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Cointegration between Nifty 50 Spot and Future Indices: An Empirical Analysis Applying Vector Error Correction Model

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Abstract -This paper aims to investigate the cointegration of the spot market and future indices (NIFTY, NIKKEI, S&P 500 AND Singapore FTSE) of selected developed and developing nations from January 2011 to December, 2021. The Johansen cointegration test, Granger Causality Test, and Vector Error Correction Model (VECM) are all used to gauge the degree of cointegration. The study's empirical findings support the hypothesis that there is cointegration between the spot market and future market indices of selected global markets. Comparative Granger tests for causality using the error correction model and results of error correction tests reveal interdependencies. The fact that the S&P 500 spot market index and future market index have a bi-directional causality shows that how interdependent these stock indices are. But, in case of Singapore FTSE, there is uni-causality from SGX future to SGX Spot indices. And in rest of indices (NIFTY and NIKKEI), there is no causality between spot and future stock indices. The study's conclusions show that investors may create diverse portfolio strategies to manage risk.

Keywords -Cointegration, Vector Error Correction Model (VECM), Stock Market, Future Market

I. INTRODUCTION

In the fields of international finance and economics, stock market integration is a key topic of study. The interconnection of global financial markets has received significant attention in financial literature. Deregulation, globalisation, and information technology advancements have increased interest in communications and trade systems[33]. Recently, economists, academics, and researchers have been interested in the integration of stock markets throughout the world [12],[3],[11]. Trade investment has grown significantly during the past 20 years. The integration of global financial markets is facilitated by the influx of outside capital investment[10]. In reality, investing in foreign markets and diversifying one's portfolio have increased cross-border capital flow, especially when it comes from rich countries to emerging ones [20],[8],[21].

In recent decades, the link between stock market indexes and index future prices has generated considerable study interest in the field of finance. Particularly, thorough study has been done with a variety of results on how stock market index prices are adjusted and how predictable their prices are. The spot prices and the prices of the futures on the same asset would be concurrently tied in a totally efficient market without any intervention. In other words, their prices at the same moment would have an impact on one another but not over time [29]. In economics, long-term or equilibrium connections and short-term linkages are the two different types of links that may occur between two time series. In a long-term relationship, a change in one variable has a lasting impact on another variable's equilibrium level. In a short-term relationship, the impact of a change in one factor on another factor has a finite lifespan and is reversible. Short-term relationships are studied in their differenced form, whereas long-term links are revealed statistically by the existence of co-integration between the variables in their level form.

Integration is the process of joining two distinct markets in order to give investors the same, unrestricted access to financial assets. Long-term convergence between market prices and the prices of financial assets is seen as this trend. Additionally, it describes the movement of capital from less profitable to highly profitable markets and combines these returns into one [30]. There is a long-term or equilibrium link

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between two variables if they are cointegrated. However, there could be disequilibrium in the near term, which is fixed by the "error correcting mechanism." Cointegration is a relatively new statistical concept, pioneered by [14]. Cointegration is the long-term equilibrium connection between non-stationary variables when their deviations from equilibrium are stationary[14]. The cointegration test reveals the long-term structural link between the variables being examined. It aims to determine the extent to which the variables under examination would trend into the same direction over the long term. The goal of the present study is to determine whether or not the spot and futures markets will eventually move in the same direction. If two or more series are non-stationary on their own but are stationary when combined in the same sequence of integration. Then it is considered that both series are co-integrated[1]. Although each of the time series in the cointegration model follows a different stochastic trend, it's feasible that in the long run they all follow the same stochastic trend [24].

The structure of this paper is as follows: the literature on the cointegration of stock markets is discussed in Section 2. The data utilised and the techniques used in the study are described in Section 3. The study's Section 4 also includes an analysis and presentation of the empirical findings. The study is concluded in Section 5 with a summary of its consequences.

II. Review of Literature

It would appear sensible to provide a brief assessment of literature that is directly or indirectly connected to the topic in order to be able to articulate the problem accurately and identify the justification for its endeavour. Since Granger's (1983) [14] research formalised the idea of cointegration, investigations on the cointegration between stock markets have been a crucial issue in the financial literature. A model to examine the linear linkages among the financial markets was developed from later investigations by [14] and [15]. Stock price variations are a result of unfavourable circumstances occurring in one market. Due to the interconnectedness of the stock markets, a single news incident in one nation might trigger a global meltdown [34]. The interconnections between the developed stock markets of the United States of America (US), Japan, and Europe have been reported in research by [16],[5],[28][23], among others. [6],[4], and [7], among others, provided proof of the connections between the US, Japanese, and Asian markets. Additionally, this research linked the cointegration and interlinkages of stock markets to the drop in stock indices during the Asian Financial Crisis of 1997, the Global Financial Crisis of 2008, and the United States stock market crash of October 1987.

For the years 1996 to 2007,noted a lack of cointegration between the stock markets of Greece, Poland, Romania, and the Czech Republic in Southeast Europe. The findings show that the degree of integration of the stock markets in Greece, Poland, and Romania is generally declining. There has reportedly been a fall in integration between the stock markets of Southeast Europe, which is attributed to both the extent of trade openness and local stock market trends. Between 1990 and 2000, the Asian stock markets implemented deregulation and crisis-prevention measures, which resulted in their cointegration. It was also revealed no cointegration between the US and India, despite the connection improving since 1998, according to a country-specific study [6]. Johansen Co-integration and Error correction mechanisms were utilisedby them to determine the short- and long-term relationships between developed market returns (US, UK, and Germany) and emerging market returns (Brazil, China, Mexico, Russia and Turkey) [2]. There was a short-term unity between developing and emerging markets. However, in the long run, Germany and the emerging had a substantial link. Johansen Co-Integration, Vector Error Correction technique, and Granger Causality test was used to demonstrate experimentally examined market integration amongst the main Asian stock markets, including China, Malaysia, Singapore, Hong-Kong, Japan, India, and Australia [36]. They discovered that there was considerable long-term as well as short-term co-integration between India and other Asian stock markets. They examined and analysed the cointegration among the stock markets of the BRIC economies (Brazil, Russia, India, and China) during the reform era in order to investigate the opportunities for global diversification [3],[18]. They discovered a long-term cointegrating association among the chosen stock markets of the BRIC economies[11]. The stock markets of India, Pakistan, and Sri Lanka in South Asia were analysed by using a wavelet technique and a portfolio management viewpoint. They discovered limited co-movement, which may result in a wealth of arbitrage possibilities for investors in these growing nations[38]. Between 2001 and 2016, it was studied the correlation between a few international stock markets and the Indian stock market[35]. They discovered little connection between the French and Indian stock markets. On the other hand, there has been a noticeable short-term integration between the stock markets of India and the USA, Germany, and Germany. They examined the integration as well as the spillover impact of the global financial crisis on the financial markets in Asia over a period of ten years using the cointegration test of Johansen and Juselius, the Vector Error Correction Model, and the Garch-Bekk model [17].

A thematic map is a two-dimensional representation of typological concepts [26] which is based on Bibliometric analysis shown in Figure 1. Co-word analysis is used to find keyword clusters, which leads to themes in the study topic. On

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a two-dimensional graph with centrality and density as variables, these themes may be separated into four quadrants based on their density and centrality. On the map, each subject is represented by a bubble. The terms cointegration, Stock market, and wavelet decomposition are all depicted on the graph. The applicable word is cointegration, however it hasn't been well explored. Futures markets were significant in price discovery for the underlying spot market, according to various research [9], [25]. Because of this price discovery mechanism, futures and spot prices were assumed to be the same. Markets are consistently connected in the short and/or long run. The existence of an equilibrium connection that connects the two prices together was signified by the price discovery function in cointegration language. Prices in one or both markets should adapt to narrow the gap if one or both markets diverge from equilibrium. [34] was the first to utilise cointegration and causality analysis to look for a lead-lag connection between oil spot and futures prices series, whereas [37] employed a non-linear causality framework to establish bidirectional causation. [39],[22] and [31] are just a few of the research that employed a cointegration technique to look at oil prices[27].

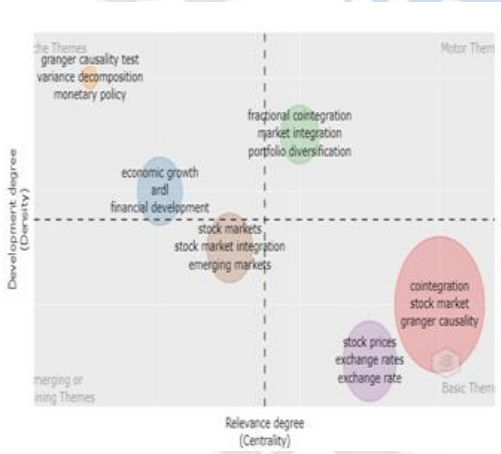

Figure: 1 Thematic map of Cointegration between spot market and future market indices

The analysis of the literature shows that the experts have either concentrated only on developed economies or on regional economies. Only a few others have concentrated on the chosen methodology. The corpus of literature also demonstrates that there are conflicting findings about stock market cointegration. The cointegration of the stock market and future market indices is highlighted between developed and developing economies in this current study.

2.1 Objectives of the Study

1. To examine the long-term relationship between spot and future market equity indices of selected global markets (NIFTY, NIKKEI, S&P 500 AND Singapore FTSE).
2. To study the error correction mechanism lying between the Co-integrated future and spot market equity indices of selected global markets.

III. Research Methodology

For the period between January 1, 2011 and December 31, 2021, the data of selected global market indices (Table 1) were utilised as the study's data. The official website of concerned stock exchange provides the spot and futures statistics for selected indices.

Table: 1 Selected Global markets

No.	Country	Stock Exchange	Stock Index	Rank	Status (MSCI Index)
1.	United States	New York Stock Exchange	S & P 500	1st	Developed
2.	Japan	Japan Exchange Group	Nikkei	3rd	Developed
3.	India	National Stock Exchange	Nifty	11th	Emerging
4.	Singapore	Singapore Stock Exchange	FTSE Straits Times Index	21st	Developed

Source: World Federation Exchange

3.1 Unit Root Test

Several techniques are employed to analyse the order of integration for each series. These techniques include the KPSS Test, the Phillip-Perron Test, and the Augmented Dickey Fuller (ADF) Test. Most studies employed the ADF test. According to Dickey and Fuller (1979)[13], the unit root of the series indicates that the series is non-stationary, which is the null hypothesis for the ADF test. Below is the regression equation for this test:

$$y_t=\alpha_0+\alpha_1 y_{t-1}+\sum_{i-1}^{n}\alpha_i\Delta y_t+s_t$$

Here $y_t$is the price series of stock index series, Δ is firstdifferenceoperator, i=1,2...n represents the number oflags.

3.2 Johansen Cointegration Test

A model was developed by Johansen (1988) and Johansen and Juselius (1990) [19] to examine the cointegration of numerous, say k, I(1) time series. Using the trace estimation and maximum likelihood estimation techniques, they calculated the cointegrating vector. The trace test (trace) and the maximal eigenvalue (max) tests, which are written as follows, are two techniques Johansen (1988, 1991)

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developed for determining the number of cointegrating vectors.

Trace Test

$$\lambda_{trace}(r) = -T \sum_{i=r+1} 1n(1 - \hat{\lambda}_i)$$

Maximum Eigen value Test

$$\lambda_{max}(r, r+1) = -T1n(1 - \hat{\lambda}_{r+1})$$

where r is the quantity of cointegrating vectors and I denote the estimated value of the i^{th} order eigenvalue obtained from the matrix. According to the related eigenvector, each eigenvalue will be linked to a unique cointegrating connection. A significant cointegrating vector is indicated by a significant non-zero
eigenvalue.

3.3 Vector Error Correction Mechanism

According to Tse (1999), the bivariate cointegrated series (s_t; f_t) may be represented by a vector error correction model

$$\Delta s_t = \mu_1 + \alpha_1(f_{t-1} - \beta_0 - \beta_1 s_{t-1} - \beta_2 m_{t-1}) + \sum_{i=1}^{k} \Gamma_i^{11} \Delta s_{t-i} + \sum_{i=1}^{k} \Gamma_i^{12} \Delta f_{t-i} + \varepsilon_{1t}$$

$$\Delta f_t = \mu_2 + \alpha_2(f_{t-1} - \beta_0 - \beta_1 s_{t-1} - \beta_2 m_{t-1}) + \sum_{i=1}^{k} \Gamma_i^{21} \Delta s_{t-i} + \sum_{i=1}^{k} \Gamma_i^{22} \Delta f_{t-i} + \varepsilon_{2t}.$$

(VECM), that is**:**

The dynamics of the long-run relationship linking the two series together, ensuring that any periods of disequilibrium are rectified in succeeding ones, are represented by the delayed EC term. The index's (futures') loading α1 (α2) is how quickly it returns to equilibrium.

IV. Empirical Results

4.1 The time series behavior of the selected equity indices is shown below:

The time series behaviour of selected equity indices shows that series are of non-stationary nature. The means, variances, and covariances of data points (shown in figure 2) are frequently non-stationary or fluctuate over time. As a rule, non-stationary data is unexpected and cannot be predicted or modelled. The findings acquired using non-stationary time series might be spurious. Thus, it is to be checked that whether a model can be fit on a non-stationary data, we have to apply co-integration test.

4.2 Descriptive analysis

This section discusses the descriptive analysis of the spot and future markets of the selected equity indices (*Nifty Index, Nikkei Index, S & P Index and SGX Index*). The descriptive analysis illustrates the nature of central tendency, deviation and the distribution of the index spot prices, spot returns, future prices and future returns. The results of descriptive statistics are shown below:

Above table 2 reported the central tendency, dispersion and distribution features of the spot and future indices of the selected equity indices. For Nifty index, the results depicts that the daily returns are positively skewed and leptokurtic in nature and do not follow a normal distribution (p value of Jarque Bera measure is insignificant). The average spot price of the Nifty index spot market during the sample period is found to be 9020.783 with the standard deviation 3152. The average price of Nifty index futures is 9036 with the standard deviation 3154.

For Nikkei index, the results depicts that the daily returns are positively skewed and leptokurtic in nature and do not follow a normal distribution (p value of Jarque Bera measure is insignificant). The average spot price of the Nikkei index spot market during the sample period is found to be 18115.13 with the standard deviation 5830.918. The average price of Nikkei index futures is 18098.68 with the standard deviation 5823.868.

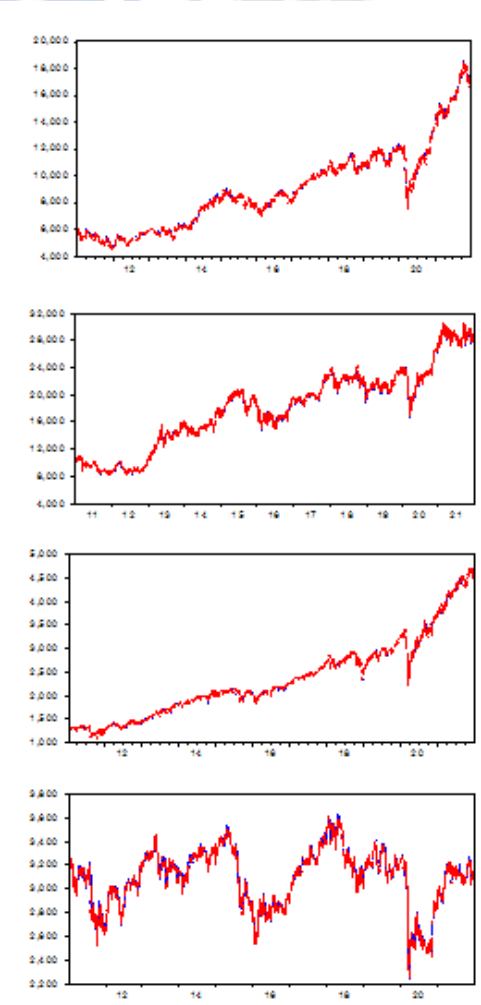

Figure:2 Time Series behaviour of Selected Equity Indices

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For S&P index, the results depicts that the daily returns are positively skewed and leptokurtic in nature and do not follow a normal distribution (p value of Jarque Bera measure is insignificant). The average spot price of the S&P index spot market during the sample period is found to be 2364.280 with the standard deviation 862.1375. The average price of S&P index futures is 2361.316 with the standard deviation 862.2949.

For SGX index, the results depicts that the daily returns are positively skewed and leptokurtic in nature and do not follow a normal distribution (p value of Jarque Bera measure is insignificant). The average spot price of the SGX index spot market during the sample period is found to be 3087.95 with the standard deviation 243.93. The average price of SGX index futures is 3092.32 with the standard deviation 244.34.

Table:2 Descriptive Statistics

	Mean	Median	Min	Max	SD	Skewness	Kurtosis	Jarque Bera
Nifty Spot Index	9020.783	8522.150	4544.20	18477.05	3152.30	0.80	3.25	303.24
Nifty Future Index	9036.853	8542.050	4554.50	18495.40	3154.30	0.80	3.25	302.41
Nikkei Spot Index	18115.13	18931.31	8160.01	30670.10	5830.91	0.005	2.28	56.66
Nikkei Future Index	18098.68	18920.00	8160.00	30600.00	5823.86	0.006	2.29	56.43
S & P Spot Index	2364.280	2125.850	1099.23	4793.060	862.13	0.82	3.14	317.72
S & P Future Index	2361.31	2121.00	1086.25	4784.50	862.29	0.82	3.13	314.05
SGX Spot Index	3087.95	3136.00	2234.00	3608.00	243.93	-0.61	2.93	171.53
SGX Future Index	3092.32	3139.83	2233.48	3615.28	244.34	-0.59	2.91	165.18

Source: Author's Calculation

Above table 2 reported the central tendency, dispersion and distribution features of the spot and future indices of the selected equity indices. For Nifty index, the results depicts that the daily returns are positively skewed and leptokurtic in nature and do not follow a normal distribution (p value of Jarque Bera measure is insignificant). The average spot price of the Nifty index spot market during the sample period is found to be 9020.783 with the standard deviation 3152. The average price of Nifty index futures is 9036 with the standard deviation 3154.

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For S&P index, the results depicts that the daily returns are positively skewed and leptokurtic in nature and do not follow a normal distribution (p value of Jarque Bera measure is insignificant). The average spot price of the S&P index spot market during the sample period is found to be 2364.280 with the standard deviation 862.1375. The average price of S&P index futures is 2361.316 with the standard deviation 862.2949.

For SGX index, the results depicts that the daily returns are positively skewed and leptokurtic in nature and do not follow a normal distribution (p value of Jarque Bera measure is insignificant). The average spot price of the SGX index spot market during the sample period is found to be 3087.95 with the standard deviation 243.93. The average price of SGX index futures is 3092.32 with the standard deviation 244.34.

4.3 Unit root test- Test of stationarity

Mostly financial times series are found non-stationary in literature and contains unit root. A financial time series is strictly stationary if all the moments of its probability distribution (mean, variance, skewness and kurtosis) remain same with time, which is rare in practice. Thus, mostly series required to be transformed into weekly stationary series (i.e., its mean, variance and co-variance between the lags are time invariant). The stationary time series have the tendency to come back to its mean (mean reversion process), fluctuates around the mean (variance) and have near constant amplitude. The non-stationary time series have problems as most of the statistical test are non-applicable on non –stationary time series. Hence, in order to generalize results, the selected non-stationary spot and future equity indices transformed into stationary series, the most popular transformation is converting stock prices into continuously compounded returns. In this research study the stock prices of the selected companies are tested using ADF unit root test, the unit root test assumes the null hypothesis that the time series is stationary. The results of ADF unit root test of the index considered in the study for selected countries are discussed in this section.

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Table:3 Unit Root Test

Series Name	ADF Statistics	P value	Remark
Nifty Spot index	-1.836621	0.686	Non-Stationary
Nifty Future index	-1.895693	0.6564	Non-Stationary
Nikkei Spot index	-3.238052	0.0772	Non-Stationary
Nikkei Future index	-3.332657	0.0612	Non-Stationary
S&P Spot Index	-1.089465	0.9292	Non-Stationary
S&P Future Index	-1.052680	0.9350	Non-Stationary
SGX Spot Index	-2.751695	0.2157	Non-Stationary
SGX Future Index	-2.723590	0.2269	Non-Stationary

Source: Author's Calculation

Table:4 Unit Root Test at First Difference

Series Name	ADF Statistics	P value	Remark
Nifty Spot index	-18.67768	0.0001	Stationary
Nifty Future index	-52.30611	0.0001	Stationary
Nikkei Spot index	-34.93770	0.0001	Stationary
Nikkei Future index	-53.80574	0.0001	Stationary
S&P Spot Index	-16.63613	0.0000	Stationary
S&P Future Index	-16.86585	0.0000	Stationary
SGX Spot Index	-52.50226	0.0000	Stationary
SGX Future Index	-51.36702	0.0000	Stationary

Source: Author's Calculation

The results of ADF unit root test (Table 3) applied on the selected spot and future equity indices are initially non stationary at level, however, when the ADF unit root test(Table 4) is applied at the first difference of Index spot/future prices, the transformed series are found to be stationary. Thus, for further analysis the spot and future prices are transformed (continuously compounded transformation) into continuously compound returns with the help of following formula:

$$\textbf{Index Returns} = \log(P_1/P_0)$$

Where P_1 represents price of index on a particular day, P_0 represents value of index on previous day and log represents natural log to the base 'e'. For further analysis, the Index return will be used.

4.4 Johansen Cointegration Test

In stock market the future prices of the equity indices are derived from their spot prices and a theoretical relationship is supposed to maintained between the spot and future index values. The theoretical long-term relationship assumes no arbitrage principle. The long-term relationship between spot and future equity indices supports the presence equilibrium relationship. In other words, the existence of arbitrage opportunities, if any, leads to the correction of the index values. The long-term relationship between selected equity indices spot and future prices are examined using Johansen Cointegration test, applied on the spot and future prices of the selected equity indices. The all spot and future values of equity indices are found to have same order of integration, satisfying the necessary condition of Johansen cointegration test. Table reported the results of the Johansen Cointegration test applied between spot and future prices of selected equity indices. The table 5 reported two different tests explaining the long-term equilibrium relationship in the Johansen Cointegration test, where the first block reports the trace statistics however the second block reports the maximum Eigen value test statistics.

Table: 5 Johansen's Co-Integration Test on spot and future prices

Variables	Trace Statistics			Eigen value	
	No. of CEs	Trace Statistics	P-value	Eigen Statistics	P-Value
Nifty	None	175.8301	0.0001	174.9837	0.0001
	At Most 1	0.846398	0.3576	0.846398	0.3576
Nikkei	None	211.7473	0.0001	211.2807	0.0001
	At Most 1	0.466655	0.4945	0.466655	0.4945
S&P	None	195.1060	0.0001	192.9746	0.0001
	At Most 1	2.131376	0.1443	2.131376	0.1443
SGX	None	174.1505	0.0001	163.9511	0.0001
	At Most 1	10.19935	0.0014	10.19935	0.0014

Source: Author's Calculation

The results of Johansen cointegration (Table 5) failed to the support the hypothesis that there exists no cointegration between spot and future market of all the selected equiy indices. The Trace test Nifty (trace test=175.8301, maximum eigen value=174.9837), Nikkei(trace test=211.7473,maximum eigen value=211.2807), S&P(trace test=195.1060,maximum eigen value=192.9746) and SGX(trace test=174.1505, maximum eigen value=163.9511) indicates the presence of long-term equilibrium relationship between spot and future market of all the selected equity indices. The results of Johansen cointegration test namely Trace test and maximum eigen value confirms the presence of cointegrating relationship between spot and future market of all the selected equity indices. Thus, the acceptance of alternate hypothesis of Johansen cointegration test confirms the presence of cointegrating relationship between spot and future market of

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all the selected equity indices. The presence of long-term relationship between spot and future market of all the selected equity indices also ensures the presence of arbitrage opportunity in the Stock market. Whenever the error emerges between spot and future market of all the selected equity indices, the error is corrected very fast.

4.5 Error correction mechanism between Co-integrated future & spot equity stock indices

The spot and future equity indices of selected markets are expected to maintain the long-term equilibrium relationship due to cost of carry model and associated arbitrage mechanism. According to the cost of carry mechanism, the future equity index is valued as the summation of the spot prices plus the cost of carry (such as interest cost) if any. However, due to the presence of the different investors (rational vs noise traders), the equity market has volatile movement in the price of the stocks. The equity market experiences the volatile demand-supply forces and despite this fact, the spot and future equity indices maintain the long-term equilibrium. The difference in the equity spot and future indices, if any provides the arbitrage opportunities to the market participants. The arbitrageurs are always ready to welcome such opportunities and take the positions (long vs short) in the spot and future equity indices. This objective describes about the arbitrage opportunities and the error correction process in the equity market to maintain the equilibrium in the system. The presence of long-term equilibrium between the spot and future equity market and the error correction mechanism (ECM) due to arbitrage process is examined with the help of Johansen cointegration test followed by VECM system.

The spot and futures market relationship in the equity market provides the information to the market participants about the dynamism in the system. In equity markets, the spot equity index takes its value from the trading in individual securities, thus assumed to be stochastic and independent. However, the future value of equity indices is assumed to follow the spot market. The fluctuation in the equity spot indices provides the arbitrage opportunities to the market participants, thus, the future price of equity indices moves near to the spot prices. The arbitrageur formulates the strategies to take positions in spot and future price of equity indices and take the benefit of a risk-less position. The arbitrageurs make returns higher than a risk-free rate of return from their position. This mechanism of arbitrage correction ensures the presence of long-term relationship between the spot and future market of selected equity indices. In case of the error if any exists between the spot and future market of equity indices, the error is corrected very fast, and can be examined with the help of VECM method.

4.5.1 National Stock Exchange

The equilibrium relationship between the spot and future equity market of National Stock Exchange confirms the motivation to explore the arbitrage process between the spot and future market. The cointegrating relationship between NIFTY spot and future prices is discussed with the help of *ECM* process. The results of the VECM for NIFTY spot and future equity indices is shown in table 6 below:

Table 6: Error correction process

Commodity	**Variables**	**D(Nifty_Future)**		**D(Nifty_Spot)**	
		Coefficient	**T stats**	**Coefficient**	**T stats**
Nifty	Equilibrium Error	-0.268	-1.980	**0.044**	**0.335**
	D(SPOT(-1))	-0.166	-0.923	0.363	2.050
	D(SPOT(-2))	-0.013	-0.074	0.107	0.612
	D(SPOT(-3))	-0.262	-1.531	0.297	1.769
	D(SPOT(-4))	0.143	0.922	0.118	0.788
	D(FUTURE(-1))	0.166	0.934	0382	2.187
	D(FUTURE(-2))	0.018	0.106	0.112	0.648
	D(FUTURE(-3))	0.244	1.439	0.267	1.608
	D(FUTURE(-4))	-0.117	-0.765	-0.098	-0.656
	C	4.102	2.110	4.100	2.152
	R-squared	0.37%		0.5%	
	F-statistic	1.128		1.531	

The results of ECM for spot and future prices of NIFTY equity indices indicate that the equilibrium is maintained by the NIFTY spot series as indicated by t statistics of equilibrium error as 0.335. However, the t statistic in case of NIFTY future series is found to be -1.980, which depicts that the future series of NIFTY is an exogenous series. Thus, it can be concluded that the error correction of the equilibrium is maintained by the NIFTY equity spot series. In other words, when the disequilibrium or error exists between the NIFTY future and spot price series, it will be corrected soon by NIFTY spot price series, and will bring the equilibrium back in the system. The causality between the spot and price series of NIFTY equity series is shown below:

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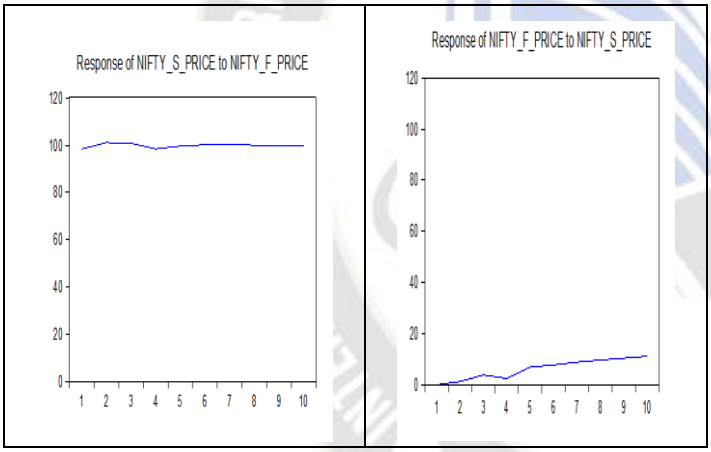
Table 7: Granger Causality

Dependent variable: D(Nifty_SPOT)				Dependent variable: D(Nifty_FUTURE)			
Excluded	Chi-Square	df	Prob.	Excluded	Chi-Square	df	Prob.
D(Nifty_FUTURE)	8.782	4	0.668	D(Hangseng_SPOT)	5.967	4	0.202
All	8.782	4	0.668	All	5.967	4	0.202

The result reported that there exists no causality between spot and future prices of NIFTY series. The causality between the NIFTY spot and future series is shown below using IRF function. The figure indicating the IRF diagrams represents the causality between spot and future prices of NIFTY equity indices. The figure indicates that the response of spot market of NIFTY series on its future market is higher as compared to response of future market on the spot market. The results indicate ***that future market of NIFTY equity indices series is more exogeneous, efficient and leads the NIFTY spot market.***

Figure 3: Response of Nifty spot to Nifty future and vice versa



The variance decomposition represents the proportion of the error of the spot and future markets of NIFTY equity indices, explained with the help of lagged values of other series. Table 8 indicates the results of VD analysis applied on the spot and future series of NIFTY equity indices. The results depicts that the spot market returns of NIFTY equity indices is explained by 98.826 % with the help of its own lagged behaviour and just 1.173 % due to the lagged behaviour of future series of NIFTY equity indices. However, in case of future market of NIFTY equity indices, it is found to be explained by 0.522% with the help of its own lagged behaviour and 99.47 % due to the lagged behaviour of its spot series.

Table 8: Variance Decomposition

Variance Decomposition of SPOT:				Variance Decomposition of FUTURE:			
Period	S.E.	SPOT	FUTURE	Period	S.E.	SPOT	FUTURE
1	99.05094	98.49113	1.508872	1	101.0391	100.0000	0.000000
2	141.7571	98.92140	1.078601	2	142.6747	99.99242	0.007580
3	174.1696	99.00750	0.992502	3	174.7922	99.94692	0.053077
4	200.1715	99.12545	0.874554	4	201.2819	99.94534	0.054660
5	223.8231	99.07625	0.923754	5	225.3187	99.86275	0.137252
6	245.4741	99.02790	0.972102	6	247.1347	99.78790	0.212104
7	265.4538	98.97709	1.022911	7	267.1916	99.71046	0.289542
8	283.9274	98.92697	1.073033	8	285.7111	99.63272	0.367277
9	301.2156	98.87640	1.123600	9	303.0319	99.55479	0.445211
10	317.5534	98.82607	1.173931	10	319.3865	99.47761	0.522388

Thus, it is concluded in the study that the future market of NIFTY series is highly efficient and exogeneous in nature. The Spot market however found to be responsive to future market. Thus, future market is found to be responsive to spot market.

The speed of arbitrage adjustment is found to be 0.044 represented by the coefficient of error term in the cointegrating equation.

4.5.2 JAPAN EXCHANGE

The equilibrium relationship between the spot and future equity market of Japan Stock Exchange confirms the motivation to explore the arbitrage process between the spot and future market. The cointegrating relationship between NIKKEI spot and future prices is discussed with the help of *ECM* process. The results of the VECM for NIKKEI spot and future equity indices is shown in table 9 below:

Table 9: Error correction process

Commodity	**Variables**	**D(Nikkei_Future)**		**D(Nikkei_Spot)**	
		Coefficient	**T stats**	**Coefficient**	**T stats**
Nikkei	Equilibrium Error	-0.525	-0.443	**0.302**	**2.661**
	D(Future(-1))	-0.133	-1.056	0.253	2.087
	D(Future(-2))	-0.129	-1.044	0.0315	0.265
	D(Future(-3))	-0.0822	-0.718	0.037	0.340
	D(Future(-4))	-0.013	-0.014	0.049	0.561
	D(Spot(-1))	0.110	0.861	-0.285	-2.320
	D(Spot(-2))	0.173	1.383	0.022	0.182
	D(Spot(-3))	0.036	0.312	-0.073	0.111
	D(Spot(-4))	0.026	0.289	-0.046	-0.523
	C	6.864	1.452	6.881	1.519
	R-squared	0.65%		2.14%	
	F-statistic	1.952		6.507	

The results of ECM for spot and future prices of NIKKEI equity indices indicate that the equilibrium is

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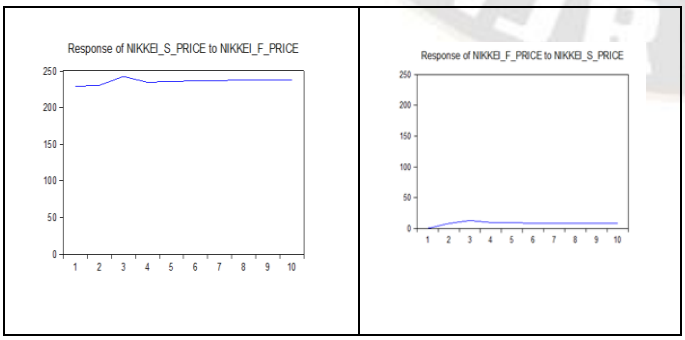
maintained by the NIKKEI spot series as indicated by t statistics of equilibrium error as 2.661. However, the t statistic in case of NIKKEI future series is found to be -0.443, which depicts that the future series of NIKKEI is an exogenous series. Thus, it can be concluded that the error correction of the equilibrium is maintained by the NIKKEI equity spot series. In other words, when the disequilibrium or error exists between the NIKKEI future and spot price series, it will be corrected soon by NIKKEI spot price series, and will bring the equilibrium back in the system. The causality between the spot and price series of NIKKEI equity series is shown below:

Table 10: Granger causality

Dependent variable: D(Nikkei_SPOT)				Dependent variable: D(Nikkei_FUTURE)			
Excluded	Chi-Square	Df	Prob.	Excluded	Chi-Square	df	Prob.
D(Nikkei_FUTURE)	2.57	4	0.632	D(Nikkei_SPOT)	7.447	4	0.114
All	2.57	4	0.632	All	7.447	4	0.114

The result reported that there exists no causality between spot and future prices of NIKKEI series. The causality between the NIKKEI spot and future series is shown below using IRF function. The figure indicating the IRF diagrams represents the causality between spot and future prices of NIKKEI equity indices. The figure indicates that the response of Future market of NIKKEI series on its spot market is higher as compared to response of spot market on the future market. The results indicate ***that future market of NIKKEI equity indices series is more exogeneous, efficient and leads the NIKKEI spot market.***

Figure 4: Response of Nikkei spot to future and vice versa



The variance decomposition represents the proportion of the error of the spot and future markets of NIKKEI equity indices, explained with the help of lagged values of other series. Table 11 indicates the results of VD analysis applied on the spot and future series of NIKKEI equity indices. The results depicts that the spot market returns of NIKKEI equity indices is explained by 99.07 % with the help of its own lagged behaviour and just 0.927 % due to the lagged behaviour of future series of NIKKEI equity indices. However, in case of future market of NIKKEI equity indices, it is found to be explained by 0.1302% with the help of its own lagged behaviour and 99.869 % due to the lagged behaviour of its spot series.

Table 11: Variance Decomposition

Variance Decomposition of SPOT:				Variance Decomposition of FUTURE:			
Period	S.E.	SPOT	FUTURE	Period	S.E.	SPOT	FUTURE
1	234.4053	95.62312	4.376885	1	244.5069	100.0000	0.000000
2	329.4874	97.40642	2.593578	2	340.0784	99.94486	0.055138
3	410.1714	97.86473	2.135267	3	419.5554	99.86918	0.130818
4	472.8850	98.24104	1.758956	4	480.8965	99.86052	0.139479
5	528.8094	98.47638	1.523623	5	537.4940	99.85526	0.144743
6	579.5786	98.64774	1.352258	6	588.2586	99.86097	0.139032
7	626.4351	98.78907	1.210926	7	635.1441	99.86290	0.137104
8	670.2081	98.90037	1.099633	8	678.6830	99.86517	0.134832
9	711.3808	98.99440	1.005596	9	719.6429	99.86743	0.132570
10	750.3605	99.07269	0.927313	10	758.4257	99.86972	0.130275

Thus, it is concluded in the study that the future market of NIKKEI series is highly efficient and exogeneous in nature. Thus, future market is found to be responsive to spot market. The speed of arbitrage adjustment is found to be 0.302 represented by the coefficient of error term in the cointegrating equation.

4.5.3 NEW YORK STOCK EXCHANGE

The equilibrium relationship between the spot and future equity market of New York Stock Exchange confirms the motivation to explore the arbitrage process between the spot and future market. The cointegrating relationship between S&P spot and future prices is discussed with the help of *ECM* process. The results of the VECM for S&P spot and future equity indices is shown in table 12 below:

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Table 12: Error correction process

Commodity	Variables	D(S&P_Future)		D(S&P_Spot)	
		Coefficient	T stats	Coefficient	T stats
S&P	Equilibrium Error	0.031	-0.227	**0.353**	**2.612**
	D(Spot(-1))	-0.171	-1.156	0.338	2.320
	D(Spot(-2))	0.052	0.346	0.350	2.357
	D(Spot(-3))	0.051	0.358	0.285	2.023
	D(Spot(-4))	-0.294	-2.253	-0.211	-1.638
	D(Spot(-5))	0.255	2.541	0.322	3.257
	D(Future(-1))	0.027	0.185	-0.464	-3.184
	D(Future(-2))	0.038	0.257	-0.273	-1.844
	D(Future(-3))	-0.042	-0.295	-0.260	-1.851
	D(Future(-4))	0.227	1.749	0.128	1.003
	D(Future(-5))	-0.270	-2.737	-0.325	-3.336
	C	1.426	2.872	1.401	2.863
	R-squared	5.46%		7.5%	
	F-statistic	14.482		20.382	

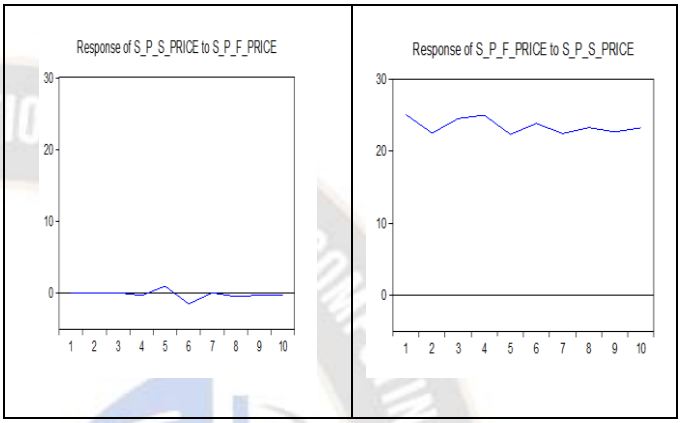
The results of ECM for spot and future prices of S&P equity indices indicate that the equilibrium is maintained by the S&P spot series as indicated by t statistics of equilibrium error as 2.612. However, the t statistic in case of S&P future series is found to be -0.227, which depicts that the future series of S&P is an exogenous series. Thus, it can be concluded that the error correction of the equilibrium is maintained by the S&P equity spot series. In other words, when the disequilibrium or error exists between the S&P future and spot price series, it will be corrected soon by S&P spot price series, and will bring the equilibrium back in the system. The causality between the spot and price series of S&P equity series is shown below:

Table 13: Granger Causality

Dependent variable: D(S&P_SPOT)				Dependent variable: D(S&P_FUTURE)			
Excluded	Chi-Square	df	Prob.	Excluded	Chi-Square	df	Prob.
D(S&P_FUTURE)	37.752	5	0	D(S&P_SPOT)	64.509	5	0
All	37.752	5	0	All	64.509	5	0

The result reported that there exists bi-directional causality between spot and future prices of S&P series. The causality between the S&P spot and future series is shown below using IRF function. The figure indicating the IRF diagrams represents the causality between spot and future prices of S&P equity indices. The figure indicates that the response of Future market of S&P series on its spot market is higher as compared to response of spot market on the future market. The results indicate ***that future market of S&P equity indices series is more exogeneous, efficient and leads the S&P spot market.***

Figure 5: Response of S & P Spot to future and vice versa



The variance decomposition represents the proportion of the error of the spot and future markets of S&P equity indices, explained with the help of lagged values of other series. Table 14 indicates the results of VD analysis applied on the spot and future series of S&P equity indices. The results depicts that the spot market returns of S&P equity indices is explained by

99.93 % with the help of its own lagged behaviour and just 0.069 % due to the lagged behaviour of future series of S&P equity indices. However, in case of future market of S&P equity indices, it is found to be explained by 0.553% with the help of its own lagged behaviour and 99.446 % due to the lagged behaviour of its spot series.

Table 14: Variance Decomposition

Variance Decomposition of SPOT:				Variance Decomposition of FUTURE:			
Period	S.E.	SPOT	FUTURE	Period	S.E.	SPOT	FUTURE
1	25.94660	100.0000	0.000000	1	25.58877	96.38130	3.618695
2	34.16279	99.99997	2.78E-05	2	34.11263	97.89578	2.104220
3	42.39681	99.99991	9.20E-05	3	42.05956	98.55038	1.449621
4	49.05173	99.99454	0.005465	4	48.96779	98.92186	1.078136
5	54.16545	99.96478	0.035224	5	53.86668	98.97841	1.021586
6	59.09675	99.90322	0.096784	6	58.93744	99.13055	0.869453
7	63.28223	99.91558	0.084420	7	63.08012	99.22550	0.774496
8	67.43944	99.91987	0.080128	8	67.24958	99.31808	0.681918
9	71.16370	99.92610	0.073901	9	70.97636	99.38745	0.612546
10	74.89581	99.93110	0.068901	10	74.70179	99.44633	0.553670

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Thus, it is concluded in the study that the future market of S&P series is highly efficient and exogeneous in nature. The Spot market however found to be responsive to future market. Thus, future market is found to be responsive to spot market. The speed of arbitrage adjustment is found to be 0.353 represented by the coefficient of error term in the cointegrating equation.

4.5.4 Singapore Stock Exchange and State Times Index

The equilibrium relationship between the spot and future equity market of Singapore exchange confirms the motivation to explore the arbitrage process between the spot and future market. The cointegrating relationship between SGX spot and future prices is discussed with the help of *ECM* process. The results of the VECM for SGX spot and future equity indices is shown in table 15 below:

Table 15: Error correction process

Commodity	**Variables**	**D(SGX_SPOT)**		**D(SGX_FUTURE)**	
		Coefficient	**T stats**	**Coefficient**	**T stats**
SGX	Equilibrium Error	-0.113	-1.959	**0.287**	**17.582**
	D(SPOT(-1))	-0.114	-1.906	0.677	39.779
	D(SPOT(-2))	-0.03	-0.461	0.242	12.932
	D(FUTURE(-1))	0.071	1.07	-0.253	-13.424
	D(FUTURE(-2))	0.031	1.604	-0.004	-0.75
	C	-0.053	-0.11	-0.013	-0.098
	R-squared	3.86%		91.92%	
	F-statistic	2.133		6253.93	

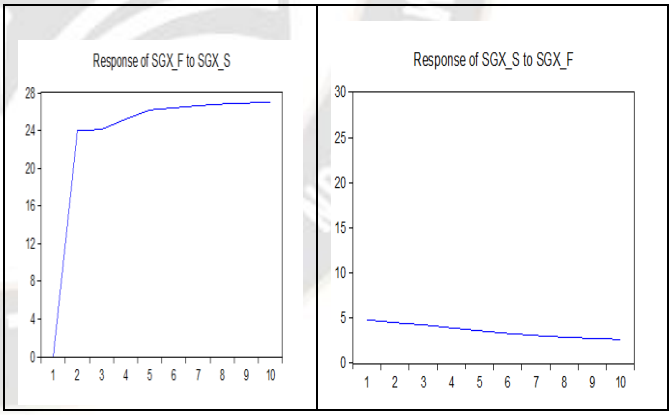
The results of ECM for spot and future prices of State Times equity indices indicate that the equilibrium is maintained by the SGX future series as indicated by t statistics of equilibrium error as 17.582. However, the t statistic in case of SGX spot series is found to be -1.959, which depicts that the spot series of SGX is an exogenous series. Thus, it can be concluded that the error correction of the equilibrium is maintained by the SGX equity future series. In other words, when the disequilibrium or error exists between the SGX future and spot price series, it will be corrected soon by SGX future price series, and will bring the equilibrium back in the system. The causality between the spot and price series of SGX equity series is shown below:

Table 16: Granger Causality

Dependent variable: D(SGX_SPOT)				Dependent variable: D(SGX_FUTURE)			
Excluded	Chi-Square	Df	Prob.	Excluded	Chi-Square	df	Prob.
D(SGX_FUTURE)	3.360	2	0.186	D(SGX_SPOT)	1617.813	2	0.000
All	3.360	2	0.186	All	1617.813	2	0.000

The result reported that there exists uni-causality from SGX future to SGX Spot. The causality between the SGX spot and future series is shown below using IRF function. The figure indicating the IRF diagrams represents the causality between spot and future prices of SGX equity indices. The figure indicates that the response of future market of SGX series on its spot market is higher as compared to response of spot market on the future market. The results indicate ***that spot market of SGX equity indices series is more exogeneous, efficient and leads the SGX future market.***

Figure 6: Response of SGX future to spot and vice versa



The variance decomposition represents the proportion of the error of the spot and future markets of SGX equity indices, explained with the help of lagged values of other series. Table 17 indicates the results of VD analysis applied on the spot and future series of SGX equity indices. The results depicts that the spot market returns of SGX equity indices is explained by 5.168% with the help of its own lagged behaviour and just 94.831 % due to the lagged behaviour of future series of SGX equity indices. However, in case of future market of SGX equity indices, it is found to be explained by

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98.168 % with the help of its own lagged behaviour and 1.831% due to the lagged behaviour of its spot series.

Table: 17 Variance Decomposition

Variance Decomposition of SPOT:				Variance Decomposition of FUTURE:			
Period	S.E.	SPOT	FUTURE	Period	S.E.	SPOT	FUTURE
1	7.147718	100.0000	0.000000	1	25.30291	3.554825	96.44518
2	26.24373	16.44357	83.55643	2	35.72112	3.346385	96.65361
3	36.46289	12.90124	87.09876	3	44.31304	3.091219	96.90878
4	44.80929	10.64450	89.35550	4	51.88917	2.818910	97.18109
5	52.22864	9.048556	90.95144	5	58.52874	2.585881	97.41412
6	58.75048	7.877152	92.12285	6	64.53149	2.384563	97.61544
7	64.67020	6.969363	93.03064	7	70.04701	2.212739	97.78726
8	70.12639	6.245135	93.75487	8	75.17283	2.065874	97.93413
9	75.21072	5.656044	94.34396	9	79.98184	1.939825	98.06018
10	79.99129	5.168750	94.83125	10	84.52580	1.831058	98.16894

Thus, it is concluded in the study that the spot markets highly efficient and exogeneous in nature. The future market however found to be responsive to spot market. Thus, future market is found to be responsive to spot market. The speed of arbitrage adjustment is found to be 0.287 represented by the coefficient of error term in the cointegrating equation

V. Conclusion

The current study makes an effort to investigate the cointegration of the spot market and future indices (NIFTY, NIKKEI, S&P 500 AND Singapore FTSE) of selected developed and developing nations. The cointegration test and Granger causality test based on a vector error correction model are used in the present study to examine the short- and long-run relationships. The study also observes the integration of the most significant stock markets, including Germany, Hongkong, India, Japan, USA and Singapore. A precise long-term equilibrium relationship between all stock markets is confirmed by the Johansen cointegration test as a general strength. Comparative Granger tests for causality using the error correction model and results of error correction tests reveal interdependencies. The fact that the S&P 500 spot market index and future market index have a bi-directional causality shows that how interdependent these stock indices are. But, in case of Singapore FTSE, there is uni-causality from SGX future to SGX Spot indices. And in rest of indices (NIFTY and NIKKEI), there is no causality between spot and future stock indices.

Furthermore, the study advises investors to exercise caution while investing in the stock market because of the markets' considerable cointegration and long-term equilibrium linkages between spot market and future market indices. Similar dangers may manifest in both markets at the same time. Opportunities for Indian businesses operating in the US to hedge against foreign investment are still scarce. As a consequence, it is highly anticipated that the study's empirical findings would be beneficial to policymakers, investment firms, investment funds, institutional investors, individual investors, and institutional investors.

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