IJER © Serials Publications
12(3), 2015: 787-803
ISSN: 0972-9380

EMERGING MARKET NEXUS FOR CROSS LISTED STOCKS: EMPIRICAL EVIDENCE FROM INDIA

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Abstract: *This study explores the long run and short run relationship of returns for cross listed stocks on two non-synchronous (US and India)global markets using daily data for the period from Jan 2001 to May 2012. We also examine the co movements of prices and causative relationships on ADRs of Indian stocks concerning to Banking and Software sectors cross listed in the US markets employing Vector Error Correction Model. Results exhibited the co integration between domestic stock price series and ADR prices in the long run. In short run, we find evidence of strong error correction of ADR opening prices and NYSE opening returns. But there is only a weak short run relationship in the domestic stock closing price and the foreign market closing index returns. As an outcome of this, the gait of international market assimilation gets reduced in developing markets like India due to information asymmetry.*

Keywords: *Cross listed stocks; Co integration; VECM;ADR; NYSE; NIFTY*

1. INTRODUCTION

The globalization of financial markets has prominently roused the inevitability of cross-border capital flows. In reaction to this globalization drift, an intensifying number of companies have preferred to list their shares on international stock markets. Stock exchanges in various countries are helping to promote cross-listing of securities.

Cross listing of shares means a firm listing its equity shares on one or more foreign stock exchange in addition to its domestic exchange. Cross-listing on a foreign market reduces the cost of capital over an enrichment of the firm's information environment. Cross-listing augments the firm's reputation and profile in global markets, afford access to extensive range of investors, and enhance the liquidity of the firm's securities. Conversely, the regulatory and operating costs of listing on foreign securities exchanges can offset the benefits.

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Indian Stocks are listed in foreign exchanges likes NYSE, NASDAQ, as American Depository Receipt (ADR) Global Depository Receipt (GDR), ADRs are the best common vehicle over which Indian companies cross-list shares in the U.S. ADRs are U.S. share certificates that signify underlying foreign shares that are held in custody outside the U.S. They are traded and settled in the U.S. like any other U.S. share. ADR's are issued by U.S depositary banks like JPMorgan, Deutsche Bank,Citibank and the Bank of New York Mellon. The ADR prices, corresponds to the dollar price of the local market stock, accustomed by the ratio of the ADR.

When an asset is traded in different markets an imperative question is which market is more informative for fundamental valuation. In the literature this topic is known as price discovery (Kim, L. C. H. 2010). The price discovery concept assumes that prices for an asset in different markets share a common efficient price which represents the fundamental value of the asset. In the long run the prices in different markets converge to the efficient price, but in the short run they might deviate from it due to trading frictions. As a growing number of companies become cross listed internationally, price discovery in two countries becomes an interesting subject. It is generally expected that price discovery in the home country dominates that of the foreign country because fundamental information about the firm is typically released in the home market. However, a large and liquid foreign market, like the U.S. equity market, may lead to a significant contribution to price discovery.

One aspect of the ADRs is that the holder of ADRs can convert the shares into the foreign currency denominated underlying shares with respect to cancellation and conversion fees. Similarly, holders of underlying shares can also convert the shares into ADRs in the US markets. Consequently, an investor who relates the ADR price with the dollar price of the underlying share can acquire a riskless profit if the price differential is sufficient to protect the transactions costs. Therefore the arbitrage force would retain the price of ADRs delineating with the dollar price of underlying shares. Under a supposition of constant foreign exchange rates over time, an upward or a downward movement of the underlying share in the foreign country would move up or down the price of the ADR in the US market. In order to look into the potentials of arbitrage on a real time basis, a parenthesis on the timing of trading in the two sets of Stock Exchanges, *viz*., domestic and foreign market is provided in Table 1. Within the same calendar day, the Asian markets close first, and the US market is the last one to close. The trading timings in India begins at IST 9.15 AM and endures till IST 15.30 PM and the trading session in the US begins at IST 19.30 PM on the same day and closes at IST 2:30 A.M on the next day. Therefore Indian trading session is 10 hrs 15 min ahead of the US trading session. If the markets are informationally efficient, and the underlying share prices actually affect the prices of ADRs, a shock from the home market should be reflected in the ADR prices by the same calendar day.

Table 1
Trading Sessions of NSE and NYSE

(Indian Standard Time)

DAY T			*DAY T+1*
NSE OPEN	NSE CLOSE	NYSE OPEN	NYSE CLOSE
▼	▼	▼	▼
09.15HRS	15.30 HRS	19.30 HRS	02.30 HRS

2. LITERATURE REVIEW

The previous literature relating to stock market integration affords strong evidence of nexus among the international markets, as an effect of worldwide economic integration.There exist enormous research literature fanatical to the issues of the cross listed securities; and the recent work by many authors has been reviewed in this section.

Corporate investment to stock price is higher for firms cross-listed in the U.S. than for firms non cross-listed with 633 firms from 39 countries was analyzed for the period 1989-2006 (Foucault, T., & Frésard, L 2012). The hypothesis suggested that a cross-listing had a positive impact on the investment-to-price sensitivity which in turn assists managers to acquire more useful feedback from the stock market. Phylaktis, K., &Korczak, P. (2004) scrutinized the influence of US trading to the process of price discovery of British and French companies cross-listed on the NYSE by applying Co integration test and Vector Error Correction Modeling. The findings of the study revealed that the contribution of the US market is positively related to the trading of share in the US relative to home trading and ADR institutional holdings.But inversely related to the ratio of spreads in the US and home market. Tsai, B. H., & Li, S. H. (2004) focused on price dynamics of depositary receipts (DRs) issued by Taiwanese and Hong Kong firms. The empirical results using VECM and VAR indicated that long-term equilibrium relationships between depositary receipts and underlying security prices exist for firms listed in Hong Kong, a free-entry market, but do not necessarily exist for firms listed in Taiwan with foreign ownership restrictions.

Another study by Eun, C. S. and S. Sabherwal (2003) examined the impact of cross-listings to price discovery for Canadian stocks listed on both the Toronto Stock Exchange (TSE) and a U.S. exchange. The findings revealed that prices on the TSE and U.S. exchange are mutually adjusting and cointegrated. Kim *et al.* (2000) applied vector auto regression (VAR-SURE) model to investigate the interrelations between ADR returns and their pricing factors: returns on the underlying shares, exchange rates and US market returns. They also identified how a shock in one market is transmitted to another and how long the shock persisted. They concluded that ADRs appear to initially over-react to the US market index but under-react to changes in underlying stocks and exchange rates.

Further studies of Kim, L. C. H. (2010) Takayama, S., & Ozsoylev, H. (2005), Chang, M. T., & Marisetty, V. (2006), Baruch, S., *et al.* (2007), Bris, A., Cantale, S., & Nishiotis,

G. P. (2007), Gagnon, L., & Andrew Karolyi, G. (2010) and Caporale, G. M., & Girardi, A. (2013) added volume to literature of international cross-listing.

Wang, S. S *et al.* (2002), reconnoitered the return and volatility behavior of stocks traded from HongKong to London, and from London to Hong Kong. The results exhibited that returns and volatility spillovers are bidirectional. Ding *et al.* (1999) explored the extent of contribution to price discovery for the Kuala Lumpur Stock Exchange and the Stock Exchange of Singapore (SES). The Results indicated that the price series were co integrated and the raw data indicated the existence of arbitrage opportunities, but none exist after considering exchange rate changes.

More recently, a number of studies examined the short-term and long term relationship on some emerging stock markets. The long-run and short-run performance of 192 Australian cross-listed firms was examined (Ng, Y. H., Yong, *et al.* 2012). The findings revealed that in short run, the mean cumulative abnormal returns are statistically significant for the cross-listed firms during the long-run analysis, rival firms carried out negative abnormal returns. Further analysis revealed liquidity gains are mostly not a factor for cross listed firms' abnormal returns. Dağli, H., Sivri, U., & Bank, S. (2012) employed Johansen cointegration analysis to scrutinize the existence of long-run relationship between the Turkish and 20 emerging stock markets using index data from 1994 - 2010 of international stock indices. The findings indicated the presence of cointegration relationships between the Turkish and the most of other emerging stock markets.

In the Indian context, Srinivasan, P. (2011) examined the integration and causality between the two dominating Indian stock markets:(BSE) and (NSE) by employing Johansen's cointegration and Vector Error Correction Model. The analysis revealed the existence of market integration between the BSE and NSE. The study further confirmed a bidirectional relationship between the two markets and they strongly influenced each other. It also suggested that correction to long-run equilibrium allows systematic profits to be acquired in the short run. Hansda S. K., & Ray, P. (2003) investigated the price interdependence of dually listed 10 Indian Companies stocks, using causality test. The strong correlation between the prices is supported by the finding of bidirectionalcausality.

The review of literature brings to light that our research differs from previous literature in many significant ways. This paper aims to provide a thought-provoking avenue to inspect whether ADRs respond more to shocks in cross listed markets or because of events in the home market.Furthermore, the literature on the Indian ADRs is scant.All existing studies pertain to cross listed shares of developed markets. This study investigates the long run and short run dynamics in the prices of dually-traded stocks and existence of arbitrage opportunities due to price differences employing Indian ADRs listed in NYSE and their domestic stocks in a more precise manner.

3. METHODOLOGY

3.1 Data Set

The study is confined to ADRs of Banking and software sectors. Table 2 lists the ADRs employed for this study and provides the names of the respective industries along with the dates of their initial listings. Data set used in this study encompasses daily open and close prices of HDFC, ICICI, WIPRO and INFOSYS listed in National Stock Exchange (NSE) as well as in NYSE stock exchange floated as ADRs. The period of selected samples is from January 2, 2001 to May 31, 2012. The data were collected from Bloomberg. E views 7.0 package is used for the implementation of econometric analyses.

Table 2
Details of ADR Employed in the Study

Company	*Symbol*	*Exchange*	*Adr: Domestic Share*	*Industry*	*Depositary bank*	*Eff Date*
Wipro	WIT	NYSE	1:1	Software	JPMC	Oct 24,2000
Infosys	INFY	NYSE	1:1	Software	DB	Mar 16,1999
ICICI Bank	IBN	NYSE	1:2	Banks	DB	Mar 31,2000
HDFC Bank	HDB	NYSE	1:3	Banks	JPMC	Jul 25,2001

Source: (www.adrbnymellon.com)

3.2. Techniques

Initially, the data have been converted to natural logarithms before the analysis process. Secondly the stationarity analysis has been conducted for data concerning to the variables used in the study. The most extensively used test among parametric tests is Augmented Dickey-Fuller (Dickey, D., Fuller, W. 1979) that considers possible structural fracture and trend in the time series. A long term association between time series has been examined by applying co-integration test developed by Johansen and Juselius (1990). The long run and short run dynamics were investigated through granger causality and vector error correction model.

3.2.1. Co integration test

The Johansen Maximum Likelihood (ML) procedure was used to determine the long-run relationship among the variables.

The likelihood ratio test based on maximal eigenvalue of the stochastic matrix and the test based on trace of the stochastic matrix were used to determine the number of cointegrating vectors. The two statistics are:

$$\lambda_{Trace}(r) = -T \Sigma_{i=r+1}^{g} in(1-\hat{\lambda_i}) \quad (1)$$

$$\lambda_{Max}(r, r+1) = -T\, in(1-\hat{\lambda}_{r+1}) \quad (2)$$

Where $\hat{\lambda_i}$ is the estimated eigenvalue of the characteristic roots, *r*-0, 1, 2,.., T = number of observations.The null hypothesis of trace is to test whether the number of cointegrating vectors is less than or equal to *r*, against the alternative and the null hypothesis of the max eigenvalue test the number of cointegrating vectors is *r*, against an alternative of (*r*+1). The procedure of Johansen ML is to first calculate the Trace and Maximum Eigenvalue statisticsand then compare with the critical values.As a result, the long-run coefficients are determined and the error correction model is produced.

3.2.2. Error Correction Model

A vector error correction model (VECM) has cointegration relations reinforced into the requirement so that it limits the long-run behavior of the endogenous variables to congregate to their cointegrating relationships while permitting for short-run adjustment dynamics. The cointegration term is known as the *error correction* term since the deviation from long-run equilibrium is corrected progressively through a sequence of partial short-run modifications.

Engle and Granger (1987) state that if a bivariate I(1) vector $Y_t = (Y_{1t}, Y_{2t})'$ is cointegrated with cointegrating vector $\beta = (1, -\beta_2)'$ then there subsists an error correction model (ECM)

$$\Delta Y_{1t} = \delta_1 + \phi_1(Y_{1,t-1} - \beta_1 Y_{2,t-1}) + \Sigma_{j=1}\, \alpha_{11}^{j} \Delta Y_{1,t-j} + \Sigma_{j=1} \alpha_{12}^{j} \Delta Y_{2,t-j} + \epsilon_{1t} \quad (3)$$

$$\Delta Y_{2t} = \delta_2 + \phi_2(Y_{1,t-1} - \beta_2 Y_{2,t-1}) + \Sigma_{j=1}\, \alpha_{21}^{j} \Delta Y_{1,t-j} + \Sigma_{j=1} \alpha_{22}^{j} \Delta Y_{2,t-j} + \epsilon_{2t} \quad (4)$$

that describes the long term relations of Y_{1t} and Y_{2t}. If both time series are I (1) but are co integrated, there is a dynamism that brings the error term back towards zero. If the cointegrating parameter β_1 or β_2 is known, the model can be estimated by the OLS method.

4. EMPIRICAL RESULTS

4.1. Unit Root Test

Table 3.1-3.2 reports the result of the augmented dickey fuller test on integration properties of the NYSE, NIFTY,WIPRO,INFOSYS,HDFC,ICICI-Open &Close returns. The definite values of these sequence exhibited trends, so all unit root test regressions include both constant and trend terms.

Table 3.1- 3.2 indicates that the ADF test statistic is more negative than the critical value and hence the null hypothesis of unit roots in the first differences i.e. the returns of the variables is rejected at 1% level and confirms the stationarity of the returns. In the level form, unit root tests are rejected for all the variables. Yet, the test rejects the null of non-stationarity for all the variables when they are used in their first difference.

Table 3.1
Augmented Dickey Fuller (ADF) Unit Root Test –Stock Return Data (2001-2012)

DVariables	*Deter-ministic*	*WIPRO*	*INFOSYS*	*HDFC*	*ICICI*	*Inference*
		t-statistic	*t-statistic*	*t-statistic*	*t-statistic*	
OPEN	Intercept	-41.83271*	-40.95362*	-59.95256*	-61.79956*	No Unit Root
	Trend & Intercept	-41.8422*	-40.95362*	-59.97007*	-61.79344*	No Unit Root
CLOSE	Intercept	-54.30248*	-52.67706*	-53.84491*	-38.17159*	No Unit Root
	Trend &Intercept	-54.30166*	-52.67405*	-53.86119*	-38.17030*	No Unit Root
ADROPEN	Intercept	-53.33897*	-32.26223*	-48.71614*	-48.25824*	No Unit Root
	Trend & Intercept	-53.32824*	-32.25400*	-48.71197*	-48.26072*	No Unit Root
ADRCLOSE	Intercept	-40.01350*	-39.84112*	-55.58865*	-52.44931*	No Unit Root
	Trend &Intercept	-40.00627*	-39.83550*	-55.58114*	-52.45287*	No Unit Root

Note: Critical values at 1% level:-3.432455, 5% level:-2.862356, 10% level:-2.567249
*Significant at 1% Level.

Table 3.2
Augmented Dickey Fuller (ADF) Unit Root Test –Index Return Data (2001-2012)

DVariables	*Deterministic*	*Levels*			
		t-statistic	*Probability*	*Lag Length*	*Inference*
DNIFTYOPEN	Intercept	-50.17962	0.0001	0	No Unit Root
	Trend and Intercept	-50.17250	0.0000	0	No Unit Root
DNIFTYCLOSE	Intercept	-38.29296	0.0000	1	No Unit Root
	Trend and Intercept	-38.28745	0.0000	1	No Unit Root
DNYSEOPEN	Intercept	-38.40512	0.0000	1	No Unit Root
	Trend and Intercept	-38.39710	0.0000	1	No Unit Root
DNYSECLOSE	Intercept	-54.72500	0.0001	0	No Unit Root
	Trend and Intercept	-54.71410	0.0000	0	No Unit Root

Note: Critical values at 1% level:-3.432455, 5% level:-2.862356, 10% level:-2.567249

This shows that all the series are stationary in the first difference and I (1) which justifies the need for cointegration test.

4.2. Cointegration Rank Test

The Johansen Co integration Rank summary for the four ADRs under study is presented in Table 4.

Table 4
Johansen Co integration Rank Summary (2001-2012)

	WIPRO	*INFY*	*HDFC*	*ICICI*
Data Trend	*Linear*	*Linear*	*Linear*	*Linear*
No. of CEs	Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept No Trend
Trace	4	4	4	5
Max-Eig	4	4	4	5

The cointegration results (the 'trace' or 'max' statistics) suggest that the series are cointegrated - in other words, all specifications suggest that there are at least four cointegrating vectors for WIPRO, INFY, HDFC, and five cointegrating vectors for ICICI. The lag number to be considered for cointegration test was estimated according to Akaike (AIC) criterion as 2 (two) and was included into the model.

4.3. Johansen Cointegration Test

Results of Johansen cointegration test for finding long term relationship between the variables are shown in Table 5.1- 5.4.

Table 5.1
Johansen Cointegration Test Results -WIPRO (2001-2012)

*Hypothesized no. of co-integrating equationsH(r) (p<0.05)***	*Trace test*		*MaxEigen value test*	
	Trace statistic	*Critical Value (p<0.05)***	*Max-Eigen statistic*	*Critical Value*
r = 0*	3186.792	159.5297	990.0396	52.36261
r ≤ 1*	2196.752	125.6154	860.3821	46.23142
r ≤ 2*	1336.370	95.75366	688.8979	40.07757
r ≤ 3*	647.4723	69.81889	610.9679	33.87687

Note: *denotes rejection of the hypothesis at the 0.05 level**MacKinnon-Haug-Michelis (1999) p-value

Table 5.2
Johansen Cointegration Test Results-INFY (2001-2012)

Hypothesized no. of co-integrating equations H(r)	*Trace test*		*MaxEigen value test*	
	Trace statistic	*Critical Value (p<0.05)***	*Max-Eigen statistic*	*Critical Value (p<0.05)***
r = 0*	1838.341	159.5297	510.0998	52.36261
r ≤ 1*	1328.241	125.6154	474.5347	46.23142
r ≤ 2*	853.7063	95.75366	435.4680	40.07757
r ≤ 3*	418.2383	69.81889	383.3907	33.87687

Note: *denotes rejection of the hypothesis at the 0.05 level.**MacKinnon-Haug-Michelis (1999) p-values

Table 5.3
Johansen Cointegration Test Results- HDFC (2001-2012)

Hypothesized no. of co-integrating equations H(r)	*Trace test*		*MaxEigen value test*	
	Trace statistic	*Critical Value (p<0.05)***	*Max-Eigen statistic*	*Critical Value (p<0.05)***
r = 0*	3124.210	159.5297	966.5539	52.36261
r ≤ 1*	2157.656	125.6154	804.0485	46.23142
r ≤ 2*	1353.607	95.75366	731.7580	40.07757
r ≤ 3*	621.8494	69.81889	586.6800	33.87687

Note: *denotes rejection of the hypothesis at the 0.05 level.**MacKinnon-Haug-Michelis (1999) p-values

Table 5.4
Johansen Cointegration Test Results- ICICI (2001-2012)

Hypothesized no. of co-integrating equations H(r)	*Trace test*		*MaxEigen value test*	
	Trace statistic	*Critical Value (p<0.05)***	*Max-Eigen statistic*	*Critical Value (p<0.05)***
r = 0*	3119.898	159.5297	951.2881	52.36261
r ≤ 1*	2168.610	125.6154	797.7933	46.23142
r ≤ 2*	1370.816	95.75366	698.4055	40.07757
r ≤ 3*	672.4109	69.81889	607.4405	33.87687
r ≤ 4*	64.97040	47.85613	42.41020	27.58434

Note: *denotes rejection of the hypothesis at the 0.05 level.**MacKinnon-Haug-Michelis (1999) p-values

According to the results of Table 5.1-5.4, the Trace test indicates 4 cointegrating eqn(s) at the 0.05 level and Max-eigenvalue test also indicates 4 cointegrating equations at the 0.05 level for WIPRO, INFY, HDFC and for ICICI the Trace test indicates 5 co integrating equations at the 0.05 level and Max-eigenvalue test also indicates 5 co integrating equations at the 0.05 level. Thus it is proven that a long run relationship exists between the variables taken for this study.

4.4. Vector Error Correction Model

A standard solution to combine both short run and long run dynamics is to make use of an error correction model.Table 6.1-6.4 present the short-run components of the estimated Vector Error Correction Model (VECM), with the restrictions implied by the CEs imposed.

The C_1 values (Table 6.1-6.4) reflect the log-run price of instancy embedded in the cointegrating vectors. C_2 coefficients reflect the long run risk premiums for the various series.The choice of lag length was assigned 2 based on Akaike Information Criterion (AIC).

Table 6.1
Estimated Vector Error Correction Model Results of WIPRO

COINTEGRATING EQ:	*COINTEQ1*	*COINTEQ2*	*COINTEQ3*	*COINTEQ4*
LWIPROADRCLOSE(-1)	1.000000	0.000000	0.000000	0.000000
LWIPROADROPEN(-1)	0.000000	1.000000	0.000000	0.000000
LWIPROCLOSE(-1)	0.000000	0.000000	1.000000	0.000000
LWIPROOPEN(-1)	0.000000	0.000000	0.000000	1.000000
LNIFTYCLOSE(-1)	-3146.5[-17.7528]	-3154.01[-17.7353]	3278.704[26.3494]	3286.159 [26.3655]
LNIFTYOPEN(-1)	3144.126[17.7440]	3151.630[17.7266]	-3276.75[-26.3406]	-3284.2 [-26.3567]
LNYSECLOSE(-1)	-2066.02[-28.9422]	-2073.69[-28.9519]	195.3292[3.89758]	199.3217[3.97065]
LNYSEOPEN(-1)	2067.851[28.9559]	2075.518[28.9656]	-197.202[-3.93333]	-201.201[-4.00644]
C_1	-0.06308	-0.0189	-4.44264	-4.42535

Error Correction	*D(LWIPRO ADR CLOSE)*	*D(LWIPRO ADR OPEN)*	*D(LWIPRO CLOSE)*	*D(LWIPROOPEN)*	*D(LNIFTY CLOSE)*	*D(LNIFTYOPEN)*	*D(LNYSE CLOSE)*	*D(LNYSE OPEN)*
ecm$_1$	-0.14624	0.808663	0.300611	0.036083	0.054092	0.052382	0.020345	0.011205
	[-2.78990]	[22.6240]	[3.97159]	[0.61677]	[2.18403]	[2.04756]	[0.78092]	[0.85132]
ecm$_2$	0.144443	-0.80638	-0.29951	-0.03783	-0.05434	-0.05262	-0.02037	-0.01168
	[2.76666]	[-22.6502]	[-3.97282]	[-0.64920]	[-2.20284]	[-2.06501]	[-0.78482]	[-0.89081]
ecm$_3$	0.678366	0.376172	0.013601	1.035136	0.200316	0.203507	0.079084	0.013230
	[14.9816]	[12.1830]	[0.20802]	[20.4827]	[9.36314]	[9.20918]	[3.51398]	[1.16353]
ecm$_4$	-0.67863	-0.37519	-0.01338	-1.03477	-0.20037	-0.20328	-0.0791	-0.01362
	[-14.9920]	[-12.1549]	[-0.20465]	[-20.4816]	[-9.36855]	[-9.20149]	[-3.51577]	[-1.19838]
C$_2$	0.000145	0.000233	-0.00056	-0.00062	0.000622	0.000622	0.000105	0.000124
	[0.25572]	[0.60185]	[-0.67715]	[-0.98123]	[2.31813]	[2.24448]	[0.37192]	[0.86934]
R-squared	0.302808	0.687913	0.014419	0.520363	0.365874	0.335530	0.049375	0.755524
Adj. R-sq	0.297087	0.685352	0.006330	0.516427	0.360670	0.330077	0.041573	0.753517
Sum sq. res	1.920209	0.892905	4.003912	2.391961	0.428748	0.457438	0.474378	0.121081
S.E. eqn	0.028070	0.019141	0.040534	0.031329	0.013264	0.013701	0.013952	0.007049
F-statistic	52.92263	268.5860	1.782630	132.1965	70.30433	61.52924	6.328802	376.5620

Note: Figures in [ ] are t-values associated with the respective parameters

According to the VECM Results of WIPRO (Table 6.1) reveal that the normalized cointegrating coefficients load on four variables - the NIFTYOPEN, NYSEOPEN series with negative coefficients & NIFTYCLOSE,NYSECLOSE series with positive coefficients. Examination of the F-statistics and the adjusted R^2 (Table 6.1), suggests that the variables in the VECM significantly explained short-run changes in only the WIPROADROPEN and NYSEOPEN, accounting for 69% and 75% of the short-run variation in the two series respectively. However, the R-squared for the WIPROCLOSE and NYSECLOSE logarithmic returns is 0.0144 and 0.0493, indicating the role of other factors responsible for the variations in explaining the WIPROCLOSE and NYSECLOSE returns.

Table 6.2
Estimated Vector Error Correction Model Results of INFY

COINTEGRATING EQ:	*COINTEQ1*	*COINTEQ2*	*COINTEQ3*	*COINTEQ4*
LINFYADRCLOSE(-1)	1.000000	0.000000	0.000000	0.000000
LINFYADROPEN(-1)	0.000000	1.000000	0.000000	0.000000
LINFYCLOSE(-1)	0.000000	0.000000	1.000000	0.000000
LINFYOPEN(-1)	0.000000	0.000000	0.000000	1.000000
LNIFTYCLOSE(-1)	-3515.34[-7.45205]	-3515.7[-7.44630]	1348.323[13.2255]	1379.743[13.7954]
LNIFTYOPEN(-1)	3512.693 [7.44820]	3513.055 [7.44246]	-1347.8[-13.2235]	-1379.2 [-13.7933]
LNYSECLOSE(-1)	-4607.07 [-22.6875]	-4611.05 [-22.6872]	-679.121 [-15.4737]	-643.144 [-14.9374]
LNYSEOPEN(-1)	4610.050 [22.6954]	4614.032 [22.6951]	679.2225[15.4714]	643.2137 [14.9345]
C_1	-9.68378	-9.68657	-12.4841	-12.3351

Error Correction:	*D(LINFY ADR CLOSE)*	*D(LINFY ADR OPEN)*	*D(LINFY CLOSE)*	*D(LINFY OPEN)*	*D(LNIFTY CLOSE)*	*D(LNIFTY OPEN)*	*D(LNYSE CLOSE)*	*D(LNYSE OPEN)*
ecm$_1$	-0.0771	0.895904	0.110866	-0.12918	0.079022	0.081024	-0.00678	0.011530
	[-0.91543]	[17.7443]	[0.86194]	[-1.16003]	[1.81138]	[1.81018]	[-0.15359]	[0.52219]
ecm$_2$	0.072098	-0.89824	-0.11058	0.121377	-0.08059	-0.08265	0.006231	-0.01191
	[0.85627]	[-17.7943]	[-0.85986]	[1.09024]	[-1.84776]	[-1.84688]	[0.14111]	[-0.53965]
ecm$_3$	0.631072	0.376623	-0.01897	0.957483	0.200978	0.198805	0.072987	0.029705
	[8.82492]	[8.78501]	[-0.17372]	[10.1266]	[5.42533]	[5.23065]	[1.94613]	[1.58434]
ecm$_4$	-0.63054	-0.37505	0.018699	-0.95598	-0.20068	-0.19799	-0.07294	-0.02998
	[-8.83257]	[-8.76338]	[0.17151]	[-10.1280]	[-5.42647]	[-5.21805]	[-1.94812]	[-1.60175]
C$_2$	3.05E-05	-3.15E-05	-0.00029	-0.00032	0.000495	0.000489	0.000137	0.000129
	[0.05392]	[-0.09290]	[-0.33715]	[-0.42153]	[1.68651]	[1.62514]	[0.46044]	[0.86700]
R-squared	0.284251	0.714262	0.023485	0.359846	0.311871	0.285253	0.058265	0.762834
Adj. R-sq	0.272717	0.709657	0.007749	0.349530	0.300782	0.273735	0.043089	0.759012
Sum sq.resid	1.614526	0.580279	3.765962	2.822569	0.433256	0.456083	0.444079	0.110985
S.E. eqn	0.026883	0.016117	0.041058	0.035545	0.013926	0.014288	0.014099	0.007048
F-statistic	24.64464	155.1205	1.492416	34.88295	28.12451	24.76610	3.839365	199.5993

Note: Figures in [ ] are t-values associated with the respective parameters.

The VECM Results of INFOSYS from Table 6.2 indicate that the normalized cointegrating coefficients load on four variables - the NYSECLOSE, NIFTYCLOSE series with positive coefficients & NYSEOPEN, NIFTYOPEN series with negative coefficients. Assessment of the F-statistics and the adjusted R^2 (Table 6.2), proposes that the variables in the VECM considerably elucidate short-run variation in only the INFYADROPEN and NYSEOPEN, explaining 71% and 76% of the short-run changes in the two series respectively. However, the R-squared for INFYCLOSE and NYSECLOSE logarithmic returns is 0.02348 and 0.05826, indicating a possible under-specification in as far explaining the INFYCLOSE and NYSECLO7SE returns are concerned.

Table 6.3
Estimated Vector Error Correction Model Results of HDFC

COINTEGRATING EQ:	*COINTEQ1*	*COINTEQ2*	*COINTEQ3*	*COINTEQ4*
LHDFCADRCLOSE(-1)	1.000000	0.000000	0.000000	0.000000
LHDFCADROPEN(-1)	0.000000	1.000000	0.000000	0.000000
LHDFCCLOSE(-1)	0.000000	0.000000	1.000000	0.000000
LHDFCOPEN(-1)	0.000000	0.000000	0.000000	1.000000
LNIFTYCLOSE(-1)	1224.829[22.2245]	1226.708[22.2138]	669.7321[5.37602]	674.7203[5.41083]
LNIFTYOPEN(-1)	-1225.97[-22.2508]	-1227.85[-22.2400]	-671.191[-5.38909]	-676.177[-5.42389]
LNYSECLOSE(-1)	-195.915[-8.37231]	-197.26[-8.41283]	-1471.46[-27.8183]	-1471.94[-27.8004]
LNYSEOPEN(-1)	196.3362[8.38486]	197.6793[8.42521]	1473.017[27.8295]	1473.490[27.8116]
C_1	3.266554	3.285997	-8.40266	-8.41407

Error Correction:	*D(LHDFC ADRC LOSE)*	*D(LHDFC ADR OPEN)*	*D(LHDFC CLOSE)*	*D(LHDFC OPEN)*	*D(LNIFTY CLOSE)*	*D(LNIFTY OPEN)*	*D(LNYSE CLOSE)*	*D(LNYSE OPEN)*
ecm$_1$	0.046530	1.005139	0.119826	-0.02759	0.221803	0.208240	0.058492	0.056948
	[0.67885]	[25.8195]	[1.18309]	[-0.29596]	[6.38043]	[5.80194]	[1.64310]	[3.34275]
ecm$_2$	-0.04491	-1.00293	-0.12068	0.030720	-0.22075	-0.20644	-0.05848	-0.0563
	[-0.65592]	[-25.7905]	[-1.19282]	[0.32988]	[-6.35707]	[-5.75806]	[-1.64439]	[-3.30819]
ecm$_3$	0.561583	0.380433	-0.11441	0.964883	0.265849	0.262566	0.077528	0.005284
	[10.9651]	[13.0785]	[-1.51174]	[13.8516]	[10.2346]	[9.79043]	[2.91464]	[0.41512]
ecm$_4$	-0.56145	-0.37966	0.114493	-0.96496	-0.26581	-0.26266	-0.0774	-0.00596
	[-10.9625]	[-13.0519]	[1.51287]	[-13.8526]	[-10.2332]	[-9.79369]	[-2.90976]	[-0.46803]
C$_2$	0.001035	0.000840	0.000230	0.000361	0.000785	0.000783	0.000166	0.000196
	[1.84395]	[2.63467]	[0.27695]	[0.47312]	[2.75773]	[2.66491]	[0.56796]	[1.40178]
R-squared	0.205974	0.699460	0.011884	0.296874	0.318307	0.286646	0.059005	0.782794
Adj. R-sq	0.199102	0.696859	0.003332	0.290789	0.312408	0.280473	0.050861	0.780915
Sum sq. res	1.683214	0.542970	3.675195	3.113769	0.432970	0.461532	0.454023	0.103985
S.E. equation		0.026988	0.015328	0.039879	0.036707	0.013688	0.014132	0.014016
0.006708								
F-statistic	29.97423	268.9242	1.389691	48.78757	53.95450	46.43133	7.245532	416.4344

Note: Figures in [ ] are t-values associated with the respective parameters

From the VECM Results of HDFC (Table 6.3) it is evident that the normalized cointegrating coefficients load on four variables – the NIFTYOPEN, NYSECLOSE series with positive coefficients & NYSEOPEN, NIFTYCLOSE series with negative coefficients. Evaluation of the F-statistics and the adjusted R^2 (Table 6.3), implies that the variables in the VECM extensively explained short-run changes in only the HDFCADROPEN and NYSEOPEN, accounting for 69% and 78% of the short-run variation in the two series respectively. However, the R-squared for HDFCCLOSE and NYSECLOSE logarithmic returns is 0.0118 and 0.0590, representing insufficient explanation for HDFCCLOSE and NYSECLOSE returns.

Table 6.4
Estimated Vector Error Correction Model Results of ICICI

COINTEGRATINGEQ:	*COINTEQ1*	*COINTEQ2*	*COINTEQ3*	*COINTEQ4*	*COINTEQ5*
LICICIADRCLOSE(-1)	1.000000	0.000000	0.000000	0.000000	0.000000
LICICIADROPEN(-1)	0.000000	1.000000	0.000000	0.000000	0.000000
LICICICLOSE(-1)	0.000000	0.000000	1.000000	0.000000	0.000000
LICICIOPEN(-1)	0.000000	0.000000	0.000000	1.000000	0.000000
LNIFTYCLOSE(-1)	0.000000	0.000000	0.000000	0.000000	1.000000
LNIFTYOPEN(-1)	9.147480	9.154002	6.572960	6.497824	-0.99975
	[1.04125]	[1.04142]	[0.98731]	[0.98586]	[-5826.41]
LNYSECLOSE(-1)	28878.46	28894.30	21887.33	21669.05	-0.15142
	[31.7527]	[31.7528]	[31.7571]	[31.7570]	[-8.52361]
LNYSEOPEN(-1)	-28900.8	-28916.6	-21904.1	-21685.6	0.151303
	[-31.7657]	[-31.7658]	[-31.7699]	[-31.7698]	[8.51371]
C_1	119.8510	119.9473	88.47464	87.66801	-0.00058

Error Correction	*D(LICICI ADR CLOSE)*	*D(LICICI ADR OPEN)*	*D(LICICI CLOSE)*	*D(LICICI OPEN)*	*D(LNIFTY CLOSE)*	*D(LNIFTY OPEN)*	*D(LNYSE CLOSE)*	*D(LNYSE OPEN)*
ecm_1	-0.11734	0.827139	0.155820	-0.01239	0.055352	0.051725	0.004034	-0.00279
	[-2.07909]	[24.8850]	[2.64375]	[-0.33580]	[2.31575]	[2.08096]	[0.14924]	[-0.19871]
ecm_2	0.084594	-0.84201	-0.13116	0.016393	-0.06053	-0.05622	-0.01402	-0.00013
	[1.49993]	[-25.3505]	[-2.22692]	[0.44478]	[-2.53417]	[-2.26355]	[-0.51902]	[-0.00904]
ecm_3	0.113027	-0.03192	-0.14481	0.866398	-0.02994	-0.02929	0.011550	-0.02425
	[2.11504]	[-1.01437]	[-2.59455]	[24.8074]	[-1.32453]	[-1.24600]	[0.45124]	[-1.82539]
ecm_4	-0.07061	0.052659	0.113501	-0.88049	0.037182	0.035622	0.001642	0.028420
	[-1.30914]	[1.65780]	[2.01473]	[-24.9772]	[1.62988]	[1.50159]	[0.06356]	[2.11963]
ecm_5	-0.61946	-0.34204	0.235334	-0.29213	-0.18201	0.680023	-0.32839	0.240294
	[-1.83491]	[-1.72042]	[0.66747]	[-1.32410]	[-1.27400]	[4.57732]	[-2.03085]	[2.86360]
C_2	5.29E-05	8.78E-05	0.000481	0.000612	0.000347	0.000348	-7.33E-06	7.29E-05
	[0.09292]	[0.26175]	[0.80771]	[1.64351]	[1.43995]	[1.38755]	[-0.02686]	[0.51479]
R-squared	0.427675	0.772979	0.032903	0.740447	0.489864	0.458171	0.114540	0.759738
Adj. R-sq	0.422733	0.771018	0.024552	0.738206	0.485459	0.453493	0.106894	0.757663
Sum sq. res	1.925237	0.667688	2.099845	0.822234	0.344764	0.372830	0.441675	0.118944
S.E. eqn	0.028136	0.016569	0.029384	0.018387	0.011906	0.012382	0.013476	0.006993
F-statistic	86.53974	394.3167	3.940142	330.3796	111.2073	97.92879	14.98074	366.2040

Note: Figures in [ ] are t-values associated with the respective parameters

With reference to the VECM results of ICICI provided in Table 6.4, it is obvious that the normalized cointegrating coefficients load on three variables - the NYSEOPEN series with positive coefficient & NIFTYOPEN, NYSECLOSE series with negative coefficients. Estimation of the F-statistics and the adjusted R^2 (Table 6.4), advocate that the variables in the VECM notably explained short-run changes in only the ICICIADROPEN, ICICIOPEN and NYSEOPEN, accounting for 77%, 73% and 76% of the short-run variation in the three series respectively. However, the R-squared for the ICICICLOSE and NYSECLOSE logarithmic returns is 0.03290 and 0.11454, indicating the role of other issues responsible for the variations in the ICICICLOSE and NYSECLOSE returns. Time series of closing values of ADRs and stocks are represented in Fig. 1.

4.5. Granger Causality Test

One of the ways to determine short run causality amid variables is to apply Granger Causality Test (Engle and Granger, 1987). Table 7.1-7.4 presents the result of pair wise causality.

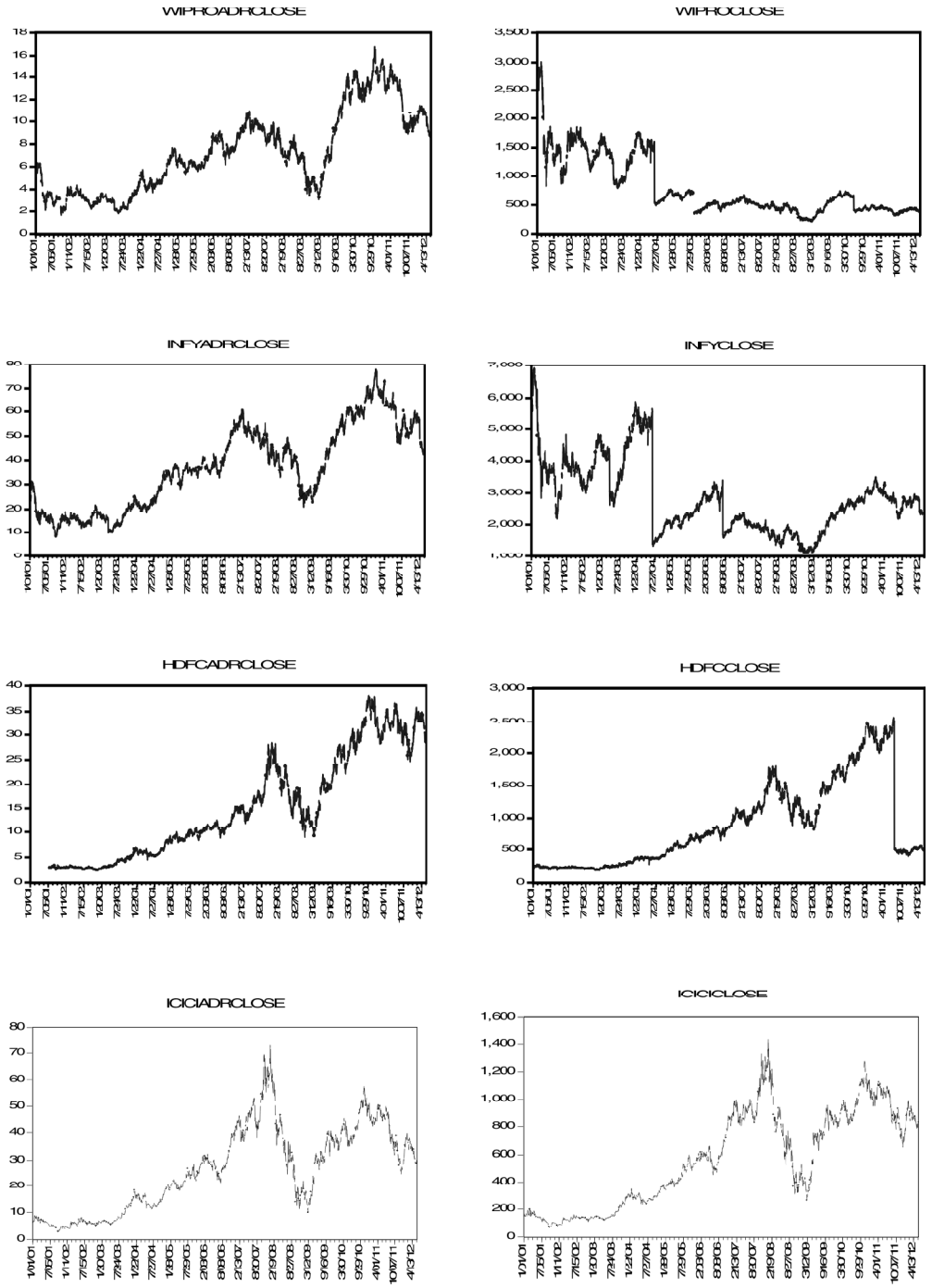

Figure 1: Time series of closing values of ADRs and Stocks

Table 7.1
Granger Causality Test-WIPRO

Direction	*Lag 1*		*Lag 2*	
	F-statistic	*Probability*	*F-statistic*	*Probability*
WIPADRCLOSE ⟶ WIPCLOSE	81.1358	4.0E-19	36.3546	2.7E-16
WIPADRCLOSE ⟶ NIFTYCLOSE	96.2035	2.5E-22	47.1597	7.9E-21
NYSECLOSE ⟶ WIPCLOSE	46.0285	1.4E-11	21.5749	5.1E-10
NYSECLOSE ⟶ NIFTYCLOSE	104.183	5.3E-24	58.4189	1.6E-25

Table 7.2
Granger Causality Test- INFOSYS

Direction	*Lag 1*		*Lag 2*	
	F-statistic	*Probability*	*F-statistic*	*Probability*
INFYADRCLOSE ⟶ INFYCLOSE	110.182	2.9E-25	50.3676	3.6E-22
INFYADRCLOSE ⟶ NIFTYCLOSE	99.1606	6.0E-23	46.5672	1.4E-20
NYSECLOSE ⟶ INFYADRCLOSE	23.4390	1.4E-06	11.5188	1.0E-05
NYSECLOSE ⟶ INFYCLOSE	44.6243	2.9E-11	19.9850	2.5E-09
NIFTYCLOSE ⟶ INFYCLOSE	3.93783	0.04731	3.55589	0.02868
NYSECLOSE ⟶ NIFTYCLOSE	104.183	5.3E-24	58.4189	1.6E-25

Table 7.3
Granger Causality Test- HDFC

Direction	*Lag 1*		*Lag 2*	
	F-statistic	*Probability*	*F-statistic*	*Probability*
HDFCADRCLOSE ⟶ HDFCCLOSE	46.5926	1.1E-11	26.1827	5.7E-12
HDFCADRCLOSE ⟶ NIFTYCLOSE	82.6927	1.9E-19	48.1846	3.1E-21
NYSECLOSE ⟶ HDFCCLOSE	22.5219	2.2E-06	14.7693	4.2E-07
NYSECLOSE ⟶ NIFTYCLOSE	104.183	5.3E-24	58.4189	1.6E-25

Table 7.4
Granger Causality Test- ICICI

Direction	*Lag 1*		*Lag 2*	
	F-statistic	*Probability*	*F-statistic*	*Probability*
ICICIADRCLOSE ⟶ ICICICLOSE	215.867	5.4E-47	122.907	1.2E-51
ICICIADRCLOSE ⟶ NIFTYCLOSE	92.0220	1.9E-21	46.1767	2.0E-20
NYSECLOSE ⟶ ICICICLOSE	101.053	2.4E-23	50.7942	2.4E-22
NYSECLOSE ⟶ NIFTYCLOSE	104.183	5.3E-24	58.4189	1.6E-25

Conferring to Table 7.1 – 7.4 the pair wise Granger causality test reveals that both ADRCLOSE and NYSECLOSE granger cause respective domestic stock CLOSE as well as NIFTYCLOSE.This result holds good for all the stocks under study viz., WIPRO, INFOSYS, HDFC & ICICI .This lends support to the fact that emerging markets like India reacts to global developments. Further, it is observed from the Table 7.2, the unidirectional causality runs from NYSECLOSE to INFYADRCLOSE.

5. CONCLUSION

Since there has been a significant upsurge in trading volumes in Indian markets and the associated high volatility, it becomes essential to investigate the spillover effects of global market developments on the price movements of Indian stocks. The results of Granger causality test indicate that ADR close prices and the foreign index close prices influence both domestic stock close price as well as the domestic index returns. The VECM findings of the present study reveal a long run cointegrating relationship between domestic stock prices and ADR prices. Also a long run spillover effect of global (Largely US) market which is a proxy of the foreign market returns has an impact on the price movements. Examination of R^2 values indicate a strong short run relationship among ADROPEN & NYSEOPEN returns which indicates that only the opening prices of ADRs are influenced by the foreign market opening returns. But there is only a weak short run relationship in the domestic stock closing price and the foreign market closing index returns. Due to cross listing, the weak relationship in the domestic stock closing price and the foreign market closing index returns creates the possibilities of arbitrage in the short run. Further the results provide convincing evidence that ADRs respond to shocks in cross listed markets due to the global market cues as well as in the home market because fundamental information about the firm is typically released in the home country.This finding affords practical insight to firms that intent to cross list their shares in U.S market. Future research can be carried out to examine the presence of arbitrage opportunities with the price series adjusted for exchange rates.

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