GLOBAL TRANSMISSION OF STOCK MARKET VOLATILITY– A COMPARITIVE STUDY ON SELECTED COUNTRIES

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Abstract:

Capital market (Share Market) in India has changed vastly during the last few decades. Many individual investors switched their mode of investment from traditional avenues to stock market. Besides return, there is a risk in the share market. Volatility is a standard measure of financial vulnerability. It is a measure of how far the current price of an asset deviates from its average past prices. This study is done with the objective of studying the average return of Indian Stock Market during the period of study (2009 to 2018) and return-risk trade off; and to evaluate global transmission of volatility of stock prices; For this study stock indices of three developed countries (US, UK and Japan) and three developing countries (Singapore, Hongkong and India) are taken. This study uses time series data for daily high, low, closing and opening stock prices for a period

of 10 years from 2010 to 2019. The data was collected from websites of concerned stock exchange and from Thomson Reuters Eikon Market Database. The collected data was analyzed using standard formula for Volatility. Parkinsons model, RSV, Skewness, Kurtosis and Granger tools were also used. The analyzed data is presented in the tables and inferences were drawn.

Keywords: ISMB, Volatility, RSV, Granger and Stock Indices

The capital markets have changed vastly during the last few decades and money management has undergone a concurrent evolution. In the early 1960's the term asset allocation did not exist. Traditionally, for an individual investor, diversification meant owning several stocks and bonds along with some cash. But modern portfolio theory redefined the concept of diversification, by adding to the traditional two-dimensional risk / return focus, a third dimension of 'diversification effect' on portfolio.

Share market in India, is growing rapidly. Many individual investors are switching their mode of investment from traditional avenues (savings in post offices, banks etc) to stock market. Institutional investors (both Indian and Foreign) are increasing in number. The market has seen many microstructure changes after 1991 (introduction of BOLT). This has attracted more number of investors to enter the stock market.

Most of the investors, judge the movement of the market based on the movements of stock prices in the financial market. For example, when inflation rates are announced every Thursday, there is a change in the market movements. An announcement from government of any change in the interest rate also influences the market.

At the same time, there is risk in share market. Risk and return are closely associated. If there is high risk, the return may also be high. Many investors are also ready to take high risk. The unpredictable behavior of the stock market gives it a tag-'a volatile market'.

India, after United States, hosts the second largest number of listed companies. Global investors now ardently seek India as their preferred location for investment. Once viewed with skepticism, stock market now appeals to middle class Indians also. Many Indians working in foreign countries now divert their savings to Indian stocks.

This recent phenomenon is the result of opening up of online trading and lower interest rates from banks. The stockbrokers based in India are opening offices in different countries mainly to cater to the needs of non-resident Indians. The time factor also works for the NRI's. They can buy or sell stock online after returning from their work places. To them, the performance of the Indian stock market is important and it is closely watched. Their attention extends to the interrelationship between Indian stock market and the economy.

Volatility

As a concept, volatility is simple and intuitive. It measures variability or dispersion about a central tendency. To be more meaningful, it is a measure of how far the current price of an asset deviates from its average past prices. Greater this deviation, greater is the volatility. At a more fundamental level, volatility can indicate the strength or conviction behind a price move.

Since volatility is a standard measure of financial vulnerability, it plays a key role in assessing the risk / return trade-offs and forms an important input in asset allocation decisions. In segmented capital markets, a country's volatility is a critical input in the cost of capital (Bekaert and Harvey 1995). Peters (1996) noted that stock prices and returns are cyclical, imperfectly predictable in the short run, and unpredictable in the long run and that they exhibit nonlinear, and possibly chaotic, behavior related to time varying positive feedback.

Therefore there are several reasons that demand this study for India. First, perceptions vary about the dispersions of Indian stock prices. Second, there is need for a comprehensive study on the volatility in Indian stock markets covering as long a period as 20 years along with intra – day volatility and international comparison. Third, comparison of time-series volatility of Indian equity market, with other emerging and developed markets, distributional characteristics of the variance process and evidence if any, of asymmetries in volatility under different market conditions many shed light on the evolving characteristics of Indian equity market.

Statement of the Problem

In investment in stock there are two sets of factors affecting the share price movements. One set is the fundamentals of the economy, and the other is the technical movements or market behavior. Any positive or negative news affects the market price of the shares. Therefore there is risk in investing in the shares because of the volatility in the stock market.

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Objectives

1. to study the average return of Stock Market in India and selected countries during the period of study (2009 to 2018) and return-risk trade off;
2. to compare the returns of the markets under study and to evaluate global transmission of volatility of stock prices;

Hypothesis

There is significant global transmission of volatility across the markets.

Reviews

Lao and Singh (2011)studied the existence of herding behavior that challenged the validity of the ‘‘efficient market hypothesis’’ in the Chinese and Indian stock markets. Their findings suggested that herding behavior existed in both. The level of herding was seen to depend on market conditions. In the Chinese market, herding behavior was greater when the market was falling and the trading volume was high. On the other hand, in India, it occurred during up-swings in market conditions. Herding behavior was more prevalent during large market movements in both markets. In relative terms, a lower prevalence of herding behavior was detected in the Indian stock market.

Schwert (2011) used monthly returns for years from 1802 to 2010, daily returns for years from 1885 to 2010, and intraday returns for the years from 1982 to 2010 in the USA to show how stock volatility changed over time. They used various measures of volatility implied by option prices to infer what the market was expecting to happen in the months following the financial crisis in late 2008. This episode was associated with historically high levels of stock market volatility, particularly among financial sector stocks, but the market did not expect volatility to remain high for long and it did not. This was in sharp contrast to the prolonged periods of high volatility during the Great Depression. Similar analysis of stock volatility in the

United Kingdom and Japan reinforced the notion that the volatility seen in the 2008 crisis was relatively short-lived. While there was a link between stock volatility and real economic activity, such as unemployment rates, it could be misleading to overstate it.

Lettau and Ludvigson (2003) attempted to see whether excess stock market returns were predictable over time and, if so, at what horizons and with which economic indicators? They characterized the risk-return tradeoff as the conditional expected excess return on a broad stock market index divided by its conditional standard deviation, a quantity commonly known as the Sharpe ratio.

The two components of the risk-return relation (the numerator and the denominator of the Sharpe ratio) were the conditional mean excess stock return, and the conditional standard deviation of the excess return. They tried empirically measuring and statistically modeling each of these components separately, a process that unified to reveal an estimate of the conditional Sharpe ratio, or price of stock market risk.

Campbell and Viceira(2004) documented that expected excess returns on bonds and stocks, real interest rates, and risk shift over time in predictable ways. Furthermore, these shifts tended to persist over long periods of time. They proposed an empirical model that was able to capture these complex dynamics, yet was simple to apply in practice, and explored its implications for asset allocation.

They found that mean-reversion in stock returns decreased the volatility per period of real stock returns at long horizons, while reinvestment risk increased the volatility per period of real T-bill returns. Inflation risk increased the volatility per period of the real return on long-term nominal bonds held to maturity. They also found that stocks and bonds exhibited relatively low positive correlation at both ends of the term structure of risk, but they were highly positively correlated at intermediate investment horizons. Inflation was negatively correlated with bond and stock real returns at short horizons, but positively correlated at long horizons.

Bali and Peng (2006) study provided strong evidence of a positive relation between risk and return for the aggregate stock market using high-frequency data. They constructed the daily realized, GARCH, and range based volatility estimators that incorporated valuable information from intra-day returns and thus yielded more precise measures of market risk. In addition, the implied volatility index that used option prices to infer volatility expectations was considered as an alternative measure of risk. These alternative measures of

market risk were employed to investigate the existence and significance of a risk-return tradeoff for several stock market indices. In support of the ICAPM, there was a positive and statistically significant relation between conditional mean and conditional volatility of market returns at the daily level.

Lundblad (2004) pointed out that while many asset pricing models implied a positive relationship between the risk premium on the market portfolio and the variance of its return, previous studies found the empirical relationship to be weak, at best. He contended that the weak empirical relationship was an artifact of the small sample nature of the available data, as an extremely large number of time-series observations was required to precisely estimate this relationship.

Shah and Thomas (2001)showed that at a *technical* level, India's equity market fared very well in the decade of the 1990s. Starting from extremely primitive conditions, policy makers at SEBI, the Finance Ministry and NSE were able to create complex, technology-intensive market infrastructure which transformed the mechanics of trading securities. The decision at NSE to use a "demutualised" structure was an important innovation.

Selection of Countries

As the aim of the study is to understand the global transmission on volatility and considering the time constraint of an individual researcher and also voluminous data to be collected for different countries, this study is restricted to five countries - three developed countries viz., United States of America (USA), United Kingdom (UK) and Japan and two developing countries Singapore and Hongkong besides India

Indian Stock Market

India has two major stock exchanges: Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE). Started as the "The Native Share and Stock Brokers Association" in 1875, BSE is the oldest stock exchange in India and also in Asia. For many years BSE was the premier exchange in the country. The NSE was founded as recently as 1994, to provide facilities that serve as a model for the securities industry in terms of trading systems, practices and procedures .

Indices

An index is an indicator of the performance of the market. There are various indices available for the Indian Stock Market. A good stock market index captures the behaviour of the overall equity market and it serves:

- as a barometer for market behaviour,
- as a benchmark portfolio performance,
- as an underlying feature in derivative instruments like index futures and
- in passive fund management by index funds.

Sensex (BSE - Index)

The BSE Index, Sensex, is India's first stock market index that enjoys an iconic stature , and is tracked worldwide. It is an index of 30 stocks representing 12 major sectors. The Sensex is constructed on a 'free-float' methodology, and is sensitive to market sentiments and market realities.

Materials and Methods

Data

This study uses time series data for daily high, low, closing and opening stock prices for a period of 20 years from 1991 to 2010 for all the countries under study.

Analysis

The analysis begins with the study of time series of volatility. As a simple and convenient measure, standard deviation is taken as a proxy for variability in stock returns. The first step is to calculate returns using logarithmic method.

$$r_t = \ln\left[\frac{I_t}{I_{t-1}}\right]$$

Wherert and It indicate return and index value respectively at time 't'. for t = 1,2…,n

Arithmetic mean, standard deviation, skewness and kurtosis are computed as discussed later. Past cross – country studies have indicated non-normality of stock returns. Therefore the

researcher went beyond the first and second order moments and computed third and fourth order movements to infer more information about the patterns of price returns.

Volatility

The following standard formula is used for computing standard deviation (volatility).

$$\sigma = \sqrt{(1/n-1)\sum(r_1 - \bar{r})^2}$$

Parkinsons' model is used for estimating intra-day volatility by using intra-day highs and lows. Since, most asset pricing models are based on continuous time the extreme value estimators are more efficient. The following Parkinson model is used to estimate intra-day volatility. This volatility measure is referred to as high – low volatility (HLV). In the study use of a factor 0.601 scales down volatility although, statistically, it is correct. Therefore, in order to provide additional information on intra – day (high – low) volatility for σ forK = 1 is also computed.

$$\sigma = K\sqrt{(1/n)\sum \log(H_t / L_t)^2}$$

where K=0.601 and H_t and L_t denote intra-day high and low respectively.

$$\sigma = K\sqrt{(1/n)\sum \log(H_t / L_t)^2}$$

where K=1 to measure high and low high and low volatility.

Time Series Analysis

It is about identification, estimation and diagnostic checking of stationarity of the time series. All the above measures require the time series of stock prices to be stationary, but it may not hold in real data. Therefore, the time series are tested first for stationarity. If the time series are non – stationary, necessary corrections are made to make them stationary. The test for stationary is as follows:

A series $\{Y_t\}$ is said to be covariance stationary if for all t and t ~ s:

1. $E\{Y_t\} = E\{Y_S\} = \mu$
2. $E(Y_t - \mu)^2 = E(Y_{t-S} - m)^2 = \sigma^2$
3. $E(Y_t - \mu) = (Y_{t-S} - \mu) = E(Y_{t-j} - \mu) = (Y_{t-j-s} - \mu) = y_s$

It means that the mean, variance and covariance are invariant to the time origin.

Dickey – Fuller Test

Dickey and Fuller (1979, 1981) devised a procedure to formally test for the presence of a unit root, on the simple assumption that a series Xt is following AR (1) process of the form:

4. $E\ (X_t) = \rho X_{t-1} + e_t$

It is tested for $\rho = 1$ (unity and hence unit root). They consider three different equations to test for the presence of unit root:

5. $X_t = \rho X_{t-1} + e_t$

6. $X_t = a_0 + \rho X_{t-1} + e_t$

7. $X_t = a_0 + \rho X_{t-1} + a_1 t + e_t$

The difference between the equations is the presence of a_0 and a_1. The regression equation (5) is a *pure random walk* model; (6) adds an intercept term (a_o) to allow for *drift* if any and (7) includes both *drift* (a_0) and *linear time trend* (a_1) . In all the three linear regressions, the interest is on parameter ρ. If$\rho = 1$, the null hypothesis (Ho: $\rho = 1$) is not rejected, then the series X_t in *non – stationary* and the usual *tests of significancedo not apply*. If the H_o is rejected and the alternative hypothesis,.$H_A : \rho < 1$ is accepted then the series X_t is stationary. The restriction in the model is the assumption of R (1) process and it was relaxed in the ADF test. Therefore, it is used in this study.

Engle - Granger's Causality Test

The Granger's causality test is generally used to test whether there is bilateral causality or unilateral causality between two variables, for example between PCE and PDI. The formula for this test is:

$F = [\ (RSS_R - RSS_{UR}) / (m)]\ /\ [(RSS_{UR}) / (n-k)]$

where,

RSS_R = Residual Sum of Square of Restricted Regression

RSS_{UR} = Residual Sum of Square of Unrestricted Regression

m = Number of lags in unrestricted regression

n = Sample size

Results and Discussion:

Stock Price Indices

The stock price indices of India and other countries are presented in Table 1

Table 1: Stock Price Indices of Selected Countries - 1991 – 2010

Countries (j) Year (i)	India	USA	UK	Japan	Singapore	Hongkong
1991	1909	3169	2493	22984	1477	4297
1992	2615	3301	2847	16925	1524	5512
1993	3346	3754	3418	17417	2426	11888
1994	3927	3834	3066	19723	2240	8191
1995	3110	5117	3689	19868	2267	10073
1996	3085	6448	4119	19361	2217	13452
1997	3659	7908	5136	15259	1530	10723
1998	3055	9181	5883	13842	1393	10049
1999	5006	11497	6930	18934	2480	16962
2000	3972	10788	6223	13786	1927	15096
2001	3262	10022	5217	10543	1624	11397
2002	3377	8342	3940	8579	1341	9321
2003	5839	10454	4477	10677	1765	12576
2004	6603	10783	4814	11489	2066	14230
2005	9398	10718	5619	16111	2347	14876
2006	13787	12463	6221	17226	2986	19965
2007	20287	13265	6457	15308	3482	27813
2008	9647	8776	4434	8860	1762	14387
2009	17465	10428	5413	10546	2898	21873
2010	20509	11578	5900	10229	3190	23035

Note: *Indices are: 1.Sensex, 2.NYSE, 3.FTSE, 4.Nikkie, 5.ST Index and 6. Hang Seng.*

The time series of data for each country were first tested for stationarity (or unit root) with the help of augmented Dickey – Fuller (ADF) test.

Stationarity Tests

Any empirical work based on time series data assumes that the underlying time series is stationary. If it is not stationary, it may be a cause of autocorrelation and also the problem of **spurious** or **nonsense regression**. Financial time series such as stock prices exhibit random walk phenomenon. If this were in fact the case, **forecasting** asset prices would be a **futile exercise**. For the present research, **causality** test of Granger is used. It assumes that the time series of stock prices are **stationary**.

Table 2: Results of Augmented Dickey Fuller Test for Unit – root

Sl. No	**Country**	**Without Constant and Trend**		**With Constant and Without Trend**		**With Constant and Trend**	
		$(\hat{\tau})$	(τ)	$(\hat{\tau})$	(τ)	$(\hat{\tau})$	(τ)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	India	-5.715862	-1.961409	-6.144017	-1.961409	-4.760214	-1.961409
2	USA	-4.229091	-1.961409	-4.471658	-1.961409	-4.903856	-1.961409
3	UK	-3.619254	-1.961409	-3.937913	-1.961409	-4.671272	-1.961409
4	Japan	-4.524074	-1.961409	-4.343050	-1.961409	-4.652356	-1.961409
5	Singapore	-5.521849	-1.961409	-5.491374	-1.961409	-4.698141	-1.961409
6	Hongkong	-6.101642	-1.961409	-5.402351	-1.961409	-5.127078	-1.961409

Note: *ADF Test was carried out at one difference level with zero lag difference for all the countries*

Table values are critical values (τ) *for 5% level*

As seen in the table above, in all cases - i.e., for all the countries and for each of the three hypotheses the estimated tau $(\hat{\tau})$ values are larger than critical (table values of (τ)) for five percent level of significance. Therefore H_0: $\delta = 0$ is rejected and all the time series are seen to be **stationary**. Therefore, the indices were used, without any need for adjustment, for estimating returns (r), volatility (σ) and the ratio (r/σ). The estimates are presented in Table 3

Table 3: Average Annual Returns (r), Volatility (σ) and Ratio (r / σ) of Stocks of Selected Countries in Current Prices in Local Currencies - 1991 - 2010

(%)

Country (j) / Year (i)	India			USA			UK		
	r	σ	(r/σ)	r	σ	(r/σ)	r	σ	(r/σ)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1991	2.623	4.137	0.634	0.504	2.103	0.240	0.015	1.751	0.009
1992	1.140	7.968	0.143	0.148	0.971	0.152	0.480	2.350	0.204
1993	0.892	3.713	0.240	0.465	0.768	0.606	0.663	1.337	0.495
1994	0.579	3.517	0.165	0.077	1.630	0.047	-0.394	1.944	-0.203
1995	-0.844	2.562	-0.329	1.044	1.051	0.994	0.670	0.892	0.751
1996	-0.030	3.409	-0.009	0.837	1.238	0.676	0.398	0.820	0.486
1997	0.617	3.460	0.178	0.739	2.219	0.333	0.799	1.923	0.415
1998	-0.652	3.787	-0.172	0.540	2.830	0.191	0.492	2.164	0.227
1999	1.787	3.473	0.515	0.814	1.760	0.462	0.593	1.478	0.401
2000	-0.837	3.063	-0.273	-0.230	2.117	-0.109	-0.390	1.908	-0.204
2001	-0.712	3.485	-0.204	-0.267	2.549	-0.105	-0.638	1.828	-0.349
2002	0.125	2.564	0.049	-0.664	2.744	-0.242	-1.016	2.581	-0.394
2003	1.981	3.016	0.657	0.817	1.431	0.571	0.462	1.926	0.240
2004	0.445	3.012	0.148	0.112	0.911	0.123	0.263	0.789	0.333
2005	1.278	2.776	0.460	-0.022	1.090	-0.020	0.559	1.008	0.555
2006	1.387	2.682	0.517	0.546	0.588	0.929	0.368	0.997	0.369
2007	1.398	2.663	0.525	0.226	1.276	0.177	0.135	1.113	0.121
2008	-2.690	4.939	-0.545	-1.495	2.370	-0.631	-1.360	2.768	-0.491
2009	2.148	4.030	0.533	0.624	2.819	0.221	0.722	2.370	0.305
2010	0.582	2.068	0.281	0.378	2.173	0.174	0.312	2.161	0.144

Note:*r - average returns (%) for stocks (indices); σ = volatility (%) and ratio (r / σ) all in current prices*

Table3contd

Country (j) / Year (i)	Japan			Singapore			Hongkong		
	r	σ	(r/σ)	r	σ	(r/σ)	r	σ	(r/σ)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1991	-0.692	3.050	-0.227	-0.276	1.446	-0.191	0.979	1.422	0.689
1992	-1.107	3.262	-0.340	0.114	1.697	0.067	0.901	2.959	0.305
1993	0.104	3.391	0.031	1.681	2.321	0.724	2.782	3.910	0.711
1994	0.450	2.452	0.184	-0.289	2.323	-0.124	-1.348	3.198	-0.422
1995	0.027	3.214	0.008	0.043	1.620	0.027	0.749	2.783	0.269
1996	-0.094	2.309	-0.041	-0.080	1.856	-0.043	1.047	2.014	0.520
1997	-0.862	2.378	-0.362	-1.342	3.252	-0.413	-0.821	5.440	-0.151
1998	-0.353	2.936	-0.120	-0.340	7.257	-0.047	-0.235	5.688	-0.041
1999	1.134	1.742	0.651	2.088	3.295	0.633	1.895	3.918	0.484
2000	-1.149	2.983	-0.385	-0.913	3.406	-0.268	-0.422	3.304	-0.128
2001	-0.971	2.567	-0.378	-0.620	3.841	-0.161	-1.017	3.422	-0.297
2002	-0.746	2.605	-0.286	-0.692	2.587	-0.268	-0.728	2.384	-0.305
2003	0.792	2.091	0.379	0.993	1.525	0.651	1.084	1.847	0.587
2004	0.265	1.594	0.166	0.571	0.978	0.584	0.447	2.068	0.216
2005	1.224	1.899	0.644	0.462	1.194	0.387	0.161	1.646	0.098
2006	0.242	1.734	0.140	0.871	1.642	0.530	1.065	1.329	0.801
2007	-0.427	1.279	-0.334	0.557	1.942	0.287	1.200	2.793	0.430
2008	-1.979	4.337	-0.456	-2.466	4.091	-0.603	-2.385	4.619	-0.516
2009	0.631	3.027	0.208	1.801	3.388	0.532	1.516	3.179	0.477
2010	-0.111	2.725	-0.041	0.348	1.755	0.198	0.187	2.015	0.093

Note:*r - average returns (%) for stocks (indices); σ = volatility (%) and ratio (r / σ) all in current prices*

The average returns to Sensex (of India) is observed (vide Table 3) to be larger – rather significantly larger than the returns to stock indices of all other five countries (USA, UK, Japan, Singapore and Hongkong) in the years 1991, 1992, 1994, 2003, 2005, 2006, 2007, 2009 and 2010 (i.e. in nine out of 20 years). Only in one year (2008) it is smaller than that of USA. The return is smaller than those for indices of UK, Japan, Singapore and Hongkong in 1995, 1996, 1998, 2000, 2001, 2002, 2008 and only of UK in 1997. *Thus, Indian stock market has shown strength -larger as compared to other five countries – in majority of the years in two decades (1991- 2010) in terms of average annual (percentage) returns.*

However, volatility of Sensex (of India) is also larger – rather significantly larger – than that for indices of the other five countries. The opposite (smaller volatility) is seen only for few years and few indices viz., 1995, 2002 and 2003 for Japan; 1998, 2000, 2001 and 2003 for Singapore and 1998, 1999 and 2000 for Hongkong. *Thus, ISM has larger volatility in stock return as compared to other developed and developing counties in most of the years, the exceptions being a few. Thus larger return to stocks has a price in larger volatility for India.*

The effect of larger return and also larger volatility is seen in relatively smaller ratio (r/σ) for India as compared to selected five countries. In a fast developing economy of India that demands larger investments in infrastructure, machines and technology, the above result is rational to be expected. Thus, the inference is clear: ISM is healthy inspite of larger volatility. It is seen (vide column 3 of Table 3) that over the years, the volatility of Sensex is becoming smaller, exceptions being years 2008 and 2009 only. ISM is growing in efficiency yielding high returns and falling volatility but its progress is slow though not halting. Then, volatility in ISM can be expected to impact on and to be impacted by volatility in other countries. That is the focus of further analysis.

Conversion to a Common Currency

The stock price indices are published in the currency of local markets. Analysis presented earlier used these data to know returns and volatility of the chosen six stock indices. In a study on international transmission of volatility, it is however, necessary to convert all indices into one common currency. The US dollar ($) was the choice of common currency. Then, annual average exchange rates (x) of each of the five countries (including India) with $ were collected for each of the 20 years (1991 – 2010) and their inverse (reciprocals (1/x) were used as conversion factor. The daily returns of stock indices were then multiplied by their

conversion factor (CF) to know the dollar value of the returns for each of the countries were computed. The annual average currency exchange rate (CER) and Conversion Factor (CF) are presented in Table 4 below.

Table 4: CER and CF for selected Countries – 1991 - 2010

Countries (j) / Year (i)	India		UK		Japan		Singapore		Hongkong	
	CER	CF	CER	CF	CER	CF	CER	CF	CER	CF
1991	30.75	0.033	0.57	1.763	134.4	0.007	1.73	0.579	7.77	0.129
1992	31.25	0.032	0.57	1.756	126.6	0.008	1.63	0.614	7.74	0.129
1993	31.37	0.032	0.67	1.502	111.1	0.009	1.62	0.619	7.74	0.129
1994	31.37	0.032	0.65	1.531	102.1	0.010	1.53	0.655	7.73	0.129
1995	32.41	0.031	0.63	1.579	94.00	0.011	1.42	0.706	7.74	0.129
1996	35.38	0.028	0.64	1.561	108.7	0.009	1.41	0.710	7.73	0.129
1997	36.29	0.028	0.61	1.639	120.9	0.008	1.48	0.674	7.74	0.129
1998	41.23	0.024	0.60	1.657	130.8	0.008	1.67	0.598	7.75	0.129
1999	43.04	0.023	0.62	1.617	113.7	0.009	1.69	0.590	7.76	0.129
2000	44.86	0.022	0.66	1.514	107.7	0.009	1.72	0.580	7.79	0.128
2001	47.12	0.021	0.69	1.441	121.4	0.008	1.79	0.558	7.80	0.1
2002	48.51	0.021	0.67	1.501	125.1	0.008	1.79	0.559	7.80	0.128
2003	46.50	0.022	0.61	1.634	115.9	0.009	1.74	0.574	7.79	0.128
2004	45.20	0.022	0.55	1.832	108.1	0.009	1.69	0.592	7.79	0.128
2005	43.98	0.023	0.55	1.819	110.0	0.009	1.66	0.601	7.78	0.129
2006	45.18	0.022	0.54	1.840	116.2	0.009	1.59	0.629	7.77	0.129
2007	41.34	0.024	0.50	2.001	117.7	0.008	1.51	0.664	7.80	0.128
2008	43.62	0.023	0.54	1.836	103.4	0.010	1.41	0.707	7.79	0.128
2009	48.42	0.021	0.64	1.560	93.58	0.011	1.45	0.688	7.75	0.129
2010	45.72	0.022	0.65	1.545	87.78	0.011	1.36	0.734	7.77	0.129

Note: *1. CER – Currency Exchange Rate in local currency for US $ (x)*

2. CF – Conversion Factor – (1 / x) to US $

Source:*www.oanda.com/currency/historical-rates*

US Dollar Values of Returns and Volatility

By using the respective CF, the US $ values of daily stock prices were first obtained. These values were then used to estimate annual average returns (r), volatility (σ) and the ratio (r/σ) for each of the six countries. The estimates are presented in Table 5

Table 5: In US Dollar Values, Average Annual Returns (r), Volatility (σ) and Ratio (r / σ) of Stocks in Selected Countries - 1991 – 2010

(%)

Country (j) / Year (i)	India			USA			UK		
	r	σ	(r/σ)	r	σ	(r/σ)	r	σ	(r/σ)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1991	2.623	4.137	0.634	0.504	2.103	0.240	0.263	2.171	0.121
1992	1.140	7.968	0.143	0.148	0.971	0.152	-0.117	2.374	-0.049
1993	0.892	4.112	0.217	0.465	0.768	0.606	0.524	1.512	0.346
1994	0.578	3.519	0.164	0.077	1.630	0.047	-0.237	1.989	-0.119
1995	-1.233	2.478	-0.498	1.044	1.051	0.994	0.628	0.996	0.630
1996	-0.118	3.541	-0.033	0.837	1.238	0.676	0.682	1.039	0.656
1997	0.294	3.626	0.081	0.739	2.219	0.333	0.791	2.072	0.382
1998	-0.951	4.106	-0.232	0.540	2.830	0.191	0.512	2.165	0.237
1999	1.709	3.483	0.491	0.814	1.760	0.462	0.464	1.414	0.328
2000	-1.096	2.989	-0.367	-0.230	2.117	-0.109	-0.741	2.138	-0.347
2001	-0.800	3.559	-0.225	-0.267	2.549	-0.105	-0.695	1.771	-0.392
2002	0.108	2.546	0.042	-0.664	2.744	-0.242	-0.667	2.309	-0.289
2003	2.182	3.060	0.713	0.817	1.431	0.571	0.819	2.128	0.385
2004	0.570	3.448	0.165	0.112	0.911	0.123	0.614	1.306	0.470
2005	1.146	2.824	0.406	-0.022	1.090	-0.020	0.196	1.240	0.158
2006	1.464	2.890	0.507	0.546	0.588	0.929	0.792	0.682	1.162
2007	1.839	3.006	0.612	0.226	1.276	0.177	0.238	1.153	0.206
2008	-3.466	5.922	-0.585	-1.495	2.370	-0.631	-2.464	3.346	-0.736

2009	2.326	4.240	0.549	0.624	2.819	0.221	1.036	2.830	0.366
2010	0.668	2.302	0.290	0.378	2.173	0.174	0.169	2.447	0.069

Table 5.contd..

(%)

Country (j) / Year (i)	Japan			Singapore			Hongkong		
	r	σ	(r/σ)	r	σ	(r/σ)	r	σ	(r/σ)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1991	-0.318	3.463	-0.092	0.118	1.506	0.078	0.994	1.335	0.745
1992	-0.991	3.335	-0.297	0.127	1.689	0.075	0.916	2.967	0.309
1993	0.542	3.911	0.139	1.775	2.435	0.729	2.790	3.929	0.710
1994	0.784	2.201	0.356	0.023	2.428	0.009	-1.355	3.204	-0.423
1995	-0.036	3.152	-0.011	0.171	1.579	0.108	0.750	2.801	0.268
1996	-0.499	2.256	-0.221	-0.043	1.919	-0.022	1.046	2.019	0.518
1997	-1.329	3.105	-0.428	-1.937	3.583	-0.541	-0.825	5.428	-0.152
1998	0.015	3.624	0.004	-0.344	8.512	-0.040	-0.236	5.689	-0.041
1999	1.613	1.925	0.838	2.038	3.404	0.599	1.883	3.921	0.480
2000	-1.471	3.210	-0.458	-1.043	3.583	-0.291	-0.434	3.304	-0.131
2001	-1.430	2.069	-0.691	-0.824	3.731	-0.221	-1.017	3.422	-0.297
2002	-0.583	2.971	-0.196	-0.522	2.453	-0.213	-0.726	2.382	-0.305
2003	1.233	2.191	0.563	1.079	1.615	0.668	1.099	1.889	0.582
2004	0.401	2.097	0.191	0.722	1.241	0.582	0.441	2.096	0.210
2005	0.743	2.048	0.363	0.386	1.180	0.327	0.172	1.655	0.104
2006	0.280	1.649	0.170	1.175	1.591	0.739	1.055	1.329	0.794
2007	-0.273	0.893	-0.306	0.779	1.993	0.391	1.189	2.883	0.412
2008	-1.227	3.835	-0.320	-2.544	4.664	-0.546	-2.364	4.587	-0.515
2009	0.692	2.898	0.239	2.014	3.759	0.536	1.515	3.185	0.476

2010	0.157	2.625	0.060	0.586	2.017	0.291	0.178	2.050	0.087

Note: *r - average returns (%) for stocks (indices); σ = volatility (%) and ratio (r / σ) all in US $ values (for conversion factor see Table 4)*

As seen in the table above, the returns to Sensex is more than those of all other indices under study in the years 1991, 1992, 2002, 2003, 2005, 2006, 2007, 2009 and 2010 (i.e. nine out of 20 years). Sensex yielded lesser return in the years 1995, 1996, 1997, 1998, 2000, 2001 and 2008 than USA and UK (i.e. seven out of 20 years) and in one year 2004 than that of UK. All other years the return is higher than USA and UK.

The returns to Sensex is lesser than returns to Nikkie (index of Japan) in three years viz., 1995, 1998 and 2008; for other years the return is higher than Nikkie. The return is smaller than that of Singapore and Hongkong in seven years 1993, 1995, 1996, 1998, 1999, 2000 and 2008. *Thus Indian stock market has shown strength – larger as compared to other five countries – in majority of the years of the two decades (1991 – 2010) in terms of annual average (percentage) returns.*

However, volatility of Sensex (of India) is also larger – rather significantly larger than that for indices of the other five countries. For the years 1995, 1997, 1998, 1999 and 2000 (five years) the volatility of Sensex is lesser than that of Hongkong. For three years (1998, 2000 and 2001) it is lesser than that of Singapore. Nikkie of Japan showed a higher volatility than Sensex in the years 1995, 2000, 2002 and 2010. The volatility of USA and UK markets is higher only in one year of study, in the year 2002 and 2010 respectively.

Thus, ISM has larger volatility in stock returns as compared to other developed and developing countries in most of the years, the exceptions being few. Thus larger returns to stocks has a price in larger volatility for India.

Transmission of Volatility

The transmission of volatility in stock prices between markets (countries) is studied with the help of Granger Causality test. The statement "y_i causes y_j" is just a short hand for the more precise but long winded statement, "y_i contains useful information for predicting y_j" (in the linear least square sense), over and above the past histories of the other variables in the system. To save space it is said that *"y_i causes y_j"*.

The empirical model has a two – step regression procedure for Granger test. Since the present cannot affect the past, the direction of causation is from the past to the present. An important issue in applying Granger test is the choice of a definite log - length to approximate the theoretically infinite lag distribution. In the absence of any prior information to help choose the lag – length, a trial was made allowing for one to seven lags and the final choice based on F test was **three lags.** To allow for sufficient degree of freedom the quarterly data for 19 years (1991 to 2010 with omission of 1996 for its extreme values of volatility) were used. So, F test for 3, 73 degrees of freedom for five percent level of significance was used to reject or accept (not to reject) the null hypothesis H_0.

H_0: Volatility of stock prices in country i does not Granger cause that in country j for i, j = 1, 2, …6 markets (countries).

Defined this way, this study uses Granger's causality test to know whether there is *bilateral, unilateral or no causality* between two variables viz$\sigma_i$andσ_j(i.e) volatility of stock prices in markets (country i and j).

In Local Currencies

The Granger causality test was first applied to stock prices in local currencies of the selected countries and the results are presented in Table 6.

As seen in the table, for five percent level of significance, H_0 is not rejected for causality between volatility of Sensex (India) and the other five countries, both ways. This shows that there is no causality in volatility of stock prices between India or any of the five countries, both ways. *The inference is: Volatility in stock prices has no unilateral or bilateral causality (in Granger sense) between India and other countries. In other words there is not transmission of volatility of stock prices from and to India.*

H_0 : Volatility of Stock Prices in Country i does not Granger Cause that in Country j for i, j = 1,2,…,6

Table 6: Granger Causality Test for Transmission of Volatility in Stock Prices between Selected Countries - in Local Currencies.

Sl. No	Country (i)	Country (j)	d.f	$\widehat{F}$	Prob	H_0 is
1	India	USA	73	0.55917	0.6437	Not Rejected
2	USA	India	73	0.37167	0.7737	Not Rejected
3	India	UK	73	0.16299	0.9209	Not Rejected
4	UK	India	73	0.76387	0.5181	Not Rejected
5	India	Japan	73	2.10827	0.1069	Not Rejected
6	Japan	India	73	2.07798	0.1109	Not Rejected
7	India	Singapore	73	0.17587	0.9124	Not Rejected
8	Singapore	India	73	0.67675	0.5692	Not Rejected
9	India	Hongkong	73	0.50884	0.6775	Not Rejected
10	Hongkong	India	73	0.13525	0.9387	Not Rejected
11	USA	UK	73	0.25306	0.8589	Not Rejected
12	UK	USA	73	0.11545	0.9508	Not Rejected
13	USA	Japan	73	0.05236	0.9841	Not Rejected
14	Japan	USA	73	0.81472	0.4900	Not Rejected
15	USA	Singapore	73	0.51377	0.6741	Not Rejected
16	Singapore	USA	73	0.31546	0.8141	Not Rejected
17	USA	Hongkong	73	0.18405	0.9069	Not Rejected
18	Hongkong	USA	73	0.66946	0.5736	Not Rejected
19	UK	Japan	73	2.36396	0.0785	Not Rejected
20	Japan	UK	73	1.2266	0.3066	Not Rejected
21	UK	Singapore	73	1.40242	0.2494	Not Rejected
22	Singapore	UK	73	2.54922	0.0627	Not Rejected
23	UK	Hongkong	73	0.83674	0.4783	Not Rejected
24	Hongkong	UK	73	3.04448	0.0344	Rejected

contd..

Table 6 contd..

25	Japan	Singapore	73	0.35966	0.7829	Not Rejected
26	Singapore	Japan	73	0.9185	0.4265	Not Rejected
27	Japan	Hongkong	73	2.5695	0.0611	Not Rejected
28	Hongkong	Japan	73	3.43313	0.0215	Rejected
29	Singapore	Hongkong	73	1.95987	0.128	Not Rejected
30	Hongkong	Singapore	73	6.93421	0.0004	Rejected

Note:*1. Tests were based on quarterly data on stock prices to have sufficient degree of freedom - years 1991 - 2010, except four quarters of 1996 - a very abnormal year for India.*

2. No of lags: 3 d.f: 76 - 3 = 73

3. $\widehat{F}$ *= estimated value of* $F_{3,73}$*, Table Value* $F_{3,73}$ *is : 3.053 for 5% level of significance*

4. If $\widehat{F} > F$*, then* H_0 *is rejected, otherwise it is not rejected*

By the same reasoning it is concluded that there is no causality between volatility of stock prices between USA and other five countries. Between UK and other countries, between Japan and other countries, between Singapore and other countries and between Hongkong and other countries also the same inference is valid with one exceptionofHongkong.

The H_0 is rejected for Granger causality in stock price volatility between Hongkong and UK, Japan and Singapore, while H_0 is not rejected for Granger causality from stock markets in UK, Japan and Singapore to Hongkong. Therefore, *the inference is: There is* ***one way*** *transmission of volatility in stock prices of Hongkong to UK, Japan and Singapore.*

With only one exception that too one way transmission of volatility from Hongkong to three other countries, the general inference is that the international (or inter market) transmission of volatility ***does not occur****.*

In US $ Values

One reason for this result may be that volatility (σ) is measured for variation in stock prices in local currencies. The results may differ if the stock prices were measured in a common currency. Therefore, the exercise was repeated for stock prices of all the selected countries expressed in US dollar values (vide Table 4 for the data). The results are presented in Table 7.

H_0: Volatility of Stock Prices in Country i does not Granger Cause that in Country j for i, j = 1,2,…,6

Table 7: Granger Causality Test for Transmission of Volatility in Stock Prices in US $ between Selected Countries.

Sl. No	Country (i)	Country (j)	d.f	$\widehat{F}$	Prob	Ho is
1	India	USA	73	1.40972	0.2478	Not Rejected
2	USA	India	73	1.18683	0.3216	Not Rejected
3	India	UK	73	1.99317	0.1235	Not Rejected
4	UK	India	73	1.84946	0.1468	Not Rejected
5	India	Japan	73	0.76680	0.5167	Not Rejected
6	Japan	India	73	1.52850	0.2153	Not Rejected
7	India	Singapore	73	1.02371	0.3879	Not Rejected
8	Singapore	India	73	1.05453	0.3745	Not Rejected
9	India	Hongkong	73	2.06069	0.1139	Not Rejected
10	Hongkong	India	73	2.05703	0.1144	Not Rejected
11	USA	UK	73	0.46133	0.7102	Not Rejected
12	UK	USA	73	1.77156	0.1612	Not Rejected
13	USA	Japan	73	0.80895	0.4934	Not Rejected
14	Japan	USA	73	0.35399	0.7864	Not Rejected
15	USA	Singapore	73	2.38916	0.0767	Not Rejected
16	Singapore	USA	73	2.48071	0.0686	Not Rejected
17	USA	Hongkong	73	1.37453	0.2583	Not Rejected
18	Hongkong	USA	73	3.05029	0.0346	Rejected
19	UK	Japan	73	2.62358	0.0578	Not Rejected
20	Japan	UK	73	0.13209	0.9406	Not Rejected
21	UK	Singapore	73	3.97160	0.0115	Rejected
22	Singapore	UK	73	0.60173	0.6162	Not Rejected
23	UK	Hongkong	73	3.98093	0.0114	Rejected
24	Hongkong	UK	73	0.77932	0.5097	Not Rejected

contd..

Table.7 contd..

25	Japan	Singapore	73	1.17999	0.3241	Not Rejected
26	Singapore	Japan	73	1.26213	0.2946	Not Rejected
27	Japan	Hongkong	73	0.34842	0.7904	Not Rejected
28	Hongkong	Japan	73	1.96078	0.1284	Not Rejected

Note:*1. Tests were based on quarterly data on stock prices to have sufficient degree of freedom - years 1991 - 2010, except four quarters of 1996 - a very abnormal year for India.*

2. No of lags: 3 d.f: 76 - 3 = 73

3. $\hat{F}$ *= estimated value of* $F_{3,73}$*, Table Value* $F_{3,73}$ *is : 3.053 for 5% level of significance*

4. If $\hat{F} > F$*, then* H_0 *is rejected, otherwise it is not rejected*

As seen in the above table, for five percent level of significance, H_0 is not rejected for causality between volatility of Sensex (India) and the other five countries, both ways. This shows that there is no causality in volatility of stock prices between India or any of the five countries, both ways. This shows *Volatility in stock prices has no unilateral or bilateral causality (in Granger sense) between India and other countries. In other words there is not transmission of volatility of stock prices from and to India.*

By the same reasoning, there is no causality between volatility of stock prices between USA and five other countries, between Japan and other countries and between Singapore and other countries. The H_0 is not rejected for volatility between UK and other countries except Singapore and Hongkong where the H_0 is not rejected for volatility between Hongkong and other countries except USA. Therefore, the inference is: *There is **one way** transmission of volatility in stock prices of UK to Singapore and Hongkong and Hongkong to USA. But India finds no transmission of volatility internally and both ways. Therefore, volatility in ISM is largely local market determined.*

The Effect of Exchange Rates

The inference that there is no international transmission of volatility in stock prices is surprising in the context of increasing globalization of economies and the associated integration and liberalization of stock markets world over. Can it be explained by the effect of changes in exchange rate of the countries on stock prices. In other words, do changes in exchange rate of local currencies weaken the volatility in stock prices for their international transmission? To

answer the question, the simple (zero order) correlation between estimated volatility (in local prices and in US $) and the exchange rate with US $ were studied. The results are presented in Table 8 below.

Table 8: Simple (zero order) Correlation between Volatility of Stock Prices and Exchange Rate of Local Currencies with US $

Sl. No	Countries	Correlation Coefficients (r) for	
		Local Currency	US $
1	India	-0.40905^{NS}	-0.360550 ^{NS}
2	UK	0.260733 ^{NS}	-0.171480 ^{NS}
3	Japan	-0.128160 ^{NS}	0.073911 ^{NS}
4	Singapore	0.082593 ^{NS}	0.038524 ^{NS}
5	Hongkong	-0.272170 ^{NS}	-0.268830 ^{NS}

Note: ** Significant at 5% level*

*** Significant at 1% level*

NS - not significant

The estimated correlation coefficients presented in the table above are all statistically not significant, even at five percent level. *Therefore, inference is clear: Exchange rate of rupees to US $ has no impact on volatility in stock prices (Sensex) in India. The causes of volatility must be found in local market conditions – viz., market competition, economic and political changes and policies on investment and money supply – that affect business in ISM.*

Overall inference is that international transmission of volatility in stock prices among the markets is weak and / or non – existing. Only local market conditions determine the size of volatility in stock prices. Local political, economic conditions such as economic growth, inflation and savings may be the real cause of volatility.

Salient Findings

The results of analysis were presented and discussed to draw specific inferences. The salient findings are brought together hereunder.

- Indian stock market has shown strength -larger as compared to other five countries – in majority of the years in two decades (1991- 2010) in terms of average annual (percentage) returns.
- ISM has larger volatility in stock return as compared to other developed and developing counties in most of the years, the exceptions being a few. Thus larger return to stocks has a price in larger volatility for India.
- The effect of larger return and also larger volatility is seen in relatively smaller ratio (r/σ) for India as compared to selected five countries. In a fast developing economy of India that demands larger investments in infra structure, machines and technology, the above result is rational to be expected. Thus, the inference is clear: ISM is healthy inspite of larger volatility. It is seen that over the years, the volatility of Sensex is becoming smaller, exceptions being years 2008 and 2009 only. ISM is growing in efficiency yielding high returns and falling volatility but its progress is slow though not halting. Then, volatility in ISM can be expected to impact on and to be impacted by volatility in other countries.
- There is no causality between volatility of stock prices between USA and other five countries. Between UK and other countries, between Japan and other countries, between Singapore and other countries and between Hongkong and other countries also the same inference is valid with one exception of Hongkong.
- There is **one way** transmission of volatility in stock prices of Hongkong to UK, Japan and Singapore.
- With only one exception that too one way transmission of volatility from Hongkong to three other countries, the general inference is that the international (or inter market) transmission of volatility **does not occur**.
- Volatility in stock prices has no unilateral or bilateral causality (in Granger sense) between India and other countries. In other words there is not transmission of volatility of stock prices from and to India.

- There is **one way** transmission of volatility in stock prices of UK to Singapore and Hongkong and Hongkong to USA. But India finds no transmission of volatility internationally both ways. Therefore, volatility in ISM is largely local market determined.
- Exchange rate of rupees to US $ has no impact on volatility in stock prices (Sensex) in India. Therefore, the causes of volatility must be found in local market conditions - viz., market competition, economic and political changes and policies on investment and money supply – that affect business in ISM.
- Overall inference is that international transmission of volatility in stock prices among the markets is weak and / or non – existing. Only local market conditions determine the size of volatility in stock prices. Local political, economic conditions such as economic growth, inflation and savings may be the real cause of volatility.

Verification of Hypothesis

In this study the following hypothesis is to be empirically verified to be true (i.e, holding) or false (to be rejected).

The hypothesis is that "there is significant global transmission of volatility across the markets". The results show that there is no or very weak transmission of volatility across the markets, for all the six countries studied including India. Therefore, the second hypothesis is rejected for both India and other countries. The alternative hypothesis that, "there is no international transmission of volatility" is accepted. Volatility must therefore find explanation in macro economic variables within the economy.

Conclusion

Indian stock market is seem to have lower return and higher volatility compared to other five markets studied. However, the ratio (r / σ) is still positive. Thus Indian stock market is growing in size and market efficiency. This attracts more investors contribution to a positive growth path.

The simple SD and RSV are seen to be robust measures of volatility in stock prices. However, size of volatility is larger with larger returns and also length of the period of study. Therefore, data for a long term period is necessary for such studies of dynamic time series analysis.

ISM has shown growth and stability largely because of liberalization policies such as foreign direct investment, foreign institutional investors and global integration. However, it has not affected stability of ISM because international transmission of volatility is proved to be nonexistent. Another reason for the development of ISM is significant structural changes, forward looking programmes and effective system. They made the process simple and efficient with little way for manipulative trade practices. Speculative trade is the basic feature of any stock market. However, it is held well under control in Indian stock market.

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