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RESEARCH ARTICLE

Using Unit Root and Cointegration Techniques to study for Evidence of Inter-Relationship among the Sensex and Selected International Indices

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ABSTRACT

Stock market indices are recognised as barometers of economic performance. While stock markets themselves can vary from one another, the corresponding indices can also differ on a variety of factors. In a globalised world it has become customary to address the issue of integration of markets around the world. In this paper the authors have tried to tackle this issue from the viewpoint of stock markets in India. The present work considered seven major international stock indices viz. – the Dow Jones Industrial Average and the NASDAQ Composite in the USA, the FTSE 100 in the UK, DAX in Germany, Nikkei 225 in Japan, Hang Seng in Hong Kong and the S&P/TSX Composite in Canada. On the domestic side the authors chose the Sensitive Index or Sensex. Using ten year data they attempted to determine whether a long-term relationship exists between the Indian markets and leading markets across the globe. For this purpose they utilised techniques like unit root testing, cointegration analysis and Granger causality analysis. The results indicated that the Sensex was influenced by all the leading international indices. However the converse did not necessarily hold true.

INTRODUCTION

Stock market indices are universally recognised as one of the barometers of economic performance in modern economies. While stock markets themselves can vary from country to country in terms of depth of the market, the securities and trading instruments, and indeed the nature of economic performance, the corresponding indices can also differ from one another with regard to the method of computation, the mode of selection of scrips for the calculation of the index, as well as the number of such scrips utilised for this calculation. In an era when globalisation and liberalisation have become commonplace in the business lexicon in the hitherto insulated developing nations, it has become customary to address the issue of integration of markets around the world. This issue holds particular relevance in a country like India where at one time the protectionist policies of the government ensured that the economy remained cocooned from occurrences on foreign shores. However, with the onset of liberalisation, Indian firms have been exposed to the full force of competitive forces from across the borders. In addition, Indian markets have also been flooded with products and service offerings from other countries. At the micro level domestic companies have had to brace themselves for the competition from the multinationals. A concurrent development has been the signing of Free Trade Agreements (FTAs) between and a number of other nations. The net effect of all these developments has been the creation of a globalised integrated system across the world. A relevant question that is often raised in this connection is the degree of such integration across countries. In this paper we have tried to find the answer for the above question from the viewpoint of stock markets in India. One of the obvious results of global integration is the undoubted influence exercised by developments in the stock markets of a particular country (specially if it is one of the relatively larger or more powerful economies of the world) on those from other nations. At a conceptual level this is to be expected since share market participants in the latter will naturally look towards the former for deducing the current state of the international market. The present work considers seven major stock indices from across the globe viz. – the Dow Jones Industrial Average (DJIA) and the NASDAQ Composite in the USA, the FTSE 100 (henceforth referred to simply as FTSE) in the UK, DAX in Germany, Nikkei 225 in Japan, Hang Seng in Hong Kong and the S&P/TSX Composite in Canada. On the domestic side we have chosen the Sensitive Index (popularly known as the Sensex) since for all intents and purposes it is the most widely followed stock index in India. Using data collected over a ten year period, we have attempted to determine whether a long-term relationship exists between the Indian markets and leading markets across the globe. This is sought to be achieved through the application of techniques like unit root testing and cointegration analysis. While the former helps in determining the existence of stationarity in a data series, the latter is useful for evaluating the possibility of a long-term relationship among two or more data series. Finally we have utilised Granger causality analysis for inferring the causal relationships among the various indices.

The rest of the paper is organised as follows:

Section 2 provides the brief survey of literature along with the justification for the study. Section 3 lists the objectives for the study. Section 4 relates to the database and methodology used in the present work. Section 5 covers the results of the analysis. Section 6 concludes the paper with the conclusions and observations.

Literature Survey

There have been various attempts at using the methodologies that constitute the framework of this paper. A major portion of such research has concentrated on evaluating the relationship between the

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real economy and the capital markets in various countries. We consider here a brief selection of the relevant literature in this area. Comincioli and Wesleyan (1996) tried to examine the causal relationship between stock prices and the economy in case of the USA using quarterly data over 24 years. Using Granger Causality Test, they found that stock prices Granger cause economic activity, but not vice versa. A study by Naka *et al*. (1999) examines the relationship between the BSE Sensex and five macroeconomic variables, viz. – the Index of Industrial Production (IIP), the Consumer Price Index, money supply, interest rate and inflation. The unique feature of this study is that it involved a comparison between the pre and post reform performance employing the techniques of cointegration and vector error correction. It was found that IIP was the largest positive determinant of stock prices, while inflation is the largest negative determinant. A different perspective is provided by the effort of Pethe and Ajit (2000) where they look into the inter-relationship between stock indices like the Sensex and the Nifty on one hand, and significant macroeconomic variables like the rupee-dollar exchange rate, the prime lending rate, narrow money supply, broad money supply and the IIP.

The methodology involved the use of unit root testing, cointegration and error-correction models. The results indicated no cointegration among the variables; further, it was suggested that though the economy is influenced by both the stock indices considered, these indices did not have any impact on the IIP. Another work by Panda and Kamiah (2001) relates to the causal relations and dynamic interactions among monetary policy, expected inflation, real activity and stock returns in the post-liberalisation period. Here the vector autoregression method was utilised to make conclusions regarding the relationship among variables like monetary policy, expected inflation, real activity and stock returns. Bhattacharya and Mukherjee (2002) used unit root tests, cointegration and the long-run Granger causality test to the causal relationship between the BSE Sensex and five macroeconomic variables. The conclusion was that there is no linkage between stock prices and money supply, national income and interest rate; the IIP induces increase in stock value; and there is a two-way causality between stock prices and the rate of inflation. Yet another attempt at establishing the relationship between real economic variables and the stock market in an Indian backdrop was undertaken by Vani *et al.* (2003). Similar efforts were also taken up by Chakravarty (2005).

Islam (2003) has carried out a study for the Malayasian economy where he has dealt with short-term dynamic adjustment and long-run equilibrium relationships among variables like interest rate, inflation rate, exchange rate and IIP. For this purpose he has utilised the error correction modelling technique. The results indicate a variety of short run and long run relationships among these variables. Osman and Yakup (2003) have undertaken a study devoted to examining the relationship between the Turkish Stock Market and macroeconomic variables like money supply, dollar exchange rate, trade balance and the index for industrial production. Here they used Engel-Granger and Johansen-Juselius cointegration tests and Granger Causality Test for the purpose determining the long-run relationship among the variables. Sharkasi *et al.* (2004) have looked into price interdependence between stock markets in Ireland, UK, Portugal, USA, Brazil, Japan and Hong Kong utilising a new testing method,based on the wavelet transform to reconstruct the data series, as suggested by Lee (2002).The authors have found evidence of intra-European (Irish, UK and Portuguese) market co-movements with the US market also weakly influencing the Irish market, apart from co-movement between the US and Brazilian markets and similar intra-Asian co-movements (Japanese and Hong Kong). According to them the European markets affect the markets in the Americas, which in turn influence those in Asia, which again impact the Europen markets, thus completing the circle. Lastly the authors claim evidence for intra-continental relationships and an increase in importance of international spillover effects since the mid 1990's. They suggest that the importance of historical transmissions has decreased since the beginning of the present century. Dritsaki (2005) has performed some empirical tests in order to examine the long-run relationship between the Stock Market Index of Greece (GEN) and variables like industrial production, inflation and interest rates. The Granger Causality Test was once again applied for identifying the causal relationship among the variables. The interaction between the real and financial sectors of the Canadian economy formed the focal point of the study by Gauthier and Fuchun (2005). They considered a long-run relationship for the determination of output, stock market and term structure of interest rates. The study utilised the Vector Correction Model over six variables. Chandrasekhar and Jayati (2005) undertook a study involving two consecutive years of the BSE Sensex; they concluded that the movements in the manufacturing IIP and the Sensex are independent of one another. Chandrasekhar and Ghosh (2005) also obtained a similar result. Bhowmik (2008) has attempted an empirical study examining the inter-rela tionship between the BSE Sensex, the sectoral indices of the BSE and some stock indices outside India.

Applying the method of cointegrated multiple regression analysis, the study concludes that the movements of the Sensex and some of the sectoral indices in India follow those of the foreign indices, specially those belonging to Asian countries and the United States. The author suggests that the results offer a strong case for integration of stock m arkets across the world. The paper by Soenen and Johnson (2008) deals with the effects of changes in the consumer price index on industrial production and stock market returns for China. The authors have worked with six different types of Chinese shares covering the period from 1994 to 1998. According to them the results suggest a very significant positive relationship between inflation and real output. Further they have found A positive and significant association between stock returns and real output in current periods. As per their study, inflation does not seem to impact real stock returns in China. While the relationships are applicable to the "B" shares, "H" shares and red chips in China, the returns for the "A" shares do not seem to be affected by the changes in domestic inflation or real industrial production. Ahmad (2009) has tried to examine the causal relationship between the stock market and the manufacturing sector in India on the basis of data relating to the BSE Sensex and the IIP. In doing so he has resorted to the Engel-Granger cointegration test for measuring the long-term relationship among the the variables and the Granger causality test for evaluating the short-term causal relationship He concludes that there is a long-term relationship between the stock market and the manufacturing sector, while in the short-term, causality runs from the BSE Sensex to the IIP.

The work by Iqbal *el al*. (2011) examines the dynamic linkages between the equity market of USA and emerging markets of Pakistan and India on the basis of daily data covering the period of January 2003–December 2009. For this purpose it uses the cointegration procedure suggested by Johansen and Johansen and Juselius for discerning the long-term relationship among the markets. It also applies the Granger causality test based on the methodology of Toda and Yamamoto. The authors found no long-term relationship among the markets. There was evidence of unidirectional causality from the New York Stock Exchange to those in Bombay and Karachi. Chi-man Hui and Ng's paper (2012) relates to examining the relationship between the residential property market and the stock market in Hong Kong. For this purpose they have utilised the Granger causality test, variance decomposition and CUSUM test. A unique feature of this study is that is that it has tried to identify the break points and variation of relation. The results suggest that the correlation between residential property price and stock index had become weaker with time, despite the fact that the residential property price follows the same trend as the stock market during the sample period. The authors suggest that in such a situation there is a greater likelihood for the investors to make more profits by going for portfolio diversification.

Brief objectives

Following the aforementioned goal of identifying the inter-relationship, if any, among the Sensex and the leading international indices, we formulate the following objectives for the present effort:

1. Examining the data collected for the study in order to evaluate the presence or absence of stationarity
2. Evaluating the possibility of existence of long-term relationship
3. Identifying how the indices influence one another

The Analytical Framework: Data and Methodology

The data utilised for this purpose consists of the values of the eight indices specified earlier over a period from 2000 to 2009. Here we have been careful to ensure that only those instances are considered where data is concurrently available for all eight indices. First we have resorted to the Augmented Dickey-Fuller (ADF) test for evidence of stationarity in the relevant data. When the ADF test has not proved conclusive, we have used the Philips-Perron test. Then we have considered the existence of long-term relationship among the different indices on the basis of the cointegration analysis technique proposed by Johansen. We have utilised this approach for discerning any possible relationship between the Sensex and the global indices. Lastly the Granger Causality Test completes the analysis by testing for the existence of different causal relationships among the indices.

Analysis

Unit Root Test for the Indian and the International Stock Indices

The results of the unit root tests have been summarised in Table 1.1. As can be seen from this table, the ADF test has been used in most cases, except 5 and 8 (NASDAQ Composite and Sensex), where the Philips-Perron Test was found to be more conclusive. Considering the fact that the critical values for 1%, 5% and 10% level of significance are -3.962644, -3.412158 and -3.128000 respectively in case of the of the ADF test, and -3.962849, -3.412160 and -3.128002 respectively in case of the Philips-Perron Test it is clear that all eight data series are non-stationary or I (1). Hence we can proceed to the cointegration test.

Cointegration Analysis for Indian and International Stock Indices

Applying the cointegration test by the Johansen procedure, the relationship is found to exist at the 5% level of significance, as suggested by the results in Table 1.2.
It is clear from the results of the tests that there may be at least one cointegrating equation at the 5% level of significance. Table 1.3 gives the cointegrating equation.
As the relationship among the variables cannot be clarified through cointegration alone, we resort to the Granger Causality test to gain a better perspective.

Granger Causality Test for Indian and International Stock Indices

Application of the Granger Causality Test to the different data series under this study yielded the results given in Table 1.4. From these results we can say that while the Sensex does not appear to have much of an effect on other international indices, the reverse does not hold true, i.e., various international indices do have an impact on the value of the Sensex. The latter is understandable, since from time to time, the Sensex does appear to respond to news regarding the major international indices, though by itself it may not merit much attention from these indices. All of these international indices also influence one another, which is not surprising. Lastly, we have tried to find out the effects of particular groups of indices on the Sensex. This grouping has been done on the basis of geographical affinity. Thus we have the Asian leaders (Nikkei225 and Hang Seng), the North American indices (DJIA, NASDAQ Composite and S&P/TSX) and those from Europe (DAX and FTSE). It is found that all three groups tend to affect the values of other international indices. The significance for the Sensex is that it is influenced not just by its Asian neighbours, but by all other groups, possibly indicating increasing levels of homogenisation as a result of the integration of stock markets across the world.

RESULTS AND DISCUSSION

The preceding results indicate that the Sensex is influenced by all the leading international indices. However the converse does not necessarily hold true, thereby suggesting that the Sensex has a long way to go before it can be considered as a major player on the international scene. Again it was also been observed that particular groupings of indices also similarly affect all other international indices. A corollary of the last observation was that the Sensex may not demonstrate the effects of its Asian counterparts alone, but rather an amalgamation of the effects of all the international heavyweights.

Table 1.1. Results of Unit Root Tests

Sl. No.	Index	Value of Test Statistic	p value
1.	DAX	-1.925151	0.6408
2.	DJIA	-1.458433	0.8433
3.	FTSE	-1.904933	0.6515
4.	Hang Seng	-2.305763	0.4300
5.	NASDAQ Composite	-2.569829*	0.2944*
6.	Nikkei225	-1.344791	0.8762
7.	Sensex	-2.151534*	0.5160
8.	TSX	-1.468720	0.8400

* Using the Philips-Perron Test

Table 1.2. Results of Trace Test and Maximum Eigen Value Test

Date: 10/31/10 Time: 02:14
Sample (adjusted): 6 1915
Included observations: 1904 after adjustments

Trend assumption: Linear deterministic trend (restricted)
Series: SENSEX DJIA FTSE NASDAQ_COMP NIKKEI225 HANGSENG DAX TSX
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.031511	200.1057	187.4701	0.0096
At most 1	0.021346	139.1421	150.5585	0.1834
At most 2	0.015994	98.05965	117.7082	0.4398
At most 3	0.011696	67.36077	88.8038	0.6103
At most 4	0.010115	44.95938	63.8761	0.6489
At most 5	0.007757	25.60302	42.91525	0.7587
At most 6	0.003162	10.77623	25.87211	0.8876
At most 7	0.00249	4.747147	12.51798	0.633

Trace 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

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.031511	60.96353	56.70519	0.0178
At most 1	0.021346	41.08249	50.59985	0.3401
At most 2	0.015994	30.69888	44.4972	0.646
At most 3	0.011696	22.40139	38.33101	0.8383
At most 4	0.010115	19.35636	32.11832	0.7023
At most 5	0.007757	14.82679	25.82321	0.65
At most 6	0.003162	6.029081	19.38704	0.9546
At most 7	0.00249	4.747147	12.51798	0.633

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

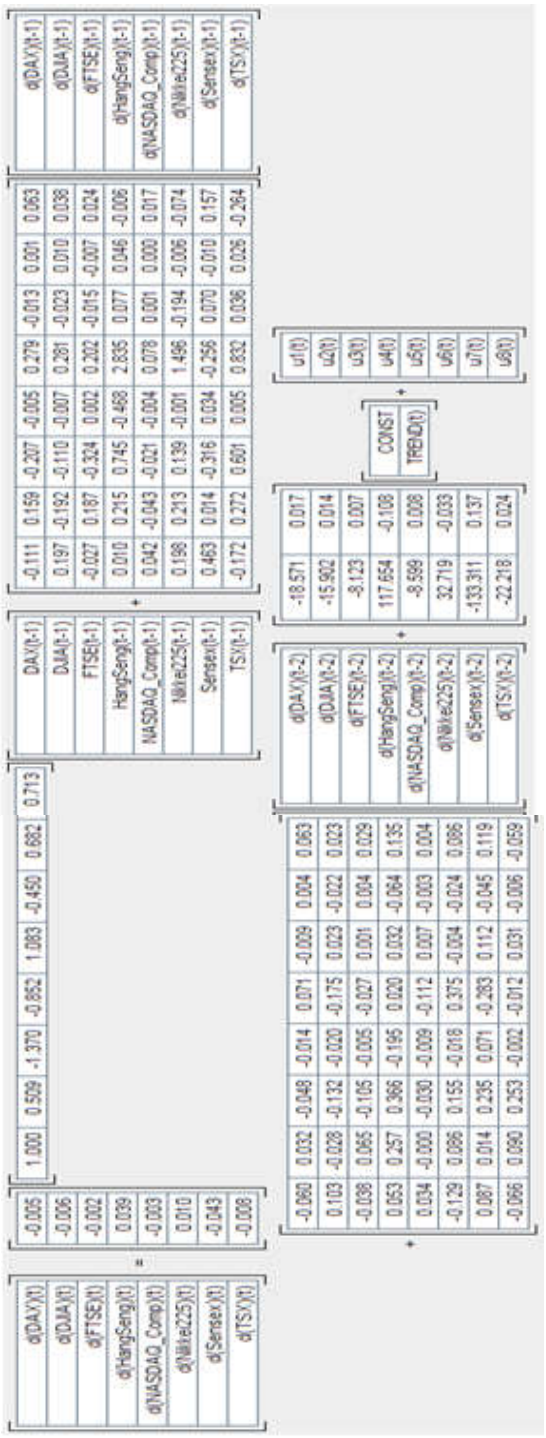

Table 1.3. Cointegrating Equation for comparison between Sensex and International Indices

Table 1.4. Results of Granger Causality Tests

Sl. No.	H_0	Result	p value
1.	Sensex does not Granger-cause other international indices.	ACCEPTED	0.2874
2.	Other international indices do not Granger-cause the Sensex.	REJECTED	0.0000
3.	DAX does not Granger-cause other international indices.	REJECTED	0.0000
4.	DJIA does not Granger-cause other international indices.	REJECTED	0.0000
5.	FTSE does not Granger-cause other international indices.	REJECTED	0.0000
6.	Hang Seng does not Granger-cause other international indices.	REJECTED	0.0000
7.	NASDAQ Composite does not Granger-cause other international indices.	REJECTED	0.0000
8.	Nikkei225 does not Granger-cause other international indices.	REJECTED	0.0000
9.	S&P/TSX does not Granger-cause other international indices.	REJECTED	0.0000
10.	Hang Seng and Nikkei225 do not Granger-cause other international indices.	REJECTED	0.0000
11.	DJIA, NASDAQ Composite and S&P/TSX do not Granger-cause other international indices.	REJECTED	0.0000
12.	DAX and FTSE do not Granger-cause other international indices.	REJECTED	0.0000

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