Integration of Capital, Commodity and Currency Markets: A Study on Volatility Spillover

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The volatility spillover tells about the extent of the integration between different markets. In this study an effort has been made to analyse the integration and interrelationship among the capital market, currency market and commodity market in India through the volatility spillover frame work by using AR (1)-GARCH (1,1) approach. This study differentiates from the earlier studies by including all three segments of the markets. The study found out that the volatility spillover from currency markets and commodity markets to capital markets. Likewise the volatility spillover from capital market to currency markets and there is no spillover from commodity market to currency markets. In case of commodity market there is no evidence of volatility spillover

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1.Introduction

Internationalization of stock markets, liberalized capital flows, huge foreign investment in Indian equity markets have led stock and foreign exchange markets to be increasingly interdependent. An understanding

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of the inter-market volatility is important for the pricing of securities within and across the markets for trading and hedging strategies as well as for formulation of regulatory policies in an emerging market like India that is rapidly getting integrated into the global economy.

Several financial as well as currency crises across emerging markets around the globe and the advent of floating exchange rate led the academicians as well as practitioners to have a re-look into the nature of volatility spillovers between stock and foreign exchange markets that have seen large correlated movements resulting in market contagion. It has been observed that exchange rate has been used to explain the behaviour of stock prices on the assumption that corporate earnings tend to respond to fluctuations in exchange rate (Kim 2003). This issue attracted a plethora of regulatory implications as well, whereby institutional restrictions were set up to mitigate the volatility spillover (Roll 1989). Besides, international diversification and cross-market return correlations have led these markets to be increasingly interdependent. To understand the risk-return trade off of international diversification and, therefore, management of multi currency equity portfolios, it is important to analyze the interaction between the exchange rate risk and stock price. With significant rise in cross border equity investments and, in particular, investments in emerging markets like India, this has become a critical issue for fund managers, especially in the domain of pricing of securities in the global market, international portfolio diversification, and hedging strategies. Moreover, continuous economic globalization and integration of Indian financial Markets with world financial markets, especially fuelled by the development of information technology, increases the international transmission of returns and volatilities among financial markets. A competent knowledge of the volatility spillover effect between the stock and foreign exchange markets, and consequently the degree of their integration, will potentially expand the information

set available to international as well as domestic investors, multinational corporations, and policy makers for decision making.

The existing research generally supports the existence of interdependence in return and volatility of stock and foreign exchange markets. However, it is very much centred on the developed markets. No such attempts have been made so far to examine the volatility spillover between the stock and foreign exchange markets in Indian context except for Apte's (2001) study. By using the data from January 2, 1991 to April 24, 2000, Apte (2001) investigates the relationship between the volatility of the stock market and the nominal exchange rate of India. The study suggests that there appears to be a spillover from the foreign exchange market to the stock market, but the reverse is not true. The main limitation of Apte's study is the fact that during the early part of the data series, there are sometimes long gaps due to the stock markets having been closed for several days at a stretch. Also, despite the fact that National Stock Exchange (NSE) started its security trading only in 1994, Apte's data period begins from January 1991 by simulating the previous data points based on post data points.

In this study an effort has been made to analyse the integration and interrelationship among the capital market, currency market and commodity market in India through the volatility spillover frame work by using AR (1)-GARCH (1,1) approach. This study differentiates from the earlier studies by including all three segments of the markets. For capital market Nifty50 index has been used as the variable for measurement. Similarly Rupees Dollar exchange rate has been taken for the currency market and MCX commodity index has been taken for commodity market. All the indices are in spot. The daily return for the period of 6th June 2005 to 31st March 2010 has been taken for the analysis.

Literature Review

The behaviour of volatility of stock market has been extensively studied using the ARCH-GARCH framework pioneered by Engel

(1982) and further developed by Bollerslev (1986), Nelson (1991) and others. The literature on volatility spillover can be broadly categorized into two groups. The first group of studies focuses on return series or errors from modelling return series and the relationship of returns across markets. For instance, Eun and Shim (1989) show that about 26 percent of the error variance of stock market returns can be explained by innovations in other stock markets, and, not surprisingly, report that the US market is the most influential stock market. The second group of research directly examines volatility. In an investigation of the crash of October 1987, King and Wadhwani (1990) study shows transmission of price information across markets through volatility innovations even when the information is market specific. They argue that there is a 'contagion' effect across markets whereby markets overreact to the events of another market irrespective of the economic value of the information.

Chiang, Yang, and Wang (2000) study points out that national stock returns in Asian countries are positively related to the value of the national currency. Similarly, Sabri (2004) evaluates features of emerging stock markets, in order to point out the most associated indicators of increasing stock return volatility and instability of emerging markets. The study shows that stock trading volume and currency exchange rate respectively represent the highest positive correlation to the emerging stock price changes. Research on volatility spillovers is not limited to stock market only. Similar tests have been conducted in other markets such as foreign exchange, cash and future markets.

Brailsford (1996) examines the issue of volatility spillovers between the Australian and New Zealand equity markets. The results indicate that volatility in the Australian market influences the subsequent conditional volatility of the New Zealand market. Similarly, conditional volatility in the Australian market appears to be influenced by volatility in the New Zealand market. Baele (2005) examines the

magnitude and time varying nature of volatility spillovers from the aggregate European (EU) and U.S. market to 13 local European equity markets.

Kanas (2000) investigates the interdependence of stock returns and exchange rate changes within the same economy by considering the six industrialized countries--US, UK, Japan, Germany, France and Canada. The study concludes: (i) there is cointegration between stock prices and exchange rates; (ii) there is evidence of spillover from stock returns to exchange rate changes for all countries except Germany; (iii) the spillovers from stock returns to exchange rate changes are symmetric in nature; (iv) volatility spillovers from exchange rate changes to stock returns are insignificant for all the countries; (v) the correlation coefficient between the EGARCH filtered stock returns and exchange rate changes is negative and significant for all the countries, which indicates a significant contemporaneous relationship between stock returns and exchange rate changes.

Bodart and Reding (2001) show that exchange rates have a significant effect on expected industry stock returns and on their volatility, though the magnitude of this effect is quite small. The study also concludes that the importance of the exchange rate spillovers is influenced by the exchange rate regime, the magnitude, and the direction of exchange rate shocks. Fang and Miller (2002) investigate empirically the effects of daily currency depreciation on Korean stock market returns during the Korean financial turmoil of 1997 to 2000. The study finds: (i) there exists a bi-directional causality between the Korean foreign exchange market and the Korean stock market; (ii) the level of exchange rate depreciation negatively affects stock market returns; exchange rate depreciation volatility positively affects stock market returns; and stock market return volatility responds to exchange rate depreciation volatility. In the light of the above discussion on volatility spillover, this study examines the information flow between the Indian stock and foreign exchange markets. A good

understanding of the determinants, which shape the first and second moments of the conditional distribution of stock return as well as exchange rate return, is crucial for efficient portfolio management strategies. Among those determinants, exchange rates have received particular attention due to the importance of currency management strategies in highly integrated financial markets and the implication of exchange rate fluctuations for company profitability (Bodart and et al. 2001).

Mishra et al (2007) studied the volatility spillover between the stock and foreign exchange markets by using AR (1)-GARCH (1, 1) frame work. By using the daily data from 4th January 1993 to 31st December 2003, they concluded that there is a bidirectional volatility spillover between stock and foreign exchange markets of India. The study also found that both the markets move in tandem and there is a long run relationship between these two markets.

It is important to analyse the integration and inter relationship among all the three segments of the market say capital, currency and commodity markets. This analysis will give the complete picture of the volatility spillover among the markets. This study includes all the three markets for the analysis.

Objectives of the Study

The objective of this paper is to examine the relationship and volatility spillovers between Indian stock, commodity market and foreign exchange markets. The extent of volatility spillover between two markets tells about the strength of the integration between both the markets.

Hypothesis

H_0: There are no interlinkages or volatility spillover among these capital, commodity and foreign exchange market.

H_1: There are inter linkages or spillover between one market to another market

Methodology

For analysing the transmission of volatility or volatility spillover effects between the stock and foreign exchange markets, Generalised Autoregressive Conditionally Heteroscedastic model (GARCH) has been estimated. GARCH model allows the conditional variance to be dependent upon previous own lags apart from the past innovation. Through GARCH model, it is possible to interpret the current fitted variance as a weighted function of long-term average value information about volatility during the previous period as well as the fitted variance from the model during the previous period.

To model the volatility spillover between the stock and foreign exchange markets, different orders of AR-GARCH have been evaluated. Since AR (1) - GARCH (1, 1) models are well fitted to the data series like index returns, AR (1)-GARCH (1, 1) models have been used in the analysis. The volatility spillover has been examined through the following way. The residuals are generated from a specific model and for a particular market. These residuals are used as shocks emanating in one market and we introduce them to the volatility equation of the other market. If the coefficient of the same is significant, this confirms the presence of volatility spillover. In other word the residuals of exchange rate market and the commodity markets have been used in the volatility equation of stock market. The residuals of stock market and the commodity markets have been used in the volatility equation of exchange rate. The residuals of stock market and the exchange rate have been used in the volatility equation of commodity markets.

The AR (1) equation as well as GARCH (1, 1) spillover equation can be specified as follows:

$$\text{AR (1): } y_t = c + \tau\, y_{t-1} + \varepsilon_t \quad \varepsilon_t \sim N(0,\sigma_t^2) \qquad (1)$$

Where yt is the return of both stock indices as well as exchange rates at time period t, c is the intercept, yt-1 is the previous period return at the time period t-1 and ɛt is the white noise error term. Here, return on daily stock prices and exchange rates are a function of previous period returns on stock indices and exchange rates plus an error term.

GARCH (1, 1) Spillover Equation

$$h_{t(stock)} = \omega_0 + \beta_1 \varepsilon_{t-1}^2 + \alpha_1 h_{t-1} + \psi_1 (squrresid_{exrate}) + \psi_2 (squrresid_{commodity}) \quad (3)$$

$$h_{t(Exrate)} = \omega_0 + \beta_1 \varepsilon_{t-1}^2 + \alpha_1 h_{t-1} + \psi_1 (squrresid_{stock}) + \psi_2 (squrresid_{commodity}) \quad (4)$$

$$h_{t(commodity)} = \omega_0 + \beta_1 \varepsilon_{t-1}^2 + \alpha_1 h_{t-1} + \psi_1 (squrresid_{stock}) + \psi_2 (squrresid_{exrate}) \quad (5)$$

Where $\omega_0 > 0$, $\beta_1 \geq 0$, $\alpha_1 \geq 0$. In all three Equations, h_t is the conditional variance of both stock indices and exchange rates respectively, which is a function of mean ω_0. News about volatility from the previous period is measured as the lag of the squared residual from the mean equation (ε_{t-1}^2), last period's forecast variance (h_{t-1}) and the squared residual of stock indices, exchange rate and commodity market respectively in the above three equations. The spillover from one market to another market can be inferred according to the significance of ψ's.

In the GARCH (1, 1) spillover equation, we use the squared residual of another market (ψ) instead of residual on their level, which is used as a proxy for shock in the other markets, because in case of GARCH, we make sure that volatility is positive.

Data

The study focused on spot market. So the spot indices of stock market (NIFTY), commodity (MCX[2]) and exchange rate (Rs/$) have been

[2] The commodity spot index given by the Multi Commodity Exchange of India (MCX)

used. The daily data 6th June 2005 to 31st March 2010 have been used for the study. The commodity index data is available only from 6th June 2005. That is why the study period is restricted to that particular time span. In the analysis all the series are in log return (first difference) form. Nifty series is collected from the Prowess data base of CMIE. Exchange rate data has been collected from the Business Beacon data base of CMIE. The commodity index has been collected from the Multi Commodity Exchange of India (MCX) website. The analysis is done by using E-Views (Econometrics Views) software package.

Empirical results

Before going to the AR-GARCH process the stationarity of the data have been checked by using Augmented Dickey-Fuller (ADF) test. The ADF test is performed with the null hypothesis of the series has a unit root (nonstationary) against the alternative hypothesis of the series doesn't have unit root (stationary). The result of the ADF test is presented in table 1.

Table 1

Unit Root Test for Different Series

Series	ADF test (t) statistics	Probability
NIFTY	-31.87971	0.000
Rs/$ Exchange rate	-33.18294	0.000
Commodity index	-33.49256	0.000

All indices are return series

The table reveals that all the three indices returns are stationary. The ADF statistic is significant at 1% level (the null hypothesis is rejected). After testing the stationarity the AR (1) has been performed to test the ARCH effect in the series. The presence ARCH effect (process) has been tested by ARCH-LM test. The ARCH-LM test is performed with the null hypothesis of there is no ARCH effect in the series against the

alternative of ARCH effect. The results of ARCH-LM test are given in table 2.

Table 2

ARCH LM Test for Different Series

Series	LM-Statistic (F)	Probability
NIFTY	12.14156	0.000
Rs/$ Exchange rate	82.77175	0.000
Commodity index	29.46342	0.000

It is evident from the table that the null hypothesis is rejected at 1% level of significance and thereby it is conclude that there are ARCH effects in all the three series.

After testing the ARCH effect by LM test the volatility spillover [GARCH (1, 1)] equation of three markets have been ran. The results of the volatility spillover equations have been presented in the tables 3, 4 and 5.

Table 3

The Result of the GARCH-Spillover Equation for NIFTY

Coefficients	Nifty
ω_0	5.44E-06 (0.083)
β_1 (ARCH)	0.184330 (0.000)
α_1 (GARCH)	0.723549 (0.000)
Ψ_1(Ex-rate)	0.743086 (0.000)
Ψ_2 (Commodity)	0.100299 (0.001)

Digits in the parenthesis are P-Values

Table 4

The Result of the GARCH-Spillover Equation for Exchange Rate (Rs/$)

Coefficients	Exchange rate
ω_0	1.06E-07 (0.1638)
β_1 (ARCH)	0.250903 (0.000)
α_1 (GARCH)	0.728556 (0.000)
Ψ_1(Nifty)	0.002759 (0.000)
Ψ_2 (Commodity)	-0.000147 (0.855)

Digits in the parenthesis are P-Values

Table 5

The Result of the GARCH-Spillover Equation for Commodity Index

Coefficients	Commodity index
ω_0	1.84E-06 (0.068)
β_1 (ARCH)	0.048950 (0.000)
α_1 (GARCH)	0.933679 (0.000)
Ψ_1(Nifty)	0.002081 (0.184)
Ψ_2 (Commodity)	0.018804 (0.597)

Digits in the parenthesis are P- Values

The tables 3, 4 and 5 represents the volatility spillover equations of capital (Nifty), currency (Rs/$), and commodity (MCX index) markets. Ψ_1 and Ψ_2 are the spillover coefficients from the other two markets to the market in consideration. From the results given in the tables, it is evident that there is spillover of volatility among the market. In case of Nifty, the soillover is positive and significant from the currency and commodity markets. In the exchange rate equation, there is volatility spillover from the capital market but not from the commodities' market. In the commodities' market's equation both the spillover

coefficients are not significant. That means that there is no volatility spillover from the capital markets (nifty) as well as from the currency market (exchange rate.) to commodity market.

Scope for Future Research

This study used a very short period of time. In the analysis of capital and currency markets it is possible to take a longer period of time. Since the commodity market data is available only from 6th June 2005, this study is restricted into the particular time span. The study can be extended by including the futures and other derivatives of all of these markets and indices.

Conclusions

The volatility spillover tells about the extent of the integration between different markets. In this study, the volatility spillover among the capital, currency and commodity markets in India have been analyzed. The study found out that the volatility spillover from currency markets and commodity markets to capital markets. Likewise the volatility spillover from capital market to currency markets and there is no spillover from commodity market to currency markets. In case of commodity market there is no evidence of volatility spillover from other markets. By and large the study conclude that the Indian markets are inter related integrated.

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