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RESULTS & DISCUSSION
FINDINGS
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VOLATILITY SPILLOVER ACROSS MAJOR EQUITY MARKETS: A CRITICAL REVIEW OF LITERATURE

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ABSTRACT

Volatility spillover among major equity markets has long fascinated academicians and researchers alike. This paper presents an elaborate survey and analysis of the literature on the subject. Review of extant studies on various basis such as markets studied, methodology employed, among others has important implications for various stakeholders. We report that there has been wide variation in results because different studies have examined different markets using wide range of financial econometric methodologies. Some have considered only volatility or both volatility and spillover. Still others have incorporated the impact of global financial crisis on volatility spillover. Future researchers should examine if there is any volatility spillovers between various sectors of an economy, between different financial markets of the same economy, amongst same sectors of different markets, probe whether size effect is relevant, identify the transmission channels of volatility spillover, enumerate reasons behind volatility spillover, examine asymmetric volatility responses among stock markets and can use more advanced econometric techniques.

JEL CLASSIFICATION
F36, F65, G01, G11, G15.

KEYWORDS
Volatility, Spillover, Equity Markets, Global Financial Crisis.

1. INTRODUCTION

Interdependence between the international stock markets can be of two forms: return and volatility transmissions. This interdependence is important because one can benefit from international diversification only if there are low correlations across international equity markets. These gains dwindle as the degree of financial market integration increases making the markets to move together and creating spillovers. Moreover, strong comovements may increase the financial instability at the global level as domestic disturbances spreads rapidly across countries without any fundamental changes. As the market integration increases, the correlation and interdependence of world financial markets have increased over time. Understanding the association between volatility and correlation along with the increasing trend between correlation coefficients of various markets deserves attention by regulators and portfolio managers.

Volatility is regarded as an important risk factor in the global financial markets. The ups and downs in prices are a general phenomenon in the stock markets. A highly liquid stock market is often characterized by the levels of volatility. Investors infer a raise in volatility level as an increase in the risk level and hence they shift their capital to less risky financial instruments. A volatility spillover occurs when changes in price volatility in one market produce a lagged impact on volatility in other markets, over and above local effects. Volatility spillover patterns seem to be prevalent in financial markets. Global integration effects have highlighted the importance of the study of spillovers between capital markets.

Academicians and researchers find it interesting to study the relationships among various stock markets in the light of global financial crisis because international linkages among stock markets play decisive role in international portfolio and risk management during periods of extreme volatilities.

The rest of the paper is framed as follows. Section 2 lays the objectives of the study. Literature review is presented in Section 3. Critical analysis of extant studies constitutes Section 4 of the paper. Section 5 discuses the scope for future research. Summary and conclusion of the present work are provided in Section 6.

2. OBJECTIVES OF THE STUDY

The present work has multiple objectives which are listed below.

1. To provide a theoretical and conceptual framework of volatility spillover.
2. To scrutinize whether volatility spillover differs across developed and developing markets.
3. To segregate the literature that has only considered volatility and those which include spillover also.
4. To analyze the literature on the basis of various methodologies applied.
5. To examine studies which have incorporated the impact of global financial crisis on volatility spillover.

3. REVIEW OF LITERATURE

This section of literature review has been segregated on the basis of markets studied, considering volatility and spillover, methodologies applied and incorporating global financial crisis in their research design.

3.1 MARKETS STUDIED

This sub section has been further categorized in two parts - those considering developed and those examining developing economics. The prominent ones are explained below.

3.1.1 DEVELOPED MARKETS

Most of the initial studies have analyzed volatility spillovers in context of developed markets. Some of the important ones are discussed below.

Susmel & Engle (1994) examined New York and London equity markets for the period between January 2, 1987 and February 29, 1989 using ARCH, GARCH models with BHHH algorithm. Minimal volatility spillovers were evidenced.

Koutmos & Booth (1995) investigated the New York, Tokyo and London stock markets for the period from September 3, 1986 to December 1, 1993 using multivariate EGARCH models. Price spillovers from New York to Tokyo and London and from Tokyo to London were found. Second moment interactions were more extensive and reciprocal.

Jeong (1999) studied international stock markets of USA, UK and Canada for the year 1992 using ARMA models and GARCH based on BHHH algorithm. Results concluded that the volatility spillover was bidirectional & its magnitude did not decrease monotonically with the increase in lag length.

Baur & Jung (2006) investigated USA and German stock markets for the period January 2, 1998 through December 29, 2000 using a variant of aggregate shock (AS) model, GARCH model and ARCH-LM tests. Results indicated that foreign daytime returns significantly influenced the domestic overnight returns in both the US and the German market.

Canarella et al. (2007) studied USA, Canadian & Mexican stock markets for the period January 1992 till December 2003 using AR (1)-APARCH (1, 1) model, BHHH algorithm, ARCH and GARCH models. Findings indicated that the returns in the Canadian and Mexican stock markets are significantly impacted by US stock market. Leverage effects were reported more intensely in Mexican market in comparison Canadian market.

Abidin et al. (2014) investigated the stock markets of Australia, New Zealand, Hong Kong, Japan and China over a period extending from May 6, 2004 to August 31, 2010 using AR-VAR model and AR-GARCH models. Significant return and volatility spillovers are evidenced across these markets.

Park et al. (2015) analyzed Japanese and US stock indices for the period from January 4, 1990 to October 31, 2014 using GARCH-BEKK model, symmetric and asymmetric GARCH models. Shock transition effect between both markets was identified with volatility transition from US to Japanese markets. Leverage and clustering effects were found in Japanese stock markets.

3.1.2 DEVELOPING MARKETS

Then the focus of literature shifted to the developing or emerging markets. Some of the extant studies are explained below.

Christofi & Pericli (1999) investigated five major Latin American stock markets: Argentina, Brazil, Chile, Columbia and Mexico from May 25, 1992 to May 16, 1997 using VAR model with errors following a multivariate EGARCH process. Stronger volatility spillovers were indicated in these markets than mean spillovers and in comparison to other regions of the world. Leverage effect in volatility was detected.

Worthington & Higgs (2004) scrutinized the developed markets of Hong Kong, Japan and Singapore and six emerging markets of Indonesia, Korea, Malaysia, the Philippines, Taiwan and Thailand for the period from January 15, 1988 to October 6, 2000 using multivariate GARCH model. Large, positive and heterogeneous mean & own-volatility spillovers were reported for the emerging markets.

Yu & Hassan (2008) investigated MENA stock markets of Bahrain, Oman, Saudi Arabia, Jordan, Egypt, Morocco and Turkey from January 1, 1999 to December 31, 2005 using VEC model, the EGARCH-M models, multivariate AR-GARCH models, BEKK model and BHHH algorithm. The estimation results evidenced large and predominantly positive volatility spillovers and volatility persistence in conditional volatility among MENA and world stock markets. Own-volatility spillovers were usually higher than cross-volatility spillovers for all the markets.

Sarwar & Bhuyan (2009) analyzed the stock indices of USA and BRIC economies for the period January 16, 1995 to April 13, 2007 using a variant of the aggregate shock model under the GARCH framework. The results indicated significant mean return and volatility spillover effects from US stock market onto the BRIC stock markets. Bidirectional mean spillover effects among Chinese and Indian stock markets and unidirectional mean spillover effects from Chinese to US stock markets were found.

Sariannidis et al. (2010) explored the stock markets of Hong Kong, India and Singapore from July 1, 1997 to October 31, 2005 using multivariate GARCH model with BEKK specification. Strong GARCH effects were evidenced. The empirical analysis showed that the markets were highly integrated reacting to information which influences the mean returns as well as their volatility.

Maghyereh & Awartani (2012) investigated the stock markets Dubai and Abu Dhabi for a period from January 7, 2005 to February 17, 2010 using VAR-BEKK framework and asymmetric DCC model. Significant return and volatility spillover were reported from the stock markets of Abu Dhabi to stock markets of Dubai.

Adrangi et al. (2014) investigated the equity indices of Argentina, Brazil and Mexico for a five year period from August 2007 to August 2012 using bivariate VAR-GARCH and VAR-EGARCH models. Leverage effects and bidirectional volatility spillovers were evidenced.

Nishimura et al. (2015) analyzed Chinese and Japanese stock markets over the period extending from November 4, 2003 to November 18, 2011 using Fractionally Integrated GARCH model. Chinese markets affects other markets while are not greatly affected by them. Information is mainly transmitted through returns and not through volatility from China to Japan.

3.2 VOLATILITY & SPILLOVER

In this sub section, the literature has been segregated on the basis of studies which considered only volatility and those which considered spillover effects also. The prominent ones are listed below.

3.2.1 VOLATILITY

First, volatility studies have been discussed.

Engle & Susmel (1993) analyzed 18 major stock markets of European, Far East and North American countries from the first week of January 1980 to the first week of January 1990 using ARCH tests and multivariate ARCH tests. Results reported similar time varying volatility in some international stock markets.

Ramchand & Susmel (1998) inspected major equity markets of European, Far East and North American countries for the time period from January 1980 through January 1990 using a switching ARCH technique, bivariate SWARCH model and GARCH models. The results reported that when the US market was in high variance state the correlations between US and other world markets are about 2 to 3.5 times higher than low variance regime.

Miykoshi (2003) explored Hong Kong, Indonesia, Korea, Malaysia, Singapore, Taiwan and Thailand equity markets along with USA and Japan for the period ranging from January 1, 1998 to April 30, 2000 using a bivariate EGARCH model. Results concluded that the returns of Asian markets were influenced from US and not from Japan. Japanese markets had more and in fact adverse influence on the volatility of Asian markets than US.

Kumar & Dhankar (2009) observed the stock markets of India, Sri Lanka, Pakistan and Bangladesh using ARCH and GARCH models. Volatility clustering in stock returns was reported. Conditional volatility in all stock markets was significantly explained by ARCH and GARCH models.

Kumar (2012) analyzed Nifty index and the volatility index of India (Ivix) for a period from November 1, 2007 till May 31, 2010 using dummy variable regression, GARCH (1, 1) model, ARCH-LM tests, quantile regression and VAR techniques. The results evidenced that Ivix returns are negatively related to stock market returns and the leverage effect was significant. Monthly volatility forecasts supported its predictive ability about future market volatility.

Ding et al. (2014) scrutinized the stock option indices of US, European, German, Japanese, and Swiss equity markets from January 1999 to December 2009 using multivariate GARCH model, general VAR (1)–VECH (1, 1) and GARCH model. The results showed asymmetric bi-directional relation between the VIX and other market volatility indices, in which VIX has a larger impact in both the pre-crisis and during crisis times.

3.2.1 SPILLOVER

Now, studies which considered spillover effects have been elaborated.

Hahm (2003) inspected USA and Korea for a sample period from November 1, 1977 to December 31, 2001 using GARCH (1, 1)-M model with higher order MA processes and GARCH (1, 1)-M model with ARMA (1, 1). Statistically significant unidirectional lagged volatility spillovers from Korea to the US were found.

Gebka & Serwa (2007) studied emerging capital markets of Central and Eastern Europe, Latin America, and South-East Asia for the period from April 1, 1998 to January 4, 2006 using the two-step procedure developed by Cheung and Ng (1996). Significant intra- and inter-regional spillovers were found with intra regional spillovers being more distinct than the inter-regional spillovers.

Wang & Wang (2010) studied the stock market of Greater China, USA and Japan from July 15, 1992 to May 21, 2004 using univariate ARCH/GARCH and multivariate GARCH (1, 1) with BEKK specification. Stronger volatility spillovers exist between the Greater China markets and the developed markets of the US and Japan.

Kutler & Torun (2014) studied the major stock markets of USA, UK, Germany, France, Japan, Brazil, China, Hong Kong, Russia and Istanbul from January 5, 2000 to January 13, 2014 using GARCH-BEKK and CCC GARCH models. Results conclude the existence of strong volatility spillover between developed economies and weak spillovers were reported from developed to developing economies.

Syriopoulos et al. (2015) investigated the BRICS and US markets from January 3, 2005 to December 31, 2013 using disaggregated VAR (1)-GARCH (1, 1) models. Return and volatility spillovers were reported to be significant between the US and BRICS stock markets.

3.3 METHODOLOGY

In this sub section, the literature has been segregated on the basis of methodology adopted.

Hamao et al. (1990) studied the major stock markets of Tokyo, London & New York for the period beginning from April 1, 1985 to March 31, 1988 using the ARCH models, GARCH-M model and BHHH algorithm. They observed evidence of price volatility spillovers from US & the UK stock markets to the Japanese market. The volatility spillover effect on the Japanese market was significant.

Pan et al. (1999) examined USA, Australia, Hong Kong, Japan, Malaysia and Singapore from January 4, 1988 to December 30, 1994 using a modified cointegration test with GARCH effects and ARCH tests. The results suggested that volatility transmissions among these stock markets exist in the short term as well as long term.

Wongswan (2006) examined USA, Japan, Korean and Thai stock markets for the period from January 3, 1995 to December 29, 2000 using AR (1)-GARCH (1, 1) model and OLS regressions of ARMA models. The study found large and significant association between US and Japan macroeconomic announcements and Korean and Thai equity market volatility but the impact was short-lived.

Chuang et al. (2007) investigated stock indices of Japan, Hong Kong, Singapore, South Korea, Taiwan and Thailand from January 3, 1992 to June 10, 2006 using six variable VAR-BEKK models, Error-Correction Model (ECM), VAR analysis and the impulse response functions. The empirical results evidenced volatility clustering effects. The Japanese market was most influential in transmitting volatility to the other East Asian markets.

Pandey & Kumar (2011) studied nine major stock markets of India, China, Singapore, Japan, Indonesia, the UK, Australia, Germany and the US for the period January 4, 2000 to July 17, 2009 using GARCH (1, 1) model with BHHH algorithm. The volatility of Indian markets was dependent on its lagged volatility along with volatility of Japan, China, Singapore, UK and Indonesian stock markets.

Saadah (2013) investigated the Singaporean and Indonesian stock market for the sample period from January 3, 2008 till August 15, 2012 using ARMA-TGARCH (1, 1) model and Langrange multiplier. The results evidenced that the transmission of the shock from the Singapore stock exchange became stronger when this market experiences a negative return and is in the bearish phase.

Prashant (2014) the stock market of India and US from January 2012 to April 4, 2014 using ARCH, multivariate ARCH and GARCH model with BEKK specification. The results indicated greater impact of US stock markets on Indian stock markets in terms of shocks and volatility transmission. Volatility clustering is observed in the returns.

3.4 FINANCIAL CRISIS

In this sub section, the studies which incorporated the effect of Global Financial Crisis have been elucidated.

Angabini & Wasiuzzaman (2010) analyzed the stock markets of Malaysia for two periods: one from June 1, 2000 to December 31, 2007 and the second from June 1, 2000 to March 16, 2010 (including the crisis) using ARMA, ARIMA, ARCH-LM and GARCH (1, 1) models. On comparison, it was observed that volatility increased by 24.5% and the persistence of volatility decreased by 2.16% during the crisis.

Sabbaghi (2011) studied G5 stock markets, namely the UK, Germany, France, Japan and the US, in the light of the global financial crisis of 2008 for a sample period from January 4, 2008 to December 31, 2010 using GARCH and EGARCH (1, 1) models. Volume was evidenced to be an important variable in explaining conditional volatility. Results suggested that trading volume captured a significant fraction of asymmetric volatility effects during the recent financial crisis.

Sed'a (2012) examined the impact of crisis on the Czech and Polish stock markets for the period of around eight years from 2004 to 2012 using AR (1) – GARCH (1, 1) and Jump-Diffusion GARCH (1, 1) model with heteroskedasticity. The results showed no statistical significant jump behavior in both markets before the crisis but the opposite was found during the crisis.

Hwang (2014) examined the Latin American stock markets of Argentina, Brazil, Chile, Mexico and USA in the light of crisis for a period from January 1, 2006 to December 31, 2010 using cointegration GARCH-BEKK and DCC-GARCH models. Evidence of financial contagion during crisis was reported. Conditional correlations were more volatile during the crisis.

Sakthivel et al. (2014) studied the volatility of Indian stock markets for the period March 1, 2005 to December 31, 2012 using GJR GARCH model and dummy variable. The results concluded that leverage effects, increased volatility and negative impact on mean returns were the outcomes of crisis.

Golosnoy et al. (2015) studied USA, German and Japanese stock markets before and during the subprime crisis for a period from January 5, 1996 to February 26, 2009 using a novel four-phase model based on conditional autoregressive Wishart framework. Significant spillovers from one market to the next trading market were found to be short-lived and which intensified during crisis. And the crisis decreased the persistence in volatility.

4. CRITICAL ANALYSIS

Initially studies in the volatility literature have majorly based their research on developed markets. Most studied developed markets include the US, the UK, Japan, Germany and France. Other developed markets such as Australia, Canada, etc. have not been examined much. All the studies found volatility transmission from other markets (mostly developed) to be significant for domestic markets in these developed nations. The studies in literature have not analyzed spillovers from emerging markets to the developed markets.

The emerging and developing markets like Latin American countries: Argentina, Brazil, Chile, Columbia and Mexico; Asia-Pacific countries: Indonesia, Korea, Malaysia Singapore, Taiwan and Thailand; Russian, Chinese and Indian economies have been the area of interest after studying the volatility among major developed countries. But a majority of lesser developed countries like South Africa, Saudi Arabia, Nigeria, Pakistan, Sri Lanka, Bangladesh, etc. are yet to be studied. Results show that volatility spillover effect is much more pronounced in case of developing economies as compared to developed economies. Also while in case of developed economies volatility transmission occurred from mainly other developed markets; in case of emerging economies transmission was from both developed and developing markets.

While many researchers measured time-varying volatility, correlations and integrations along with conditional volatility covering the symmetrical volatility in their studies, very few have taken up the asymmetrical components of volatility such as fat tails, clustering effects and leverage effects.

Studies that analyzed the spillover effects have found significant mean and volatility spillovers across countries not on friendly terms. Regionally close countries have volatility links among them. Common dependence on the global market as in the case of European Countries leads to linkages among their emerging markets. In totality, volatility spillovers were found to be stronger in comparison to return spillovers and emerging markets adjust to foreign information efficiently.

Majority of studies in the literature have applied ARCH (Auto Regressive Conditional Heteroskedasticity) and GARCH (Generalized Auto Regressive Conditional Heteroskedasticity) family of models with slight variations such as ARCH-LM, GARCH-M, AR (1)-GARCH, Jump Diffusion GARCH, GARCH with BEKK and BHHH

algorithm, CGARCH, TGARCH, ARMA-TGARCH and EGARCH. Some others apply VAR (Vector Auto Regressive) analysis and VEC (Vector Error Correction) model. Still others have used Impulse Response Functions. This marks a significant shift in financial econometric techniques applied as studies are increasingly considering second generation advanced econometric tools which relax several assumptions of traditional techniques and are more suited to financial time series data.

Most of the studies that have incorporated the impact of Financial Crisis have examined its impact mainly on the developed markets like American and European stock markets owing to the popular perception that developed markets particularly the US and European ones have taken the hardest hit. Some of the studies have investigated the impact of Financial Crisis on some developing and emerging markets like Malaysia, India etc. But the literature is scant on developing markets. The literature almost unanimously conclude that crisis accentuated volatility spillover across global equity markets but, more so in case of developed markets.

5. SCOPE FOR FURTHER RESEARCH

The critical analysis of literature review has helped to identify the following three research gaps in the literature of volatility spillover.

1. To examine if there is any volatility spillovers between various sectors of an economy.
2. To investigate for presence of volatility spillover amongst same sectors of different markets.
3. To analyze if there is any volatility spillover between different financial markets of the same economy.
4. To probe whether size effect is relevant in volatility spillovers i.e., does volatility spillover significantly vary across large cap, mid cap and small cap stocks.
5. To identify the transmission channels of volatility spillover.
6. To enumerate the reasons behind volatility spillover.
7. To examine the asymmetric volatility responses among the stock markets.
8. More advanced econometric techniques like multivariate SWARCH model can be used wherever applicable.
9. To probe the impact of trading volume volatility on the return volatilities across different countries.
10. Since nowadays, volatility indices are available for major market indices, they can be directly used instead of actual series.

6. SUMMARY & CONCLUSION

In this paper, various facets of volatility spillover across major equity markets across the world have been elucidated. The paper starts with the introduction to stock market interlinkages, volatility spillover and the impact of crisis on the volatility spillovers.

Extant studies have been analyzed on the various bases such as markets examined (developed and developing); whether considered only volatility or spillover; methodology applied and those which incorporated the impact of financial crisis. Investors infer a raise in volatility level as an increase in the risk level and hence they shift their capital to less risky financial instruments.

Critical appraisal of literature reveals that there has been volatility transmission from both developed and developing markets to emerging economies while this is mainly from advanced markets for developed economies. Analysis of previous work on volatility shows that asymmetrical components of volatility such as fat tails, clustering effects and leverage effects have not been extensively examined. Volatility spillover and links was reported amongst regionally close countries. Also, volatility spillover was stronger than return spillovers. Though, general volatility increased post crisis, developed markets were worst hit.

Future researchers should examine if there is any volatility spillovers between various sectors of an economy, investigate for presence of volatility spillover amongst same sectors of different markets, analyze if there is any volatility spillover between different financial markets of the same economy, probe whether size effect is relevant in volatility spillovers, identify the transmission channels of volatility spillover, enumerate the reasons behind volatility spillover, examine the asymmetric volatility responses among the stock markets, can use more advanced econometric techniques like multivariate SWARCH model wherever applicable, probe the impact of trading volume volatility on the return volatilities across different countries and can use volatility indices directly instead of actual series.

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