CO-MOVEMENT OF INDIAN STOCK MARKET WITH US STOCK MARKET

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US economy has been very significant for the whole world. Similarly, the US security markets also plays an important role in the global markets. This paper investigates the co-movement of Indian stock market with US stock market and their dependence structure which brings close link with one another. This paper identifies the casual relationship of one market with another. As there are considerable arguments that suggest that if the price of given stock on one exchange is fundamentally associated with the price of stock on another exchange, the Law of One Price suggests that the price of given stock on one exchange cannot be isolated with its price on another exchange in which it is traded for any extended period so it can be implied that the price of given stock on one exchange cannot be significantly differ than the price of stock on another exchange after adjusting different influencing factor. This study also investigates the transmission of pricing information and market efficiency of dully-listed stock, we also attempt to answer two crucial questions: (1) Does the transmission of information effect in unidirectional or bidirectional (from developed market to emerging market or both way) (2) how rapidly are the price the movements in one market transmitted to the other market. In present studies, Indian stock market is taken as domestic listing market (emerging market) and Indian companies' American Depositary Receipts which are listed in U.S stock market (NASDAQ or NYSE) as foreign listing market. The paper uses an appropriate empirical model to test the dependence structure of Indian equity market with US equity market. We noted remarkably high correlation coefficients across these markets reflacting strong comovement of Indian stock market.

Introduction

The modern portfolio theory concerns the primary advantage of international diversification in reducing systematic portfolio risk. Since financial system liberalization, to wider their shareholder base and to raise capital from international capital markets, number of corporations has listed their stocks on foreign exchanges as well as domestic exchange, in turn investors have seen, and are continuing to see, significant growth in different investment opportunities to diversify their systematic

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portfolio risk trough internationalization but the integration between global stock markets raises the question on the efficacy of internationalization.

Bae Hong Kee et al ,1999 and Hauser Shmuel et al ,1999, suggested that if the price of given stock on one exchange is fundamentally associated with the price of stock on another exchange, the Law of One Price suggests that the price of given stock on one exchange cannot be isolated with its price on another exchange in which it is traded for any extended period so it can be implied that the price of given stock on one exchange cannot be significantly differ than the price of stock on another exchange after adjusting different influencing factor. If it is, Arbitrageurs can ensure that the prices of a stock on one exchange will necessary co-integrate with the price of another exchange.

Given non-synchronous trading period between two exchanges in which the same underlying stock is traded provides unique opportunity to investigate the efficacy of transformation of information from one market to another market. While one exchange is closed, the information from the other exchange is available to investors or vice-versa. If both stock markets are informationally efficient, the information of one market should be reflected in opening price of another market.

With the financial sector reforms initiated in 1991, Indian companies joined worldwide to raise capital from foreign markets. Indian companies are allowed to raise foreign capital through two main source (A) issue of Foreign Currency Convertible Bonds (FCCBs)-more commonly known as 'Euro Issues' (B) issue of ordinary equity share through Depositary Receipts, namely, Global Depositary Receipts (GDRs), American Depositary Receipts (ADRs) . The integration of Indian stock market with global markets is reflected in its market microstructure , as dematerialization of shares, replacement of the Indian carry forward trading system so called badla by the index-based and scrip-based futures and options, rolling settlement in place of the account period settlement, internet trading and so on and so forth. More significantly, the domestic market movement has increased with global markets movement in general and the NASDAQ or NYSE in particular. This is reflected in change in correlation coefficient between Indian stock market and developed countries. Year wise during 1994-97, correlation coefficient between the BSE Sensex and the Nasdaq Composite Index has even been negative(Hansda and Ray, 2002). It has since started turning positive from 1997-98 and remained significantly positive during the last three year period 2005-2008.

Previous study

Previous studies suggest that dually listed stock has interdependence of price movement across stock markets (Grubel, 1968; Hilliard, 1979). The global crash of October 1987 attracted literatures' interest in this line of study. For example, Bennet and Keller (1988) did the research on international equity market linkages. In empirical findings, they have found that The US market have significant influence on the rest of world stock markets. Such integrations however raise a crucial question on the gains out of overseas diversification.

Bae (1999) carried out study on dually-listed stock. In their study, they considered Stock Exchange of Hong Kong (SEHK) as an emerging market and London Stock Exchange (LSE) as developed market. As they found that (1) SEHK overnight returns respond significantly to changes in LSE intraday return but the information transmission is not fully reflected at the opening price of stock of SEHK (2) LSE overnight returns respond significantly to change in SEHK intraday returns, but the transmission process is not completed at the opening of the LSE (3) the impact is stronger moving from the LSE to SEHK. From these results, it can be inferred that information transfer occurs both immediately and continuously throughout the trading day in both directions. Similarly, Hauser, Tanchuma and Yarri (1998) investigated five companies based in Israel whose stocks were listed on both the Tel Aviv Stock Exchange and NASDAQ. The co-integration between two stock markets was investigated by Granger-type causality using ARIMA and VAR models from which forecasting errors of stock returns were estimated for causality. Results based on empirical analysis show a weak unidirectional causality from the TASE to NASDAQ. These results suggest that the domestic market plays a dominant role relative to the foreign market.

In another set of studies on dually-listed stocks issue, ADRs and underlying foreign stocks have been considered to measure the efficacy of information transmission as Kim, Szakmary, Andrew and Mathur (2000) considered ADRs of different countries (21Japanese, 21 British, 5 Dutch, 5 Swedish, and 4 Australian firms) .The purpose of their study was to investigate the informational efficiency between markets for ADRs and their underlying foreign shares. Their results show that the price of underlying shares is the most important factor to price discovery of ADRs but exchange rate and U.S. market also have significant impact in the process of price discovery of ADRs. Rosenthal (1983) finds that ADR prices are fairly consistent

with weak-form efficiency, as abnormal returns cannot be earned from any price dependence.

In Indian Context, Agarwal (2002) found very low correlation coefficient between Indian market and developed market. On other hand, Hansda and Ray (2002) studied the price interdependence of Ten Indian Companies, which are listed in NSADAQ and NYSE as ADRs. They used Granger causality to measure cause and effect between ADRs and foreign underlying stock and Impulse response function, speed of transmission of pricing information and its persistence from one market to another. In result, they quoted that the Indian ADRs as well as the underlying domestic stock is observed to Granger cause each other, and both the markets are in general found to be informational efficient, which prevent any scope of arbitrage-profit.

ADRs as Indian Experience

ADRs are a negotiable instruments issued in the U.S. by an overseas depository bank in lieu of non-U.S companies' shares. An ADR represents a particular bunch of shares on which receipt holder has the right to receive all benefits which company announces from time to time for the shareholders.

In India, ADRs are reckoned as part of foreign direct investment and, hence before issuing ADRs, companies need to confirm to the existing FDI policy. In 2002 February, RBI allowed two-way fungibility for ADRs which means that investors (Foreign or domestic) in any company that has issued ADRs can freely convert the ADRs into underlying domestic shares and vice versa(NSE Fact book, 2008). The list of Indian ADRs is as given in table 1.

Table 1: ADRs of Indian origin trading in major US Exchanges

Company	Exchange	Effective Date	Ratio (ADRs : Share)
Dr. Reddy's Laboratories Ltd.	NYSE	11/04/2001	1:1
HDFC Bank Ltd.	NYSE	25/07/2001	1:3
ICICI Bank Ltd.	NYSE	31/03/2000	1:2
ICICI Ltd. (now merged)	NYSE	1/11/1999	1:5
Infosys Technologies Ltd.	NASDAQ	16/03/1999	2:1
Mahanagar Telephone Nigam Ltd.	NYSE	28/09/2001	1:2
Rediff.Com India Ltd.*	NASDAQ	19/06/2000	2:01
Satyam Computer Services	NYSE	14/05/2001	1:2
Satyam Infoway Ltd.*	NASDAQ	1/10/1999	4:01
Silverline Technologies	NYSE	19/06/2000	1:2
Videsh Sanchar Nigam Ltd.	NYSE	15/08/2000	1:2
Wipro Ltd.	NYSE	24/10/2000	1:1
* Trading solely in US markets, not listed in India.			
Source: Bank of New York website			

One of the aspects of ADRs is that the holder of ADRs can convert it into underlying stock subject to cancellation and conversion fees vice-versa. So an investor who compares the ADR price with the price of underlying stock can earn riskless profit it the price differential is sufficient to cover all underlying transaction costs. Due to arbitrage force, the price of ADR aligns with the dollar price of underlying shares. Under assumption of constant foreign exchange rate over time, any changes in underlying stock will reflect in ADRs within same calendar day or vice-versa. The movement of Indian foreign exchange rate against The US Dollar also influences the price of ADRs. For example, under assumption of constant underlying price of stock, any movements in foreign exchange rate will reflect in the price of ADRs. Therefore, if both stock markets are informational efficient, there would not be any opportunity to earn arbitrage profit whether there is changing in underlying stock or foreign exchange rate. In addition, given non-synchronous trading time between US and Indian market, ADRs price may also influenced by innovation in the U.S

market. As shown in table 2, within one calendar time, U.S market opens after the Indian Market.

Table 2: Trading Session of US and Indian market

Day T			Day T - 1
BSE/NSE opens	BSE/NSE closes	NASDAQ/NYSE opens	NASDAQ/NYSE closes
↓	↓	↓	↓
10:00 hrs	15:30 hrs	20:00 hrs	2:30 hrs

Note: Times in Indian Standard Time

Methodology

Data

Seven ADRs that trade in U.S markets with underlying shares trading in Indian stock market have been considered for empirical analysis. The data comprises daily opening and closing price observations of ADRs and underlying stocks, the exchange rate between U.S dollar and the Indian Rupee and closing price of S&P index and the NASDAQ index. Our data ranges from effective data (for effective date, see table 1) of each ADRs to December 31, 2008.

Data of ADRs, S&P 500 index and underlying stocks have been obtained from Yahoo Finance and Inter-bank exchange rate has been taken from www.oanda.com. To remove non- trading period, in sample only those days returns have been considered in which both markets were opened.

From the daily data of ADRs and underlying stocks, three time series are calculated (1) close to open (2) open to previous close (3) close to close return.

1. Daily Close to Open returns have been estimated through following formula

$$R^{o}_{t} = \text{Inc}\left(\frac{P^{c}_{t}}{P^{o}_{t}}\right)$$

Where, R^{o}_{t} is return for trading day t, P^{c}_{t} is closing price of stock for day t and P^{o}_{t} is opening price for day t.

2. For Open to Previous Close return time series

$$R^{c}_{t} = \text{Inc}\left(\frac{P^{o}_{t}}{P^{c}_{t-1}}\right)$$

Where, R^{c} is return for non-trading day t, P^{o}_{t} is opening price of stock for date t and P^{c}_{t-1} is closing price for day t - 1.

3. For Close to Close return time series

$$R^{c}_{t} = \text{Inc}\left(\frac{P^{c}_{t}}{P^{c}_{t-1}}\right)$$

Where, R^{c} is close to close prices for day t, P^{c}_{t} is closing price of stock for date t and P^{c}_{t-1} is closing price for day t - 1.

Compounding daily returns of exchange rate and US Stock market Index (NYSE or NASDAQ) are computed from the closing prices as the difference in the logarithm of two consecutive daily prices. Note that for the same date in the two markets – India and the US – the Indian market actually leads the US market for time zone differences.

Co-movement test

It has been found from literatures that ADRs have strong co-movement with underlying stocks. The strong co-movement of ADRs with the underlying domestic shares should not be construed as coterminous with causality. The synchronized co-movement could even be a fall out of spurious relationship. In order To steer clear of such misgivings, the popular causality test, Granger (1969a) has defined a concept of causality which, under suitable conditions, is fairly easy to deal within the context of VAR models. Therefore it has become quite popular in recent years (Lutkepohl, 2005). To put it simple, if a variable z affects a variable x, the former should help improving the predictions of the latter variable. To formalize this idea, suppose that Ωt is the information set containing all the relevant information in the universe available up to and including period t apart from {z} process to forecast the value of {x} process. Based on the Ωt the minimum sum of square of error (MSE) is MSE (Ωt) and if we include {z} process to forecast {x}

process, in result MSE(Ωt)>MSE(Ωt,{z}, we will say that {z} Granger-causes (or briefly causes) {x} process.

Before applying the causality test, it is necessary to examine the properties of time series of the stock prices (whether particular time series stationary or unit stationary). Time series properties of the stock prices have been checked by conducting the Augmented Dickey Fuller Test of stationary. The hypothesis of ADF test is that Time Series of prices is unit stationary and if it is clear from the ADF test statistics that all the stock price series are unit root stationary; their first differences turn out to be stationary. Therefore, the causality exercise between the scrip-wise prices – domestic and foreign – has been carried out in a framework of unrestricted first difference variables, addressing the concern of a non-stationary stock price series.

In this study, the number of lags in following Vector Auto Regressive model (VAR) has been chosen on the basis of Akaike's Information Criterion (AIC). AIC measures the goodness of fit and parsimony of an estimated statistical model. Given a time series, server models can be used to model time series. Competing model may be ranked according to their AIC, with the one having the lowest AIC being the best model (Walter & Elders). By AIC test following VAR model has been proposed to measure the causality.

$$\begin{pmatrix}\Delta P_{i,t}\\ \Delta A_{i,t}\end{pmatrix}=\begin{pmatrix}a_{10}\\ a_{20}\end{pmatrix}+\begin{pmatrix}a_{11}a_{12}\\ a_{21}a_{22}\end{pmatrix}\begin{pmatrix}\Delta P_{i,t-1}\\ \Delta A_{i,t-1}\end{pmatrix}+\begin{pmatrix}a_{13}a_{14}\\ a_{23}a_{24}\end{pmatrix}\begin{pmatrix}\Delta P_{i,t-2}\\ \Delta A_{i,t-2}\end{pmatrix}+\begin{pmatrix}\varepsilon 1_t\\ \varepsilon 2_t\end{pmatrix} \quad (1)$$

In above VAR model, where Δ P is first

Regression model

The price of ADRs is not only influence by underlying asset but ADRs may also be affected by exchange rate and innovation in U.S market (Kim Minho et al, 2000). Thus, the influence of underlying stock, exchange rate, and US index on ADR is also investigated by following regression model.

$$ADRs_{i,t} = \beta_{1,i}RS_{i,t} + \beta_{2,i}RS_{i,t-1} + \beta_{3,i}RS_{i,t-2} + \lambda_{1,i}RP_{i,t} + \lambda_{2,i}RP_{i,t-1} + \lambda_{3,i}RP_{i,t-2} + \gamma_{1,i}EX_{i,t} + \gamma_{2,i}EX_{i,t-1} + \gamma_{3,i}EX_{i,t-2} + \varepsilon_{i,t}$$

From above regression model, where ADRi,t is close to close return of ADRs i for period t, RSi,t is close to close return of the underlying stock i for period t and RPi,t is close to close return of U.S stock market index(NYSE or NASDAQ) for period t. β1, β2 and β3 measure the magnitude of information efficacy and the speed in information

transmission of Underlying stock on ADRs for day zero, one and two respectively. If both markets are informationally efficient, the value of, $\beta 2$ and $\beta 3$ will be significantly differ than zero . $\lambda 1, \lambda 2, \lambda 3$ and $\gamma 1, \gamma 2, \gamma 3$ have been estimated to control the impact of U.S market and the exchange rate on ADRs respectively for the day zero, one and two respectively. ε is random error with constant variance and zero mean.

Empirical Analysis - ADF tests have been performed to measure the Stationarity. This test has been done to 7 stocks and 7 ADRs. Each time series has been found unit stationary and after first integration, all time series have become stationary.

To carry out Granger Causality test; two hypotheses have been tested. (1) "The closing price of underlying stock does not cause the opening price of ADRs" and (2) "The closing price of ADRs does not cause the opening price of Underlying stock".

The empirical result of Causality Patterns between of closing price of underlying stocks (NSE) and opening price at ADRs (**NYSE or NASDAQ**) is presented in table 3. From the table 3, mostly F-statistics of sevens Granger Causality are significant at 5% level so we are able to accept our alternative hypothesis "the closing price of underlying stock at NSE has emerged to Granger cause to opening price of ADRs at NYSE/NASDAQ".

Table 3: Causality Patterns between Close Quote of Underlying Stocks at NSE and Open Quote of ADRs at US Stock Exchange (NYSE or NASDAQ)

Particular	F-Statistic
HDFC to ADRs	6.85*
DR Reddy to ADRS	1.64
Infosys to ADRs	0.09
MTNL to ADRs	66.12*
Satyam to ADRs	48.46*
Tata Motors to ADRs	37.33*
Wipro to ADRs	56.51*

*indicate significant level at 5% leve

Granger's F Statistics for second null hypothesis that the closing price of ADR does not cause opening price of underlying stock are reported in table 4.1

Table 4: Causality Patterns between Close Quote of ADRs at US Stock Exchange (NYSE or NASDAQ) and Open Quote of underlying stocks at NSE

Particular	F-Statistic
ADRs to HDFC	97.4099*
ADRs to Dr Reddy	21.1838*
ADRs to Infosys	559.039*
ADRs to MTNL	239.042*
ADRs to Satyam	517.012*
ADRs to Tata Motors	350.135*
ADRs to Wipro	478.28*

* indicate significant level at 5% level.

It is clear from table 4 that the closing price of ADRs causes the opening price of Underlying stocks for all sample companies. On the basis of Granger Causality, it can be inferred that the information at the time closing of underlying stock market is reflected in opening price of ADRs in NYSE/NASDAQ or vice-versa and this is an indication of market integrations.

The unidirectional causality from domestic stock exchange to international stock exchange or international stock exchange to domestic exchange raises a new dimension of research "Can this causality relationship be used to forecast ADRs price paten through underlying stocks or visa- versa." To find answers of this question and for another aspect of ADRs pricing, holding stock price constant, whether arbitrates have an opportunity to earn riskless profit by US stock market innovation or by any movement of currency exchange rate, regression (2) has been estimated. The result of regression equation (2) of 7 ADRs has been presented in table no 4.

ADRs		β1	β2	β3	λ1	λ2	λ3	γ1	γ2	γ3
HDFC	Coefficient	0.13*	0.05*	0.01	1.24*	-0.02	-0.03	-0.07	-0.56*	-0.72
	Std. Error	0.02	0.02	0.02	0.05	0.05	0.05	0.16	0.16	0.17
	t-Statistic	6.10	2.24	0.36	25.24	-0.38	-0.66	-0.43	-3.41	-4.27
Dr. Reddy	Coefficient	0.16*	0.11*	-0.06*	1.22*	0.08	0.01	0.19	0.04	-0.36
	Std. Error	0.03	0.03	0.03	0.06	0.06	0.05	0.20	0.20	0.21
	t-Statistic	4.96	3.43	-1.94	21.19	1.48	0.10	.97	0.17	-1.74
Infosys	Coefficient	0.48*	0.23*	-0.02	1.12*	0.12*	0.04	0.27	0.16	-0.03
	Std. Error	0.02	0.02	0.02	0.05	0.05	0.04	0.16	0.16	0.16
	t-Statistic	22.53	10.39	-1.00	23.93*	2.50	0.87	1.70	0.97	-0.18
Satyam	Coefficient	0.58*	0.15*	0.03	1.02	-0.04	-0.02	0.15	0.12	-0.33*
	Std. Error	0.02	0.02	0.02	0.04	0.04	0.04	0.15	0.15	0.16
	t-Statistic	31.60	8.06	1.42	23.22	-0.86	-0.39	1.00	0.79	-2.12
MTNL	Coefficient	0.59*	0.09*	-0.04	0.91*	0.14*	-0.01	-0.12	0.45*	-0.15
	Std. Error	0.03	0.03	0.03	0.06	0.06	0.06	0.16	0.17	0.17
	t-Statistic	22.41	3.43	-1.70	15.40	2.44	-0.12	-0.76	2.72	-0.87
TATA Motors	Coefficient	0.47*	0.14*	0.06*	0.83*	0.11	0.08	-0.42*	-0.09	0.01
	Std. Error	0.03	0.03	0.03	0.06	0.06	0.05	0.15	0.16	0.17
	t-Statistic	17.08	4.74	2.12	14.25	1.88	1.56	-2.76	-0.56	0.08
Wipro	Coefficient	0.51*	0.12*	-0.01	1.17*	0.01	-0.07	0.02	0.15	-0.23
	Std. Error	0.02	0.02	0.02	0.05	0.05	0.05	0.16	0.16	0.17
	t-Statistic	25.07	5.84	-0.68	24.79	0.20	-1.49	0.14	0.91	-1.40

*indicate significant at 5% level.

All seven slope Coefficients of day 0 are positive and large, and all of them are statistically significant at 5% level. These results indicate that the underlying stock returns for day 0 influences the return of ADRs positively and significantly. Surprisingly, all seven coefficients of day 1 are also positively significant at 5% level but the magnetite of coefficients on day 1 is smaller relative to day 0. From these result, it can be inferred that most of the underlying stock market information for day 0 incorporates same day in

ADRs pricing but the adjustment of whole information in ADRs pricing takes time.

The nature of ADRs reaction to innovations in NYSE/NASDAQ is also positively significant at 5% level for all samples of ADR for day 0. For exchange rate variable, we have not found any persistence in results.

Conclusion

The purpose of this study is to investigate the transmission of pricing information and market efficiency of dully-listed stock and finding of Granger Causality test suggests that there is cause and effect relationship exists between ADRs and Underlying stock and the regression evidence is not entirely consistent with an informational efficient ADR market. One possible interpretation of these results can be that these markets are still partially segmented, i.e., US investors initially attempt to price the ADRs partly with reference to their own market, rather than to the foreign market in which the underlying shares trade. The resulting mismatches between ADR and underlying security values are eventually eliminated by arbitrageurs but the arbitrage activity is restricted by no-synchronous trading times and transactions costs.

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