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

Dr. P.P. Sengupta. Professor  
Department of Humanities and Social Sciences  
National Institute of Technology, Durgapur

Siddhartha Bhattacharya  
Assistant Professor  
FOM . DIMAT, Raipur

Ramakant Mishra, Professor  
FOM DIMAT, Raipur

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 (due to a dependence of food production on petroleum, as well as using food crop products such as ethanol and bio diesel as an alternative to petroleum) and global inflation; a substantial credit crisis leading to the drastic bankruptcy of large and well established investment banks as well as commercial banks in various, diverse nations around the world; increased unemployment; and signs of contemporaneous economic downturns in major economies of the world, a global recession. In December 2008, the NBER declared that the world’s largest economy, the United States, had been in recession since December 2007. Development of capital market across the world and in the emerging countries of Asia has resulted in growing economic integration among financial sectors of these countries. The inevitable outcome is co movement of stock markets of these countries. A significant responsibility can be attributed to the international investors who minimize their portfolio systematic risk for a particular asset class at a given rate of expected return by investing in these emerging markets. 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 interdependency is showing a robust growth rate as those countries are becoming more open to foreign capital investment. Last time when recession heat 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 experienced a sea change by 2008. The current global economic downturn has caused significant fall in the growth rate of major stock markets across the world. The paper has considered daily data of two financial years 2007-08 and 2008-09 for evaluation. Presuming the initial year as pre recessionary phase, 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.

INTRODUCTION

The global market meltdown has shaken all of us. The crux of this issue is attributed to significant mispricing 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 spill over 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 spill over 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. Kedar nath 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 labour 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 a pivotal 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.

**MODELING**

**Data**

Daily indices of five major countries USA (Dow Jones), Japan (Nikkei), UK (S&P 500), Hongkong (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.
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.

ESTIMATION AND ANALYSIS OF EMPIRICAL RESULTS

TABLE: 1 SUMMARY STATISTICS, USING THE OBSERVATIONS (08/04/01 - 09/06/17)\(^1\)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std. Dev.</th>
<th>C.V.</th>
<th>Skewness</th>
<th>Ex. kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>d_BSE</td>
<td>-3.77593</td>
<td>-2.94000</td>
<td>-1070.63</td>
<td>2110.79</td>
<td>335.373</td>
<td>88.8187</td>
<td>0.760220</td>
<td>4.60179</td>
</tr>
<tr>
<td>d_Nekkei</td>
<td>-10.3560</td>
<td>-4.64500</td>
<td>-1089.02</td>
<td>1171.14</td>
<td>258.318</td>
<td>24.9437</td>
<td>-0.227347</td>
<td>2.85158</td>
</tr>
<tr>
<td>d_S&amp;P 500</td>
<td>-1.42583</td>
<td>0.595000</td>
<td>-106.850</td>
<td>104.130</td>
<td>25.3349</td>
<td>17.7685</td>
<td>-0.192745</td>
<td>2.56852</td>
</tr>
<tr>
<td>d_Hanseng</td>
<td>-14.4881</td>
<td>0.000000</td>
<td>-1602.54</td>
<td>1695.27</td>
<td>466.939</td>
<td>32.2291</td>
<td>0.208877</td>
<td>1.41738</td>
</tr>
<tr>
<td>d_stisingapur</td>
<td>-2.25759</td>
<td>-2.79500</td>
<td>-154.380</td>
<td>139.860</td>
<td>44.9284</td>
<td>19.9010</td>
<td>0.0998211</td>
<td>1.03936</td>
</tr>
</tbody>
</table>

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.

TABLE: 2: CORRELATION COEFFICIENTS, USING THE OBSERVATIONS 08/04/01 – 09/06/17

(Missing Values Were Skipped)

5% Critical Value (Two-Tailed) = 0.1102 for N = 317

\(^1\) (Missing values were skipped)
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.

<table>
<thead>
<tr>
<th>In</th>
<th>Lag length</th>
<th>ADF Statistics</th>
<th>p-value</th>
<th>Deterministic term</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSE</td>
<td>0</td>
<td>-0.439034</td>
<td>0.9857</td>
<td>constant and trend</td>
</tr>
<tr>
<td>DJ</td>
<td>0</td>
<td>-1.841</td>
<td>0.6824</td>
<td>constant and trend</td>
</tr>
<tr>
<td>Nikkei</td>
<td>0</td>
<td>-1.09492</td>
<td>0.9271</td>
<td>constant and trend</td>
</tr>
<tr>
<td>SNP</td>
<td>0</td>
<td>-1.51412</td>
<td>0.823</td>
<td>constant and trend</td>
</tr>
<tr>
<td>Hanseng</td>
<td>0</td>
<td>-0.64511</td>
<td>0.9753</td>
<td>constant and trend</td>
</tr>
<tr>
<td>STI</td>
<td>0</td>
<td>-0.0355935</td>
<td>0.9957</td>
<td>constant and trend</td>
</tr>
</tbody>
</table>

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

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

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 order 1 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.

<table>
<thead>
<tr>
<th>Decomposition of variance for d_bse</th>
<th>period</th>
<th>std. error</th>
<th>d_bse</th>
<th>d_dj</th>
<th>d_nikkei</th>
<th>d_snp</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>324.542</td>
<td>100.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
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<tr>
<td></td>
<td>2</td>
<td>329.532</td>
<td>97.6639</td>
<td>0.1365</td>
<td>0.3814</td>
<td>0.4952</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>331.331</td>
<td>96.7808</td>
<td>0.3899</td>
<td>0.3781</td>
<td>0.5069</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>334.082</td>
<td>95.2050</td>
<td>0.4625</td>
<td>0.3769</td>
<td>0.8372</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>334.413</td>
<td>95.0180</td>
<td>0.5217</td>
<td>0.3764</td>
<td>0.8427</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>334.815</td>
<td>94.8346</td>
<td>0.5406</td>
<td>0.4706</td>
<td>0.8453</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>335.058</td>
<td>94.7350</td>
<td>0.5764</td>
<td>0.4703</td>
<td>0.8822</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Decomposition of variance for d_bse (continued)</th>
<th>period</th>
<th>d_hanseng</th>
<th>d_stisingapur</th>
</tr>
</thead>
</table>

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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.
REFERENCES


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

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-ratio</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>const</td>
<td>-1.72897</td>
<td>19.731</td>
<td>-0.0875</td>
<td>0.93024</td>
</tr>
<tr>
<td>d_bse_1</td>
<td>0.0585506</td>
<td>0.0605024</td>
<td>0.9677</td>
<td>0.33402</td>
</tr>
<tr>
<td>d_bse_2</td>
<td>-0.0361075</td>
<td>0.0624295</td>
<td>-0.5784</td>
<td>0.56348</td>
</tr>
<tr>
<td>d_bse_3</td>
<td>-0.00860656</td>
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</tr>
<tr>
<td>d_dj_1</td>
<td>-0.799673</td>
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<td>-1.3085</td>
<td>0.19178</td>
</tr>
<tr>
<td>d_dj_2</td>
<td>-0.154298</td>
<td>0.607487</td>
<td>-0.2540</td>
<td>0.79969</td>
</tr>
<tr>
<td>d_dj_3</td>
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</tr>
<tr>
<td>d_nikkei_1</td>
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<td>0.895</td>
<td>0.37150</td>
</tr>
<tr>
<td>d_nikkei_2</td>
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<tr>
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<tr>
<td>d_snp_1</td>
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<td>5.29061</td>
<td>1.4779</td>
<td>0.14055</td>
</tr>
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<td>d_snp_2</td>
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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

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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_sn            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

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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_sn: \( F(3, 278) = 0.82871 \) [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

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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

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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

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<td>0.55996</td>
</tr>
<tr>
<td>d_bse_3</td>
<td>0.00275385</td>
<td>0.00697513</td>
<td>0.3948</td>
<td>0.69329</td>
</tr>
<tr>
<td>d_dj_1</td>
<td>0.08258</td>
<td>0.0647211</td>
<td>1.2759</td>
<td>0.20304</td>
</tr>
<tr>
<td>d_dj_2</td>
<td>-0.0500478</td>
<td>0.0064353</td>
<td>-0.7237</td>
<td>0.46989</td>
</tr>
<tr>
<td>d_dj_3</td>
<td>-0.000131015</td>
<td>0.0635881</td>
<td>-0.0021</td>
<td>0.99836</td>
</tr>
<tr>
<td>d_nikkei_1</td>
<td>0.00669278</td>
<td>0.00898276</td>
<td>0.7451</td>
<td>0.45686</td>
</tr>
<tr>
<td>d_nikkei_2</td>
<td>0.0229608</td>
<td>0.00873783</td>
<td>2.6278</td>
<td>0.00907 ***</td>
</tr>
<tr>
<td>d_nikkei_3</td>
<td>-0.020399</td>
<td>0.00873052</td>
<td>-2.3365</td>
<td>0.02018 **</td>
</tr>
<tr>
<td>d_snp_1</td>
<td>-0.169354</td>
<td>0.560297</td>
<td>-0.3023</td>
<td>0.76268</td>
</tr>
<tr>
<td>d_snp_2</td>
<td>0.964855</td>
<td>0.562122</td>
<td>1.7165</td>
<td>0.08719 *</td>
</tr>
<tr>
<td>d_snp_3</td>
<td>0.303098</td>
<td>0.557014</td>
<td>0.5441</td>
<td>0.58678</td>
</tr>
<tr>
<td>d_hanseng_1</td>
<td>0.0098787</td>
<td>0.00485841</td>
<td>2.0333</td>
<td>0.04297 **</td>
</tr>
<tr>
<td>d_hanseng_2</td>
<td>0.0260583</td>
<td>0.00509597</td>
<td>5.1135</td>
<td>&lt;0.00001 ***</td>
</tr>
<tr>
<td>d_hanseng_3</td>
<td>0.0313635</td>
<td>0.00525448</td>
<td>5.9689</td>
<td>&lt;0.00001 ***</td>
</tr>
<tr>
<td>d_stisingapur_1</td>
<td>-0.268348</td>
<td>0.0542798</td>
<td>-4.9438</td>
<td>&lt;0.00001 ***</td>
</tr>
<tr>
<td>d_stisingapur_2</td>
<td>-0.0417713</td>
<td>0.0504732</td>
<td>-0.8276</td>
<td>0.40861</td>
</tr>
<tr>
<td>d_stisingapur_3</td>
<td>-0.0860231</td>
<td>0.0465872</td>
<td>-1.8466</td>
<td>0.06588 *</td>
</tr>
</tbody>
</table>

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 = 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_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 = b0 + (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: Co Integrating Regression

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

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>std. error</th>
<th>t-ratio</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>const</td>
<td>-2.10372</td>
<td>19.3602</td>
<td>-0.1087</td>
</tr>
<tr>
<td>d_dj</td>
<td>0.128919</td>
<td>0.0883250</td>
<td>1.460</td>
</tr>
</tbody>
</table>

Mean dependent var -3.775933  
S.D. dependent var 335.3733  
Sum squared resid 33391389  
S.E. dependent var 334.7412  
R-squared 0.007098  
Adjusted R-squared 0.003766  
Log-likelihood -2168.685  
Akaike criterion 4341.371  
Schwarz criterion 4344.335  
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 = b0 + (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 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_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 = b0 + (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

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>std. error</th>
<th>t-ratio</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Const</td>
<td>-2.65238</td>
<td>19.3430</td>
<td>-0.1371</td>
</tr>
<tr>
<td>d_nikkei</td>
<td>0.108492</td>
<td>0.0749453</td>
<td>1.448</td>
</tr>
</tbody>
</table>

Mean dependent var -3.775933  S.D. dependent var 335.3733
Sum squared resid 3395266  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
rho 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 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 (\( \hat{u} \)) 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_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

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>std. error</th>
<th>t-ratio</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>const</td>
<td>-2.29148</td>
<td>19.3659</td>
<td>-0.1183</td>
</tr>
<tr>
<td>d_snp</td>
<td>1.04111</td>
<td>0.764460</td>
<td>1.362</td>
</tr>
</tbody>
</table>

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: \((1-L)y = b_0 + (a-1)y(-1) + \ldots + e\)  
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 \( d_{\text{hanseng}} \)**

Augmented Dickey-Fuller test for \( d_{\text{hanseng}} \)  
Including 3 lags of \((1-L)d_{\text{hanseng}}\)  
sample size 296  
Unit-root null hypothesis: \( a = 1 \)

Test with constant  
Model: \((1-L)y = b_0 + (a-1)y(-1) + \ldots + e\)  
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: \( d_{\text{bse}} \)

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>std. error</th>
<th>t-ratio</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Const</td>
<td>-4.38350</td>
<td>-0.2263</td>
<td>0.8211</td>
</tr>
<tr>
<td>( d_{\text{hanseng}} )</td>
<td>-0.0419354</td>
<td>-1.010</td>
<td>0.3135</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>std. error</th>
<th>t-ratio</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Const</td>
<td>-3.14147</td>
<td>19.4089</td>
<td>-0.1619</td>
</tr>
<tr>
<td>d_stisingapur</td>
<td>0.267017</td>
<td>0.426043</td>
<td>0.6267</td>
</tr>
</tbody>
</table>

Mean dependent var -3.775933
Sum squared resid 33585839
R-squared 0.001316
Log-likelihood -2169.556
Schwarz criterion 4350.520
rho 0.066256

S.D. dependent var 335.3733
S.E. of regression 335.7144
Adjusted R-squared -0.002035
Akaike criterion 4343.113
Hannan-Quinn 4346.077
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.