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Investigating Cointegration between Some Indian Stock Indices

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Abstract— In recent years researchers have taken keen interest in studying the long term relationships between stock markets of different nations and many studies have also been done on the cointegration of stock indices with major macroeconomic variables. In this study I have tried to investigate the possibility of cointegration between four indices of Indian stock market viz. CNX Small Cap, CNX Mid Cap, CNX Nifty, and CNX Nifty 500. All these indices have different market capitalization and it will be of great interest to study their co movement over a long period of time. I have used Engle-Granger test and Johansen Cointegration test for testing the presence long term relationships among the chosen indices. Results confirm the presence of at least one cointegrating relationship between the four indices.

Index Terms— Cointegration of Indian stock markets, Co movement, Engle-Granger test, Johansen test of cointegration, Long term relationship, Unit root test, Non-stationary variables.

1 INTRODUCTION

Most of the financial variables, especially stock index series are non-stationary. When we try to establish a linear relationship between these variables using Ordinary Least Squares (OLS) method, we get spurious regression and hence misleading results. For several years this problem was dealt with by first making the data series stationary by taking appropriate number of differences and then applying OLS. This method works very well until we come across situations where a linear combination of the variables (at level) becomes stationary, which ordinarily is always non-stationary. So, applying the above method to this situation will again give us misleading results as the linear combination of the variables, after they are made stationary by taking differences, will be again non-stationary. This situation gives way to the concept of cointegration. Two or more predictive variables in a time-series model are cointegrated when they share a common stochastic drift i.e. their linear combination produces a stationary time series. In this study I would like to search for possible cointegration between different stock indices of Indian market.

I have considered four stock market indices in my study viz. CNX Small Cap, CNX Mid Cap, CNX Nifty, and CNX Nifty 500. All the four indices have different level of market representation and if any sort of long term relationship can be identified between these indices, it may indicate the violation of Efficient Market Hypothesis and may also suggest that the indices are being driven by similar market forces. Market inefficiency allows investors to take informed decisions and earn big gains.

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2 LITERATURE REVIEW AND OBJECTIVE

Interdependencies of various markets and financial variables were studied just on the basis of short-run correlation analysis till Granger [9] came up with the notion of long term relationships which is called cointegration. Since then various works have been done in this direction to improve and develop the theory of cointegration. Johansen [12], [13] introduced improved methodologies for estimating and testing multivariate cointegrations.

Numerous research works have been done on the cointegration of Indian stock indices with various stock indices of other developing and developed countries. Kasa [14] used Johansen's cointegration test to study the linkages of stock markets and found strong evidence for a single common trend in the markets of the US, Japan, Germany, Britain and Canada for the period 1974-1990. Various studies [17], [14], [4] have proved long-term stocks co-movements among some developed equity markets. Mishra [20] approved of a correlation between NASDAQ index and the BSE index but found no cointegrating vector between the two. Subha and Nambi [22] used Engle Granger test of cointegration to study cointegration between Indian and American stock markets and confirmed absence of significant cointegration between the two markets. Ali et al. [1] found short-run correlations between the stock market of Pakistan with those of India, China, Indonesia, Singapore, Taiwan, Malaysia, Japan, USA and UK but failed to find any significant cointegration between these stock markets. In recent years cointegration of stock indices with major macroeconomic variables has also been a centre of attraction for researchers all over the world. Gulati & Kakhani [10] used Granger causality test to determine relationships between INR/$ exchange rate and some Indian stock market indices but could not find any significant relationship. Singh [21] explored the causal relationship between BSE Sensex and three key macroeconomic variables viz. Wholesale Price Index (WPI), Index of Industrial Production (IIP) and Exchange rate INR/$, using the Granger Causality test. He concluded that

IIP was the only variable having bilateral causal relationship with BSE Sensex. Malarvizhi & Jaya [18] studied the co movement of CNX Nifty index and INR/USD Exchange rate and found a bidirectional causal relationship between the two variables.

However, not much has been said about the long term relationship between different Indian stock indices. Globally, it has been observed that the large cap, mid cap and small cap indices behave differently and there is a significant difference in the volatility of these indices with small cap indices being the most volatile and large cap indices being the least volatile. In this study I have tried to investigate if there is any long term relationship or cointegration between four Indian stock market indices viz. CNX Small cap, CNX Mid cap, CNX Nifty, and CNX Nifty 500, which have entirely different market capitalization. Presence of cointegration will imply that certain market forces affect these indices in such a way that long term equilibrium is established between these indices.

3 Data and Time Period of Study

Monthly closing prices of CNX Small cap, CNX Mid cap, CNX Nifty, and CNX Nifty 500 for the period 30 Jan 2004 to 29 June 2012 have been downloaded from the website of Yahoo Finance. All the calculations for cointegration analysis have been done on the natural logarithm of the index series which makes mathematical sense as all the indices show monotonous non-linear pattern.

4 Methodology

4.1 Unit Root Test

I have used the Augmented Dickey Fuller test for testing whether the index series are non-stationary. The test is based on the null hypothesis that the given series is non-stationary and so significant p-value concludes non-stationarity of the concerned series. This test is necessary before applying the tests of cointegration as we cannot talk about cointegration of stationary series.

4.2 Engle – Granger Cointegration Test

Let us consider the following regression in k I(1) variables (one dependent and k-1 independent),

$$Y_t = B_1 + B_2X_{2t} + B_3X_{3t} + \ldots + B_kX_{kt} + u_t \quad (1)$$

For these k variables to be cointegrated, the residual u_t should be I(0), but u_t will be non-stationary if the variables are not cointegrated. Thus after fitting the above regression, it is necessary to test whether the residuals are stationary or non-stationary. The ADF test can be used for this purpose.

4.3 Johansen Cointegration Test

If g (g ≥ 2) I(1) variables are considered to be cointegrated, a VAR with k lags containing these variables could be set up as follows:

$$\underset{g\times 1}{y_t} = \underset{g\times g}{\beta_1}\underset{g\times 1}{y_{t-1}} + \underset{g\times g}{\beta_2}\underset{g\times 1}{y_{t-2}} + \cdots + \underset{g\times g}{\beta_k}\underset{g\times 1}{y_{t-k}} + \underset{g\times 1}{u_t} \quad (2)$$

This VAR is then turned into a Vector Error Correction Model (VECM) of the form

$$\Delta y_t = \Pi y_{t-k} + \Gamma_1\Delta y_{t-1} + \Gamma_2\Delta y_{t-2} + \cdots + \Gamma_{k-1}\Delta y_{t-(k-1)} + u_t \quad (3)$$

, where

$$\Pi = \left(\sum_{i=1}^{k}\beta_i\right) - I_g \quad \text{and} \quad \Gamma_i = \left(\sum_{j=1}^{i}\beta_j\right) - I_g$$

Johansen test can be affected by the lag length employed in the VECM and so it is useful to first select the lag length optimally using some lag length criteria. The Johansen test centers on an examination of the Π matrix which is interpreted as a long run coefficient matrix. The test of cointegration between the y variables is based on the rank of this Π matrix which is equal to the number of non zero eigenvalues or characteristic roots. Johansen test consists of two test statistics given as

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{g}\ln\left(1-\hat{\lambda}_i\right) \quad (4)$$

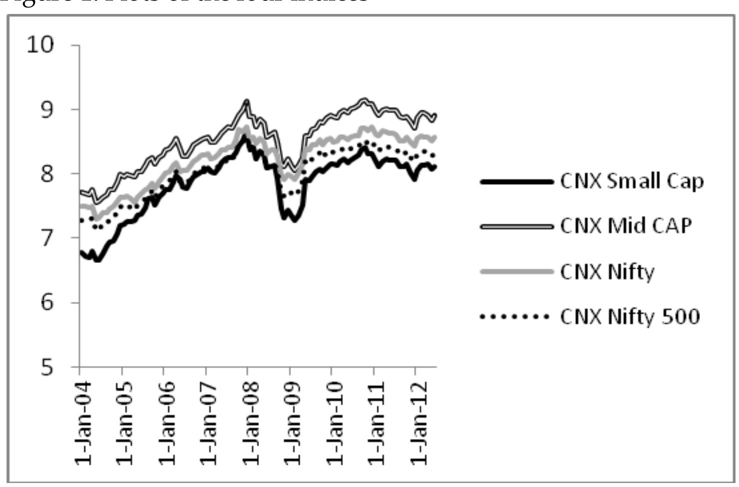
and

$$\lambda_{max}(r, r+1) = -T\ln\left(1-\hat{\lambda}_{r+1}\right) \quad (5)$$

where r is the number of cointegrating vectors under the null hypothesis, $\hat{\lambda}_i$ is the estimate of ith ordered eigenvalue of the Π matrix and g is the total number of non zero eigenvalues. The null hypothesis of the λ_{trace} test is that the number of cointegrating vectors is less than or equal to r i.e. at most r against a general alternative that there are more than r cointegrating vectors. λ_{max} applies separate tests on each eigenvalue and has its null hypothesis that the number of cointegrating vectors is r against an specified alternative of r+1. Clearly, Johansen test accounts for all the possible cointegrating relationships between the variables under consideration and hence it is considered to be a superior test over the Engle-Granger test.
All the tests have been performed using Eviews software.

5 Results and Discussion

Figure 1: Plots of the four indices



A careful observation of figure 1 helps us to notice that the plots run almost in parallel to each other and in the long run the indices tend to maintain equilibrium. CNX Small cap and CNX Mid cap seem to be more volatile and show very similar

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movements over the time period of the study. These plots also give us an idea that the cointegrating relationship, if present, may be without time trend as the lines run almost parallel to each other. With these ideas in mind, the next step would be to carry out formal statistical tests to identify the presence of long term relationships.

Unit Root Tests

I have applied Augmented Dickey-Fuller test (unit root test) to make sure that all the variables under consideration are non-stationary as the concept of cointegration can be applied to non-stationary variables only. If any of the variables are integrated of order 2 or more, appropriate number of differences should be taken to transform them to I(1) variables so that they become suitable for the Engle-Granger test and the Johansen test of cointegration.

Table 1: ADF test results (at level)

Index	Prob. (p-value)
CNX Small Cap	0.1415
CNX Mid Cap	0.4147
CNX Nifty	0.4768
CNX Nifty 500	0.3957

Table 2: ADF test results (at first difference)

Index	Prob. (p-value)
CNX Small Cap	0.0000
CNX Mid Cap	0.0000
CNX Nifty	0.0000
CNX Nifty 500	0.0000

The results in the table 1 and table 2 clearly indicates that all of the four series are I(1) i.e. have a unit root. This result encouraged me to move on with the two tests of cointegration.

Results of Engle – Granger Test of Cointegration

I have run the test four times, each time taking different variable as the dependent variable and rest as the independent variables. This was necessary as the result of the Engle-Granger test depends on the variable chosen as the dependent variable, so all the possibilities had to be explored.

Table 3: P-values (prob.) of the unit root tests on the residuals of the regression models

Dependent Variable	Prob.
CNX Small Cap	0.0474
CNX Mid Cap	0.0331
CNX Nifty	0.0547
CNX Nifty 500	0.0205

The shaded values in table 3 are significant at 5% level of significance which leads to the conclusion that we may reject the null hypotheses that the corresponding residual series are non-stationary which again implies that the Engle-Granger test suggests presence of cointegration between the four variables.

However, the basic drawback of the Engle – Granger test of cointegration is that the result depends on the regression considered by us in the initial step i.e. result depends on the choice of the dependent and the independent variables. So, before confirming the results we should apply a more formal and a superior test of cointegration called as the Johansen test of cointegration.

Results of Johansen Test of Cointegration

Table 4: Lag length criteria for VAR (taking each variable at first difference)

VAR Lag Order Selection Crteria
Endogenous variables: D(MIDCAP) D(NIFTY) D(NIFTY500) D(SMALLCAP)
Exogenous variables: C
Date: 12/19/13 Time: 14:04
Sample: 1 102
Included observations: 93

Lag	LogL	LR	FPE	AIC	SC	HQ
0	815.4681	NA	3.10e-13*	-17.45093*	-17.34200*	-17.40695*
1	830.5847	28.60764*	3.16e-13	-17.43193	-16.88728	-17.21202
2	842.9361	22.31219	3.42e-13	-17.35346	-16.37310	-16.95762
3	852.6781	16.76044	3.94e-13	-17.21888	-15.80281	-16.64711
4	866.4828	22.56249	4.17e-13	-17.17167	-15.31988	-16.42397
5	876.8591	16.06659	4.77e-13	-17.05073	-14.76322	-16.12710
6	892.2038	22.43952	4.95e-13	-17.03664	-14.31341	-15.93708
7	902.4985	14.16904	5.78e-13	-16.91395	-13.75500	-15.63846
8	919.5948	22.05976	5.89e-13	-16.93752	-13.34286	-15.48610

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Results of lag length criteria based on FPE, AIC, SC, and HQ suggest that we should run the Johansen cointegration test without lags.

Table 5: Johansen Cointegration test summary without lags

Date: 12/19/13 Time: 14:05
Sample: 1 102
Included observations: 101
Series: MIDCAP NIFTY NIFTY500 SMALLCAP
Lags interval: No lags

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	2	1	2	2	2
Max-Eig	2	1	1	1	2

*Critical values based on MacKinnon-Haug-Michelis (1999)

For each of the combination based on the choice of intercept and trend, at least one cointegrating relationship has been confirmed by the Johansen test of cointegration. However as discussed at the start of this section, the plot of the data suggests that the combination "intercept with no trend" would be the

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best choice for the present scenario. For this combination both the trace and the Max-eigen statistics conclude at least one cointegrating relationship between the four variables. The estimate of the cointegrating relationship between the variables can be seen in the following table.

Table 6: Johansen cointegration test with intercept but no trend

Date: 12/19/13 Time: 14:06
Sample (adjusted): 2 102
Included observations: 101 after adjustments
Trend assumption: Linear deterministic trend
Series: MIDCAP NIFTY NIFTY500 SMALLCAP
Lags interval (in first differences): No lags
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.282521	64.36083	47.85613	0.0007
At most 1 *	0.187101	30.82763	29.79707	0.0379
At most 2	0.079606	9.905697	15.49471	0.2881
At most 3	0.015009	1.527365	3.841466	0.2165

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.282521	33.53320	27.58434	0.0076
At most 1	0.187101	20.92194	21.13162	0.0535
At most 2	0.079606	8.378333	14.26460	0.3415
At most 3	0.015009	1.527365	3.841466	0.2165

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

MIDCAP	NIFTY	NIFTY500	SMALLCAP
15.05307	38.05242	-66.25322	9.031214
-11.51924	11.52252	4.885673	-3.727704
-8.176886	0.155592	8.924504	1.745829
10.52801	2.125382	-6.404013	-5.117101

Unrestricted Adjustment Coefficients (alpha):

D(MIDCAP)	-0.014877	0.016809	-0.007648	-0.008923
D(NIFTY)	-0.002695	0.004777	-0.008984	-0.008816
D(NIFTY500)	-0.005473	0.010559	-0.010086	-0.008782
D(SMALLCAP)	-0.024075	0.014729	-0.014882	-0.008445

1 Cointegrating Equation(s): Log likelihood 893.6053

Normalized cointegrating coefficients (standard error in parentheses)

MIDCAP	NIFTY	NIFTY500	SMALLCAP
1.000000	2.527884	-4.401309	0.599958
	(0.36692)	(0.46123)	(0.10738)

Adjustment coefficients (standard error in parentheses)

D(MIDCAP)	-0.223947
	(0.13626)
D(NIFTY)	-0.040572
	(0.12040)
D(NIFTY500)	-0.082379
	(0.12737)
D(SMALLCAP)	-0.362395
	(0.15253)

2 Cointegrating Equation(s): Log likelihood 904.0662

Normalized cointegrating coefficients (standard error in parentheses)

MIDCAP	NIFTY	NIFTY500	SMALLCAP
1.000000	0.000000	-1.551716	0.401956
		(0.13857)	(0.11181)
0.000000	1.000000	-1.127264	0.078327
		(0.06187)	(0.04992)

Adjustment coefficients (standard error in parentheses)

D(MIDCAP)	-0.417575	-0.372429
	(0.16856)	(0.35357)
D(NIFTY)	-0.095605	-0.047515
	(0.15133)	(0.31743)
D(NIFTY500)	-0.204008	-0.086580
	(0.15912)	(0.33376)
D(SMALLCAP)	-0.532064	-0.746376
	(0.19001)	(0.39856)

The first two panels in table 6 shows the results of the trace and max-eigenvalue statistics. Trace statistic suggests presence of two cointegrating relationships while max-eigenvalue statistic suggests presence of a single cointegrating relationship. The third panel gives the estimated values of coefficients in the cointegrating vector. Panel 5 gives the estimated coefficients if there were only one cointegrating relationship with the coefficient of CNX Midcap normalized to 1. Similarly, panel 6 gives the estimated coefficients if there were two cointegrating vectors.

6 Conclusion

As suggested by the plots of the indices and by the results of the Engle-Granger tests, Johansen test of cointegration also confirms the presence of at least one cointegrating relationships between the four indices CNX Small cap, CNX Mid cap, CNX Nifty, and CNX Nifty 500. The trace statistic suggests presence of two cointegrating vectors while the Max-eigenvalue statistic suggests presence of a single cointegrating vector. This shows that in the long run, the four indices move in equilibrium which again exposes the inefficiency of Indian stock markets.

References

[1] S. Ali, B.Z. Butt, and Kashif ur Rehman, "Comovement Between Emerging and Developed Stock Markets:An Investigation Through Cointegration Analysis," *World Applied Sciences Journal*, vol. 12, no. 4, pp. 395-403, 2011.

[2] K.E. Assidenou, “Cointegration of Major Stock Market Indices during the 2008 Global Financial Distres,” *International Journal of Economics and Finance*, Vol. 3, No. 2, pp. 212-222, 2011.
[3] C. Brooks, “*Introductory Econometrics for Finance*,” ed. Brooks, C., Cambridge University Press, 2011.
[4] A. Corhay, R.A. Tourani, and J.P. Urbain, “Common stochastic trends in European stock markets,” *Economics Letters*, vol. 42(4), pp. 385–390, 1993.
[5] G. Duca, “The Relationship between the Stock Market and the Economy: Experience from International Financial Markets,” *Bank of Valletta Review*, No. 36, 2007.
[6] R. Engle, and C.W.J Granger, “Cointegration and Error Correction: Representation, Estimation, and Testing,” *Econometrica*, Vol. 55, No. 2, pp. 251-276, 1987.
[7] E.F. Fama, “The Behavior of Stock Market Prices,” *Journal of Business*, Vol. 38, pp. 34-105, 1965.
[8] José Soares da Fonseca, “The Co-integration of European Stock Markets after the Launch of the Euro,” *PANOECONOMICUS*, UDC 336.76(4-672 EU: 497):339.92, pp. 309-324, 2008.
[9] C.W.J. Granger, “Some Properties of Time Series Data and Their Use in Economic Model Specification,” *Journal of Econometrics*, vol. 16, pp. 121-130, 1981.
[10] D. Gulati, and M. Kakhani, “Relationship between Stock Market and Foreign Exchange Market in India: An Empirical Study,” *Pacific Business Review International*, vol. 5, No. 5, pp. 66-71, 2012.
[11] S. Johansen, and K. Juselius, “Maximum likelihood estimation and inference on cointegration-with application to the demand for money,” *Oxford Bulletin of Economics and Statistics*, Vol. 52, pp. 169-210, 1990.
[12] S. Johansen, “Statistical analysis of cointegration vectors,” *Journal of Economic Dynamics and Control*, Vol. 12, pp. 231-254, 1988.
[13] S. Johansen, “Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models,” *Econometrica*, Vol. 59, No. 6, pp. 1551–1580, 1991.
[14] K. Kasa, “Common Stochastic trends in international stock markets,” *Journal of Monetary Economics*, Vol. 29, pp. 95-124, 1992.
[15] T.A. Khan, “Cointegration of International Stock Markets: An Investigation of Diversification Opportunities,” *Comprehensive Exercise in Economics*, Carleton College, 2011.
[16] R. Krishnankutty, and A.K. Tiwari, “Are the Bombay stock Exchange Sectoral indices of Indian stock market cointegrated? Evidence using fractional cointegration test,” *Journal of Emerging Financial Markets*, Vol. 2, No. 1, pp. 37-45, 2011.
[17] R. MacDonald, and M.P. Taylor, “Exchange Rates, Policy Convergence, and the European Monetary System,” *Review of Economics and Statistics*, Vol. 73, pp. 553-558, 1991.
[18] K. Malarvizhi, and M. Jaya, “An Analytical Study on the Movement of Nifty Index and Exchange rate,” *International Journal of Marketing and Technology*, Vol. 2, No. 7, pp. 274-282, 2012.
[19] R.C. Maysami, L.C. Howe, and Mohamad A. Hamzah, “Relationship between Macroeconomic Variables and Stock Market Indices: Cointegration Evidence from Stock Exchange of Singapore’s All-S Sector Indices,” *Jurnal Pengurusan*, Vol. 24, pp. 47-77, 2004.
[20] A.K. Mishra, “International Financial Integration of Domestic Financial Markets: A study of India,” *The ICFAI Journal of Applied Finance*, Vol. 8(2), pp. 5-15, 2002.
[21] D. Singh, “Causal Relationship between Macro-Economic Variables and Stock Market: A Case Study for India,” *Pakistan Journal of Social Sciences*, Vol. 30(2), pp. 263-274, 2010.
[22] M.V. Subha, and S.T. Nambi, “A Study on Cointegration between Indian and American Stock Markets,” *Journal of Contemporary Research in Management,* January-March, pp. 105-113, 2010.
[23] W.-K Wong, J. Penm, D.T. Richard, and Y.C.L. Karen, “The Relationship Between Stock Markets Of Major Developed Countries And Asian Emerging Markets,” *Journal of Applied Mathematics and Decision Sciences*, Vol. 8(4), pp. 201–218, 2004.