lags of (1-L)d_snp
sample size 296
unit-root null hypothesis: a = 1
test with constant
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff.for e: 0.000
lagged differences: F(3, 291) = 4.088 [0.0073]
estimated value of (a - 1): -1.30697
test statistic: tau_c(1) = -9.26712
asymptotic p-value 7.024e-017

Step 3: cointegrating regression
Cointegrating regression -
OLS, using observations 08/04/02-09/05/26 (T = 300)
Dependent variable: d_bse

	coefficient	std. error	t-ratio	p-value
const	-2.29148	19.3659	-0.1183	0.9059
d_snp	1 .04111	0.764460	1.362	0.1743

Mean dependent var	-3.775933	S.D. dependent var	335.3733
Sum squared resid	33422089	S.E. of regression	334.8950
R-squared	0.006186	Adjusted R-squared	0.002851
Log-likelihood	-2168.823	Akaike criterion	4341.647
Schwarz criterion	4349.054	Hannan-Quinn	4344.611
rho	0.063294	Durbin-Watson	1.870671

Step 4: testing for a unit root in uhat
Augmented Dickey-Fuller test for uhat
including 3 lags of (1-L)uhat
sample size 296
unit-root null hypothesis: a = 1
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff.for e: 0.002
lagged differences: F(3, 292) = 0.609 [0.6097]
estimated value of (a - 1): -1.02752
test statistic: tau_c(2) = -8.93791
asymptotic p-value 8.124e-015

There is evidence for a cointegrating relationship if:
(a) The unit-root hypothesis is not rejected for the individual variables.
(b) The unit-root hypothesis is rejected for the residuals (uhat) from the cointegrating regression.

Step 1: testing for a unit root in d_bse
Augmented Dickey-Fuller test for d_bse
including 3 lags of (1-L)d_bse
sample size 296
unit-root null hypothesis: a = 1
test with constant
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff.for e: 0.002
lagged differences: F(3, 291) = 0.498 [0.6838]
estimated value of (a - 1): -1.00705
test statistic: tau_c(1) = -8.81749
asymptotic p-value 1.747e-015

Step 2: testing for a unit root in d_hanseng
Augmented Dickey-Fuller test for d_hanseng
including 3 lags of (1-L)d_hanseng
sample size 296
unit-root null hypothesis: a = 1
test with constant
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff.for e: 0.000
lagged differences: F(3, 291) = 1.191 [0.3133]
estimated value of (a - 1): -1.12355
test statistic: tau_c(1) = -9.36504
asymptotic p-value 3.461e-017

Step 3: cointegrating regression
Cointegrating regression -
OLS, using observations 08/04/02-09/05/26 (T = 300)
Dependent variable: d_bse

Coefficient	std. error	t-ratio	p-value	
Const	-4.38350	19.3715	-0.2263	0.8211
d_hanseng	-0.0419354	0.0415354	-1.010	0.3135

Mean dependent var -3.775933 S.D. dependent var 335.3733

Sum squared resid	33515464	S.E. of regression	335.3625
R-squared	0.003409	Adjusted R-squared	0.000065
Log-likelihood	-2169.242	Akaike criterion	4342.484
Schwarz criterion	4349.891	Hannan-Quinn	4345.448
rho	0.065276	Durbin-Watson	1.866553

Step 4: testing for a unit root in uhat
Augmented Dickey-Fuller test for uhat
including 3 lags of (1-L)uhat sample size 296
unit-root null hypothesis: a = 1
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff.for e: 0.003
lagged differences: F(3, 292) = 0.364 [0.7789]
estimated value of (a - 1): -0.976625
test statistic: tau_c(2) = -8.64211
asymptotic p-value 6.626e-014
There is evidence for a cointegrating relationship if:
(a) The unit-root hypothesis is not rejected for the individual variables.
(b) The unit-root hypothesis is rejected for the residuals (uhat) from the cointegrating regression.

Step 1: testing for a unit root in d_bse
Augmented Dickey-Fuller test for d_bse
including 3 lags of (1-L)d_bse
sample size 296
unit-root null hypothesis: a = 1
test with constant
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff.for e: 0.002
lagged differences: F(3, 291) = 0.498 [0.6838]
estimated value of (a - 1): -1.00705
test statistic: tau_c(1) = -8.81749
asymptotic p-value 1.747e-015

Step 2: testing for a unit root in d_stisingapur
Augmented Dickey-Fuller test for d_stisingapur
including 3 lags of (1-L)d_stisingapur
sample size 296
unit-root null hypothesis: a = 1
test with constant
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff.for e: 0.003
lagged differences: F(3, 291) = 1.467 [0.2235]
estimated value of (a - 1): -1.01741
test statistic: tau_c(1) = -8.86858
asymptotic p-value 1.216e-015

Step 3: cointegrating regression

Cointegrating regression - OLS, using observations 08/04/02-09/05/26 (T = 300)
Dependent variable: d_bse

coefficient std. error t-ratio p-value				
const	-3.14147	19.4089	-0.1619	0.8715
d_stisingapur	0.267017	0.426043	0.6267	0.5313

Mean dependent var	-3.775933	S.D. dependent var	335.3733
Sum squared resid	33585839	S.E. of regression	335.7144
R-squared	0.001316	Adjusted R-squared	-0.002035
Log-likelihood	-2169.556	Akaike criterion	4343.113
Schwarz criterion	4350.520	Hannan-Quinn	4346.077
rho	0.066256	Durbin-Watson	1.865242

Step 4: testing for a unit root in uhat
Augmented Dickey-Fuller test for uhat
including 3 lags of (1-L)uhat
sample size 296
unit-root null hypothesis: a = 1
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff.for e: 0.002
lagged differences: F(3, 292) = 0.513 [0.6734]
estimated value of (a - 1): -1.01697
test statistic: tau_c(2) = -8.91159
asymptotic p-value 9.806e-015
There is evidence for a co integrating relationship if:
(a) The unit-root hypothesis is not rejected for the individual variables.
(b) The unit-root hypothesis is rejected for the residuals (uhat) from the co integrating regression

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