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ASSOCIATION AMONG STOCK INDICES OF BOMBAY STOCK EXCHANGE - APPLICATION OF COINTEGRATION AND VECM

Prof. Pushpa M. Savadatti
Department of Economic Studies & Planning
School of Business Studies, Central University of Karnataka
Kadaganchi, Kalburgi, Karnataka, India

ABSTRACT

Established in 1875 Bombay Stock Exchange is the Asia's premier stock exchange and it is growing at a fast rate. BSE has played an important role in developing the Indian Capital Market. The present study explored the possible association between six indices of BSE namely S&P BSE all cap, large cap, large mid cap, mid cap, mid small cap and small cap based on the monthly closing prices for the period September 2005 to March 2018. The Augmented Dicky Fuller and Phillips-Perron tests indicated that the time series under consideration are I(1) and Johansen Cointegration test revealed that there exists one cointegration among the selected six indices. Vector Error Correction Model results showed the existence of long run association between All cap index and remining five sub-indices. All the sub-indices influence the all cap index positively and significantly but large cap's influence is stronger in magnitude compared to other indices. Error term is having expected negative sign indicating that the disequilibrium is corrected during the short run. The estimated model satisfied all the model adequacy tests.

Key words: S&P BSE all cap index, Stationarity, Cointegration, Heteroskedasticity

INTRODUCTION

BombayStock Exchange (BSE) is one of the important stock exchange in Asia and it is one of the world's fastest growing stock market. BSE is playing an important role in the development of Indian Economy through the development of Indian Capital Market. In 2015

Asia Index Private Limited launched the S&P BSE All Cap Index Family which was further divided into five size-based indices comprising of S&P Large Cap, S&P Mid Cap, S&P Large Mid Cap, S&P Small Cap and S&P Mid Small Cap (bseindia.com). The present study intends to study how these five new sub-indices influence the S&P all cap indices. For this purpose, the monthly closing prices of S&P BSE all cap, large cap, large mid cap, mid cap, mid small cap and small cap have been collected to study the association between these six indices which would be of great importance to the investors, companies, policy makers and regulators. The popular technique developed by Engel & Granger has been applied for the present analysis.

LITERATURE REVIEW

Cointegration (COI) technique developed by Engle and Granger (1987) is a very powerful technique for studying the long run association and short run dynamics among the variables. Lot of work have been done by the researcher using this technique and contributed to the literature. Wong, Penn, Terrel & Lim (2004) studied the relationship between stock markets of the developed countries and Asian emerging markets with the help of COI technique and found that there existed co-movement between the selected stock markets but there was difference between the emerging markets and developed markets with respect to the long run equilibrium relationship.Narayan & Smyth (2005) attempted to study whether the New Zealand equity market was integrated with the equity markets of Australian and G7 economies applying COI technique and results showed that New Zealand stock market is cointegrated with US stock market but not with stock markets of G7 economies.Huang, Yang & Hu (2000) explored the causality and cointegration of stock markets between US, Japan and South China applying COI technique, unit root technique, etc., and found that there was no cointegration between these markets except between Shanghai and Shenzhen. Mohanasundaram & Karthikeyan (2015) aimed at exploring the possibility of short-run and long-run relationship between the stock indices of India, US and South Africa using different techniques like correlation, Granger -Causality test and JCOI test and Vector Auto Regressive model and the results suggested the absence of long run association between selected stock markets.Liu, Song & Romilly (1997) examined the relationship between two share indices Shanghai & Shenzhen stock exchanges of China and COI technique suggested for the existence of long run equilibrium relationship between two stock prices. The COI technique had also been applied in literature to test the association between agricultural prices

of different commodities and supply response of the agricultural commodities (Burark, Sharma & Meena, 2013, Ajjan Shajeena & Raveendaran, 2013, Savadatti, 2018). The insight obtained by reviewing some of the articles which used COI technique had enabled us to have the theoretical background for the present study which is presented below.

RESEARCH METHODOLOGY

Data Description

The main purpose of the present analysis is to explore the possibility of association between S&P BSE all cap index and its subcomponents mainly S&P BSE large cap, S&P BSE large mid cap, S&P BSE mid cap, S&P BSE mid small cap and S&P BSE small cap indices. For this purpose, the monthly closing prices of all the above mentioned six indices were collected from the BSE web site- bseindia.com for the period September 2005 to March 2018 resulting into 152 observations for each of the index.

Theoretical Model

The first step towards time series analysis is to check the collected data for stationarity test using Augmented Dicky Fuller (ADF,1979) test and Phillips-Perron (PP,1989) test. If the series are stationary and integrated of order one i.e., I(1) then the Johansen Cointegration (JOC, 1991) test is used to test for the long run relationship between the different selected BSE S&P indices.The model used in Johansen's method is stated below(Maggiora&Skerman, 2009)

$$\Delta Y_t = \delta_i + \sum_{i=1}^{n} \gamma_i \Delta y_{t-i} + \beta \emptyset' Y_{t-1} + \epsilon_t$$

Where

$Y_t = nx1\ vector\ of\ nonstationary\ timeseries\ data$

$\gamma_i = coefficient\ matrix\ of\ order\ n\ x\ n$

$\beta = error\ correction\ coefficients\ matirx\ of\ order\ n\ x\ r$

$\emptyset = matrix\ of\ order\ nxr\ (r\ cointegrating\ vectors)$

Maximum likelihood method is used in the Johansen process. Two tests namely Trace test and Maximum Eigenvalue test are suggested for findingcointegration between the series. The null and alternative hypotheses under Trace tests are as follows

H_0 = no cointegrating vectors (r=0)

$H_1 = cointegrating\ vector\ exists\ (r > 0)$

Similarly, the hypotheses to be tested under Maximum Eigenvalue test are

$H_0 = number\ of\ COI\ vector\ is\ r$

$H_1 = number\ of\ COI\ vector\ is\ r + 1$

If the trace and maximum eigen value tests suggest the existence of COI relationship among the selected series then the Vector Error Correction Model (VECM) is employed to estimate the cointegrating coefficients and error correction term. The lag length criteria for the analysis is based on the Schwarz Information criteria (SIC) and Akaike Information Criteria (AIC). The estimated VEC model will be stated for adequacy based on the LM test, Heteroskedasticity test, normality test, etc.

RESULTS AND DISCUSSIONS

The time series collected for the six S&P indices are first tested for the stationarity using the ADF and PP tests and the results are presented in Table 1 and 2.

Table 1: Augmented Dicky-Fuller Unit Root Test Results

Monthly Closing Prices		t- statistic	Prob*	Test critical values		
				1%	5%	10%
S&P BSE All Cap Index	at levels	-0.304767	0.9202	-3.474265	-2.880722	-2.577077
	1st diff	-11.30959	0.0000	-3.474567	-2.880853	-2.577147
S&P BSE Large Cap Index	at levels	-0.651583	0.8542	-3.474265	-2.880722	-2.577077
	1st diff	-12.01463	0.0000	-3.474567	-2.880853	-2.577147
BSE Large Mid Cap Index	at levels	-0.425114	0.9007	-3.474265	-2.880722	-2.577077
	1st diff	-11.66827	0.0000	-3.474567	-2.880853	-2.577147
BSE Mid Cap Index	at levels	0.095526	0.9644	-3.474265	-2.880722	-2.577077
	1st diff	-10.34242	0.0000	-3.474567	-2.880853	-2.577147
BSE Mid Small Cap Index	at levels	-0.247945	0.9748	-3.474265	-2.880722	-2.577077
	1st diff	-10.26785	0.0000	-3.474567	-2.880853	-2.577147
BSE Small Cap Index	at levels	-0.404392	0.9043	-3.474265	-2.880722	-2.577077
	1st diff	-11.06076	0.0000	-3.474567	-2.880853	-2.577147

*MacKinnon (1996) one-sided p-values. Source: Data Analysis

Table 2: Phillips-Perron Unit Root Test Results

Monthly Closing Prices		Adjt- stat	Prob*	Test critical values		
				1%	5%	10%
S&P BSE All Cap Index	at levels	-0.388633	0.9069	-3.474265	-2.880722	-2.577077
	1st diff	-11.30427	0.0000	-3.474567	-2.880853	-2.577147
S&P BSE Large Cap Index	at levels	-0.699151	0.8427	-3.474265	-2.880722	-2.577077
	1st diff	-12.01680	0.0000	-3.474567	-2.880853	-2.577147
BSE Large Mid	at levels	-0.471539	0.8922	-3.474265	-2.880722	-2.577077

Cap Index	1st diff	-11.6705	0.0000	-3.474567	-2.880853	-2.577247
BSE Mid Cap Index	at levels					
	1st diff					
BSE Mid Small Cap Index	at levels	0.106058	0.9653	-3.474265	-2.880722	-2.577077
	1st diff	-10.27557	0.0000	-3.474567	-2.880853	-2.577147
BSE Small Cap Index	at levels	-0.62333	0.8608	-3.474265	-2.880722	-2.577077
	1st diff	-11.07304	0.0000	-3.474567	-2.880853	-2.577147
*MacKinnon (1996) one-sided p-values. Source: Data Analysis						

Table 1 presents the ADF test results for closing prices of all the six BSE indices. It is clear from the table that all the series are non-stationary at levels as the calculated ADF test statistics are less than the critical values at 1%, 5% and 10% level. The series are stationary at first difference as the estimated value of ADF test statistic is greater than the critical values at 1% level of significance in all the six indices. Hence, it may be concluded that the monthly closing prices are integrated of order 1 i.e., I(1) according to ADF test. The PP test results are presented in Table 2. Careful observation of the results in Table 2 indicate that all the calculated adj-t statistics are less than critical values at 1% and 5% level at level series but greater than 1% level at first difference confirming the fact that all the six indices monthly closing prices are I(1) which is a prerequisite for the JCOI analysis.The next step is to check for the existence of cointegration among the monthly closing prices of six BSE indices. The JCOI test consists of trace test and maximum eigen value test and the results are shown in Table 3 and 4.

Table 3: Johansen Cointegration Results – Trace Test

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	Prob.**
None *	119.5527	95.75366	0.0005
At most 1	64.37529	69.81889	0.1259
At most 2	33.98922	47.85613	0.5025
At most 3	14.01977	29.79707	0.8395
At most 4	4.653001	15.49471	0.8445
At most 5	0.128233	3.841466	0.7203
Trace test indicates 1 cointegratingeqn(s) at the 0.05 level			
* denotes rejection of the hypothesis at the 0.05 level			
**MacKinnon-Haug-Michelis (1999) p-values ; Source: Data Analysis			

Table 4: Johansen Cointegration Results Max-Eigenvalue Test			
Hypothesized No. of CE(s)	**Max-Eigen Statistic**	**0.05 Critical Value**	**Prob.****
None *	55.17738	40.07757	0.0005
At most 1	30.38608	33.87687	0.1234
At most 2	19.96944	27.58434	0.3433
At most 3	9.366770	21.13162	0.8018
At most 4	4.524768	14.26460	0.8002
Trace test indicates 1 cointegratingeqn(s) at the 0.05 level			
* denotes rejection of the hypothesis at the 0.05 level			
**MacKinnon-Haug-Michelis (1999) p-values ; Source: Data Analysis			

The trace test results (Table 3) show that there exists one cointegrating equation at 5% level as the probability is< 0.01. The trace statistic is greater than the critical value at 5% level of significance resulting into rejection of null hypothesis of no cointegration. The maximum eigentest also suggests for the presence of one cointegrating equation as the maximum eigen statistic is greater than the critical value at 1 % level of significance. Thus both trace test and maximum eigen value test suggest that there exists one cointegration equation among the monthly closing prices of six BSE indices. This suggests that monthly closing prices of the six BSE indices are having long run equilibrium relationship and in order to understand the short run and long run association among the BSE indices and to know the speed of adjustment among the indices' closing prices VECM was employed. The results of the VECM are shown in Table 5 and6.

Table 5: Normalised Cointegrating Coefficients			
Index	**Coefficient**	**Standard Error**	**t-statistics**
S&P BSE All Cap	1.000000		
S&P BSE Large Cap	-0.528633	0.04789	-11.0377
BSE Large Mid Cap	-0.200923	0.05506	-3.64884
BSE Mid Cap	-0.009865	0.00269	-3.66490

BSE Mid Small Cap	-0.204543	0.01941	-10.5367
BSE Small Cap	-0.010930	-0.006073	-3.95357

Signs are reversed due to normalisation process.
Source: Data Analysis

Table 6: Error Correction (Speed of Adjustment)

Error Correction:	*D(BACCL)	D(BLCL)	D(BLMIDCL)	D(BMCL)	D(BMSCL)	D(BSCL)
Cointegrating Equation	-0.554438	0.134824	-0.229034	1.559491	-1.562820	-8.589259
Standard Error	(3.96993)	(3.96806)	(4.08130)	(16.3517)	(4.34339)	(22.2150)
t-statistics	[-0.13966]	[0.03398]	[-0.05612]	[0.09537]	[-0.35982]	[-0.38664]

*:D=differenced once; BACCL =BSE all cap closing price; BLCL= BSE Large cap closing price; BLMIDCL= BSE large mid cap closing price; BMCL= BSE mid cap closing price: BMSCL= BSE mid small closing price ; BSCL= BSE small cap closing price
Source: Data Analysis

Normalised coefficients estimated in the VECM help us to analyse the adjustment process of the indices in the long run. The results are normalised on the BES all cap index. The signs are reversed as a result of the normalisation process. All the five indices large cap, large mid cap, mid cap, mid small cap and small cap have excepted sign and statistically significant as it is evident from the high values of the t-statistics (Table 5). In the long run (study period) all the five indices influence positively the closing prices of all cap index. Monthly closing prices of BSE all cap index is significantly influenced by the closing prices of large cap in magnitude followed by monthly closing prices of mid small cap and large mid cap indices. Mid cap index influence is very small in magnitude.

The error correction term indicates the speed of adjustment back to the equilibrium. The results are presented in Table 6. It is interesting to observe that all the error correction terms are not statistically significant hence, indicating weakly exogenous to the system.

The results of VECM revealed that there exists long run relationship between the BSE all cap index and large, large mid, mid, mid small and small cap indices. All these indices influence positively and significantly the all cap index during the study period. But short run dynamics

indicate that the cointegrating term is having expected negative sign in case of all cap but not statistically significant indicating weak exogeneity in short run.

The model adequacy tests have been done to check how best the model is fitted to the data. The results are presented in Table 7.

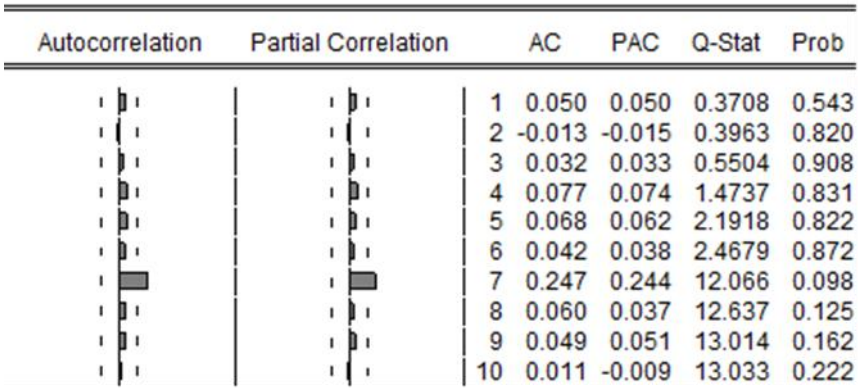
Table 7: Model Adequacy Tests

Breusch-Godfrey Serial Correlation LM Test			
F-statistic	0.670056	Prob. F(2,132)	0.5134
Obs*R-squared	1.487449	Prob. Chi-Square(2)	0.4753
Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.902272	Prob. F(18,129)	0.5769
Obs*R-squared	16.54943	Prob. Chi-Square(18)	0.5543
Normality Test			
Jarque-Bera Test	3.583708	Probability	0.166651

Source: Data Analysis

It may be observed from Table 7 that Serial Correlation LM test revealed the absence of the problem as the probability is > 0.05 hence, fail to reject null hypothesis. In case of Heteroskedasticity test also probability is high enough to enable us to accept the null hypothesis of no heteroskedasticity. The Jarque-Bera Test indicated that the residuals are normally distributed. Hence all the tests showed that the residuals satisfy the assumptions. The correlogram of the squared residuals are presented in Figure 1 depicts the absence of serial correlation among squared residuals as all the autocorrelations and partial autocorrelations are statistically insignificant due to high probability value. The model stability test is done using Cusum test and the results are presented in Figure 2.

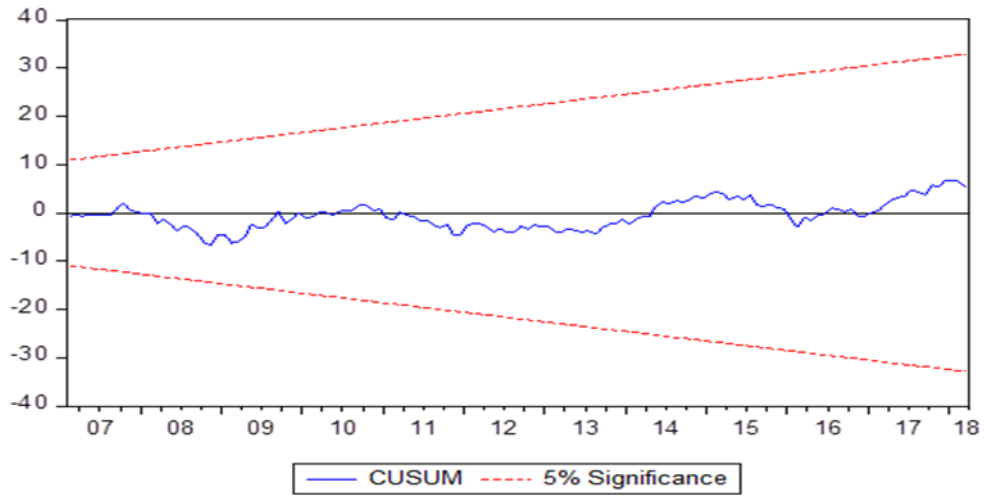
Figure 1: Correlogram of Squared Residuals



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.050	0.050	0.3708	0.543
		2	-0.013	-0.015	0.3963	0.820
		3	0.032	0.033	0.5504	0.908
		4	0.077	0.074	1.4737	0.831
		5	0.068	0.062	2.1918	0.822
		6	0.042	0.038	2.4679	0.872
		7	0.247	0.244	12.066	0.098
		8	0.060	0.037	12.637	0.125
		9	0.049	0.051	13.014	0.162
		10	0.011	-0.009	13.033	0.222

Source: Data Analysis

Figure 2: Model Stability Test



Source: Data Analysis

Figure 2 shows that the estimated VEC model is dynamically stable according to Cusum test as the blue trend line is within the 5% level interval (red lines). Hence, all the model adequacy tests are satisfied by the estimated VEC model hence, it may be concluded that the model fits fairly well to the data.

CONCLUSION

The present analysis made an attempt to understand how the S&P BSE all cap index monthly closing prices are influenced by the movements in the monthly closing prices of the sub category indices especially large cap, large mid cap, mid cap, mid small cap and small cap. For this purpose all the series under consideration are tested for stationarity and found that series are I(1) and hence applied JCOI test which revealed the presence of one COI relationship between the selected indices. VEC model was used to study the long run and short run dynamics between the closing prices of these indices and results obtained revealed that there existed strong long run association between the all cap index closing price and all other sub indices' closing prices during the study period. Monthly closing prices of BSE all cap index is significantly influenced by the closing prices of large cap in magnitude followed by monthly closing prices of mid small cap and large mid cap indices. Mid cap index influence is very small in magnitude. The short run dynamics showed that COI terms are having expected negative sign but not significant. The 55 percent of the correction in the disequilibrium in the closing prices of all cap index is corrected during one month. The estimated model is fitted fairly well to the data as the model adequacy tests are satisfied.

These results are of importance to stake holders of the stock market, policy makers, investors and regulators.

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