CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY, ISLAMABAD

Mean and Volatility Spillover between the Stock, Gold and Oil Markets during US Financial Crisis and Chinese Stock Market Crash

by

Imran Yousaf

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List of Publications

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1. Yousaf, I., & Hassan, A. (2019). Linkages between crude oil and emerging Asian stock markets: New evidence from the Chinese stock market crash. *Finance Research Letters*, 31, 207-217.

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Abstract

This study aims to examine the return and volatility spillover between different markets (Stock, Oil, and Gold) during full sample period, US financial crisis and Chinese stock market crash. Moreover, it calculates the optimal weights and hedge ratios for different portfolios during US financial crisis and Chinese stock market crash. It uses a sample period from January 2000 to June 2018. It uses a VAR-AGARCH model for the estimation of return and volatility spillover, which is proposed by McAleer et al. (2009). Following are the empirical findings of the study.

This study finds a return transmission from USA to Asian stock markets during US financial crises, whereas no return spillover is found from China to Asian stock markets during Chinese stock market crash. Moreover, volatility effect is not transmitted from US to Asian stock markets during US financial crisis, whereas volatility transmits from China to four Asian stock markets (India, Indonesia, Taiwan and Thailand) during Chinese stock market crash. It implies that US and China stock markets do not transmit risk to majority emerging Asian stock markets during crisis period.

It finds that return and volatility spillovers are not found to be significant from USA to majority Latin American markets during US financial crisis. It implies that international portfolio investors can diversify their portfolio by investing in US and Latin American stock markets. During Chinese stock market crash, return and volatility are also not transmitted from the China to Latin American stock markets. It implies that diversification benefits can increased by investing in a portfolio of Chinese and Latin American stock markets during Chinese stock market crash.

The return spillover is significant, whereas volatility transmission is insignificant from oil to majority Asian stock markets during US financial crisis. Moreover, the return spillover is significant, whereas volatility spillover is insignificant from oil to most of the Asian stock markets during Chinese stock market crash. Overall, the risk of few emerging Asian markets sensitive to the international oil prices during

both crisis. It implies that the return and risk of few emerging Asian stocks are sensitive to international oil prices during US crisis. Moreover, diversification opportunities are higher between oil and Asian stocks during Chinese crash.

The return and volatility transmission is insignificant from the oil to most of the Latin American stock markets during US financial crisis. However, only Brazil stock market is sensitive to the international oil markets during US financial crisis. Moreover, the return and volatility transmission is insignificant from the oil to Latin American stock markets during Chinese stock market crash. It suggests that investors can minimize risks by investing in a portfolio of oil and Latin American stock markets during crisis periods.

The return spillover from gold to majority Asian markets is insignificant during US financial crisis. Moreover, volatility spillover is evident from gold to three Asian markets (Indonesia, Malaysia and Taiwan)during US financial crisis. Moreover, the return spillover is significant from gold to four Asian stock markets (China, India, Pakistan and Thailand) during Chinese stock market crash. In addition, volatility is only transmitted from gold to few Asian stock markets (China, Korea, and Malaysia) during Chinese stock market crash. Overall, few Asian stock markets receive the risk from gold market during crisis. It suggests that investors can get benefit of diversification by investing in portfolio of gold and majority Asian stock markets during US financial crisis and Chinese stock market crash.

This study finds an insignificant return and volatility spillover from US to Latin American stock markets during US financial crisis. Thus, addition of gold in portfolio of Latin American stocks will reduce the risk of portfolio during US financial crisis. Moreover, the return and volatility transmission is also insignificant from gold to Latin American stock markets (except Mexico) during Chinese stock market crash. It suggest that diversification opportunities are higher in portfolio of gold and majority Latin American stock markets during crisis.

Overall, the volatility spillover results vary during crisis periods, thus portfolio investors needs to adjust their portfolios during crisis period to diversify risk. Therefore, this study estimates the optimal weights and hedge ratios to get maximum benefit of diversification during full sample, US financial crisis, and Chinese stock market crash. The optimal portfolio analysis suggests that investors should increase their asset allocation for Asian stocks in Asia-USA portfolio during US financial crisis. Moreover, investors should decrease their asset allocation in Chinese stocks during Chinese stock markets crash.

For LA-USA portfolio, investors should increase investment in Latin American stock markets during US financial crisis. For LA-China portfolio, investors should decrease their investment in Latin American stocks during Chinese stock market crash. Moreover, investors should increase their asset allocation for most of Asian stocks in Asia-oil portfolio during US financial crisis. For Asia-oil portfolio, investors should also increased the asset allocation for Asian stocks during Chinese stock market crash. Investors should increase their investment in Brazil and Chile stocks for the Brazil-OIL and Chile-OIL portfolios during US financial crisis. For LA-oil portfolio, investors should increase their investment in Latin American stock markets during Chinese stock market crash as compared to the full sample.

These results are helpful in asset allocation decisions of individual and institutional portfolio investors in the world, especially during crisis (originated from US and Chinese markets). These findings are also useful for policymakers of emerging Asian and Latin American economies, especially on how policy makers deal with higher interconnectedness between the stocks, oil-stocks and gold-stock markets during crisis period. The findings of volatility spillover between different financial markets would be of greater interest for policymakers to stabilize the economy and financial markets during different crises. Therefore, policymakers need to design such policies that would safeguard the financial sector from international financial shocks from US and China. They can also predict the impact of financial crises from other markets on their own markets with the help of spillovers between financial markets.

Keywords: Return spillover, Volatility spillover, Emerging stock markets, Oil markets, Gold markets.

Contents

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Abbreviations

ADF	Augmented Dickey Fuller
ARCH	Autoregressive Conditional Heteroskedasticity
ASEAN	Association of Southeast Asian Associations
BEKK	Baba, Engle, Kraft, and Kroner
BRAZ	Brazil
CAPM	Capital Asset Pricing Model
CCC	Constant Conditional Correlation
CHIL	Chile
CHN	China
G5	Group of Five
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
GDP	Gross Domestic Product
IMF	International Monetary Fund
IND	India
INDO	Indonesia
KOR	Korea
LA	Latin America
LAC	Latin American Countries
LAS	Latin American Stock
MENA	Middle East and North African
MEXI	Mexico
MYS	Malaysia
PAK	Pakistan
PERU	Peru

PHL	Philppine
S&P 500	Standard and Poor's 500
TAIW	Taiwan
THA	Thailand
UAE	United Arab Emirates
USA	United States of America

Chapter 1

Introduction

1.1 Introduction

The rapidly increasing economic integration between markets has become vital over the last two and half decades. The increased capital flow between countries and rapid development of technology are the main reasons to this observed globalization. Thus, financial institutions and portfolio managers need to understand the extent and nature of linkages between financial markets (Maghyereh et al., 2017). The linkages between these markets can be analyzed through finding return and the volatility spillover between different financial markets. The volatility transmission is crucial for designing hedging strategies and optimal portfolios. Frank and Hesse (2009) find that emerging markets severely affected after collapse of Lehman Brothers during subprime crisis of 2008.

Normally there is downward (or bearish) trend in stock markets during crisis. Prices move in one direction, either increases or decreases a lot in case of assets like Gold and Oil etc. Gold prices normally increase during crisis period, because it considers as a safe haven during financial crisis (Baur and Lucey, 2010). Therefore, correlation between different asset classes in different markets may differ during financial crisis. Hoffmann et al. (2013) report that perception of investors fluctuates during the time of crisis, with risk perception and risk tolerance being less volatile as compared to the return expectations. Investors risk tolerance and expectation about return decreases during the worst time of crisis (Yousaf et al., 2018). In addition,the perception of investors recovers at the end of crisis. Kim and Wei (2002) state that individual investor show herding behavior more as compared to institutional investors during crisis period. Thus, markets behave differently during crisis period. When one big market faces a financial crisis then the effect of this crisis moves towards the other financial markets which are highly integrated and vice versa. It is valuable to investigate the transmission effect of mean and volatility between assets during financial crisis. Because, investors need to adjust their portfolio assets allocation during crisis accordingly (Bouri, 2015). Moreover, investors want to reduce their risk by investing in assets mix which are uncorrelated or negatively correlated with each other during crisis period (Glick and Hutchison, 2013) . Hence, these financial crisis and stock market crashes affects the mean and spillover between the different markets i.e Stock, Oil and Gold etc. This study focuses on two crises, "Chinese stock market crash" and "US financial crisis of 2008".

The Chinese stock market crashed during 2015 (Han and Liang, 2017). The CSI 300 index has reached up to 5178 points until mid-June of 2015. Then it takes roller-coaster ride and decline up to 34 percent in just 20 days; also losing 1000 points within just one week. After rapid decline, many attempts are made by Chinese authorities to overcome this problem. Around 50 percent of the stocks lost more than half of their pre-crash market value. More than 1000 stock (one third of total stocks) lose 10 percent of their value on average during one in every four trading days from June to September. This is the most dramatic stock market crisis in the history of crashes (Han and Liang, 2017). This stock market crash affects the many other markets of the world as well. When Shanghai stock exchange declines by 8.5% in one day (Black Monday) at start of crisis then Japan based Nikkei index is down by the 4.5%. The Dow index declines by more than one thousand points. At that time, oil prices have hit to six years low. Index based on 22 commodities manage by the Bloomberg are at its lowest since 1999. Even Gold market declines at start of crisis in China. Moreover, emerging markets are also affected by this crisis which are highly dependent upon the Chinese demand for industrial and other commodities. Hence, this study focuses to investigate the spillovers between different classes of assets during Chinese market crash of 2015. It provides the useful insights to investors for better portfolio management during any financial crisis.

The Chinese market crash of 2015 is different from the past crisis like US financial crisis of 2008. In 2015, the global banking system is much better as compared to the banking system during and before US financial crisis. Financial systems is most robust and better managed in 2015 as compared to 2008. Second, the US financial crisis does not only affect the US economy, but it also affects the other economies and stock markets over the globe. Chiang and Wang (2011) investigate changes in volatility transmission mechanism between G7 Countries during US financial crisis. The crisis starts from USA during year of 2007 and then it affects the many countries. Thus, spillover between stock markets can be different during different financial crisis. This study examines the spillovers between different pairs of markets (stock-stock, oil-stock, and gold-stock) during US financial crisis and Chinese Stock Market Crash.

For stock-stock pair of market, this study estimates the spillover from US and China to emerging Asian and emerging Latin American stock(LAS) markets. United states of America (USA) is the world largest economy and its GDP share consists of the 24.32% of the Global GDP. Whereas, China is the second biggest economy of the world and its GPD consists of the 14.84% of the Global GDP in 2017(World Development Indicators Database, World Bank, 2017). The growth of Chinese economy is tremendous in 21st century. In 2016, GDP growth rate of China is 6.7% which is much more than US having GDP growth of 1.6%, according to IMF. Moreover, Chinese economy is growing at faster pace as compared to US in 21st century. Therefore, spillover can also be different from US and China to other emerging economies because the two largest economies are growing at different rate.

Moreover, the trade volume of US and China with emerging Latin American and Asian markets were also grew at different rate in last two decades. The Chinese trade with emerging Latin American and Asian economies is reported in Table

1.1 from 2001 to 2017. It reveals that the Chinese trade volume is increased in multiple folds with emerging Latin American and Asian stock markets during last two decades. Apart from the countries trade data, the total trade volume between the China and Latin American region is around $216 Billion in 2016. The trade volume of China with Latin American region in 2016 is 16 times higher than the trade volume in 2000. China has become the largest trading partner of many Latin American markets. Therefore, when trade between different countries and regions increases then spillover also changes between these markets.

Moreover, the US trade with emerging Latin American and Asian economies is provided in Table 1.2 from 2001 to 2017. It shows that US is also the important trading partner of emerging Latin American and Asian economies, because US trade is also increased with emerging Asian and Latin American economies in last two decades. Thus, Spillover from US to emerging Asian and Latin American stock markets, and from China to emerging Latin American and Asian stock markets can be different because the economic integration is rapidly changing between these countries, trade of china with emerging markets is increasing at different rate as compared to US. It is important to examine the spillovers from the stock markets of USA and China to emerging Latin American and Asian stock markets. In following sub sections, this study discusses the linkages between the pairs of stock-stock, oil-stock and gold-stock markets.

1.1.1 Spillover between Stock Markets

The emerging markets become more important to investigate (Phylaktis and Ravazzolo, 2005), because integration between developed and emerging stock markets has an implication for developed and emerging countries investors. If there is a weak interaction between emerging financial markets and developed financial markets, external shocks from developed countries might have minor effect on emerging markets, thus investors of developed markets can get benefit by adding the stocks of emerging markets in their portfolio, as this type of diversification can reduce risk. On the other hand, if there is a strong integration between emerging financial markets and developed financial markets, volatility of emerging market is determined by the developed financial markets, and then domestic investors of emerging markets get benefit from the low cost of capital (Li, 2007).

TABLE 1.1: Import and export of China with Asian and Latin American Markets (US$ Million).

Country	Partner	Trade	2001	2005	2009	2013	2017
CHN	India	Import	1699	9766	13714	16970	16345
CHN	India	Export	1896	8934	29667	48432	68042
CHN	Indonesia	Import	3888	8437	13664	31424	28574
CHN	Indonesia	Export	2836	8350	14721	36930	34757
CHN	S,Korea	Import	23377	76820	102552	183073	177553
CHN	S,Korea	Export	12519	35108	53680	91165	102704
CHN	Malaysia	Import	6204	20093	32331	60153	54426
CHN	Malaysia	Export	3221	10606	19632	45931	41712
CHN	Pakistan	Import	582	833	1260	3197	1833
CHN	Pakistan	Export	815	3428	5515	11020	18251
CHN	Philippines	Import	1945	12870	11947	18182	19239
CHN	Philippines	Export	1619	4688	8585	19868	32066
CHN	Thailand	Import	4714	13992	24897	38523	41596
CHN	Thailand	Export	2337	7819	13307	32718	38542
CHN	Brazil	Import	2347	9993	28281	54299	58857
CHN	Brazil	Export	1351	4827	14119	35895	28951
CHN	Chile	Import	1303	4992	12791	20708	21176
CHN	Chile	Export	815	2149	4928	13105	14410
CHN	Mexico	Import	761	2225	3882	10238	11803
CHN	Mexico	Export	1790	5538	12299	28966	35905
CHN	Peru	Import	498	2278	4324	8408	13367
CHN	Peru	Export	177	609	2099	6189	6959

Source: https://wits.worldbank.org/

The stock market crisis of USA in 1987 and exchange rate mechanism crisis of Europe in 1992 has arised the need of empirical analysis of shocks transmission between mature financial markets. Whereas, the crisis of 1990s in Asia leads to

Table 1.2: Import and export of US with Asian and Latin American Markets (US$ Million).

Country	Partner	Trade	2001	2005	2009	2013	2017
USA	India	Import	9,737	19,873	22,043	41,808	50,573
USA	India	Export	3,757	7,919	16,462	21,811	25,689
USA.	Indonesia	Import	10,104	12,945	13,651	18,874	21,152
USA	Indonesia	Export	2,520	3,054	5,106	9,097	6,864
USA	S,Korea	Import	35,181	45,525	40,544	62,432	73,449
USA	S,Korea	Export	22,181	27,572	28,640	41,686	48,326
USA	Malaysia	Import	22,340	34,658	23,888	27,289	38,126
USA	Malaysia	Export	9,358	10,461	10,401	13,004	12,964
USA	Pakistan	Import	2,249	3,493	3,361	3,688	3,763
USA	Pakistan	Export	541	1,252	1,625	1,646	2,808
USA	Philippines	Import	11,325	9,696	7,061	9,269	11,961
USA	Philippines	Export	7,660	6,895	5,773	8,404	8,451
USA	Thailand	Import	14,727	21,033	19,864	26,169	32,255
USA	Thailand	Export	5,989	7,257	6,920	11,797	10,991
USA	Brazil	Import	14,466	26,217	21,018	27,631	30,553
USA	Brazil	Export	15,879	15,372	26,175	44,093	37,221
USA	Chile	Import	3,495	7,444	6,620	10,384	11,296
USA	Chile	Export	3,118	5,134	9,365	17,518	13,605
USA	Mexico	Import	131,335	172,389	178,322	280,539	317,207
USA	Mexico	Export	101,295	120,247	128,998	226,070	243,314
USA	Peru	Import	1,844	5,394	4,412	8,127	7,627
USA	Peru	Export	1,564	2,309	4,925	10,119	8,663

Source: https://wits.worldbank.org/

the need of empirical analysis of contagion between emerging markets. There was large impact of these crises, thus contagion turn out to be different during turbulence in emerging financial markets. Moreover, many studies are conducted concerning different contagion channels during these crisis (Karolyi, 2003). Chiang and Wang (2011) investigate changes in volatility transmission mechanism between

G7 Countries during US financial crisis, and find that spillover between stock markets can be different during financial crisis.

In past, the empirical analyses of spillover effect in emerging markets have understandably focused on the volatility transmission initiating from developed or mature markets, rather than focusing on spillover from major emerging financial market to other emerging financial markets. This study analyzes the return and volatility transmission across financial markets during two major episodes of crisis; US financial crisis and China stock market crash. These two episodes of turbulence in advanced and emerging economies' equity markets in the first two decade of this century, propose that this can be an important research gap in empirical financial literature to study the spillover effect from China and USA to other emerging Asian and Latin American stock markets during both crises.

1.1.2 Spillover between Oil and Stock Markets

The interaction between the crude oil and stock markets is important for portfolio diversification and energy policy planning. Further, the volatility transmission between the oil and stock markets provides the understanding to design most appropriate models of risk premiums and stock valuation. Besides, the conditional volatility estimates are used in portfolio optimization, option pricing and the optimal hedging. There is an empirical evidence of association between the oil and stock prices. The change in oil prices and macroeconomic growth affect the corporate discount rates and cash flows (Apergis and Miller, 2009). When oil price increases then markets take it as negative signal and ultimately equity prices fall. Therefore, it indicates that oil and stock returns are inversely associated with each other. On the contrary, both oil prices and stock prices are likely to increase during the economic expansion. The rationale behind the association between oil and stock prices is that the value of stock is always equal to the present value of the expected future cash flows. The cash flows are also affected by the change in oil prices and due to change in economic indicators. Thus, oil price may affect the stock prices.

The spillover between oil and stock market can be different during financial crisis or Stock market crash. Liu et al. (2017) examines the mean and the volatility spillover between the oil and stock market returns during three-time phases 'before, during and after crisis period'. The results show the weakening association between oil and USA stock market in the long term, while association between oil and Russian equity market is strengthening in all time scales. Moreover, Russian stock index and US stock index shows the opposite trend of falling oil prices in post crisis period. Therefore, this study estimates the spillover from oil to Stock markets of Asia and Latin America during US financial crisis and Chinese crash.

1.1.3 Spillover between Gold and Stock Markets

The past studies of gold markets have regained the attention from the finance practitioners and researchers. This trend is explained by willingness of investors to invest in gold markets during crisis. Investors focus on diversified portfolio of stocks and other class of assets like gold to diversify risk during the time of turbulence. Gold is the good asset to make portfolio with stocks, because gold has different volatilities and returns and have lower correlation with stocks (Daskalaki and Skiadopoulos, 2011). The spillover between the gold and stock market is important for risk management, portfolio design and asset pricing. Baur and Lucey (2010) find that gold asset uses as the safe haven for the stocks in UK, Germany and the US, particularly after the extreme negative shocks in stock markets. In UK and US, Gold is a good hedge for the stocks.

Moreover, stock prices fall abruptly during financial or stock market crisis, then demand of gold increases and ultimately gold prices becomes higher. This study estimates the spillover from Gold market to Asian and Latin American emerging equity markets in the US financial crisis and the Chinese crash. This study is important to accurately forecast the spillover between both markets and to build accurate stock valuation models.

1.2 Problem Statement

The rise in globalization has increased the cross border financial flows and interdependency between the world's financial markets (Balios and Xanthakis, 2003). In case of integration between domestic and international markets, the domestic markets depend upon the information flows from the international markets. The shocks of international markets promptly transmit to the domestic markets in highly integrated markets, and ultimately the diversification benefits become lower for the investors, and vice versa. To get maximum benefit of diversification, investors need to identify those markets which are not/weakly intergated with each other.

Besides the benefits of financial globalization, there is also a huge risk of financial globalization during crisis. The crisis in big international market affects the other financial markets (stock, oil, gold). Moreover, the integration between markets may also vary during crisis period. Several studies find that integration between markets become different during crisis period (Taşdemir and Yalama (2014); Ajmi et al. (2014); Li and Giles (2015); Golosnoy et al. (2015)). Thus, portfolio managers need to adjust their asset allocation between different financial markets during crisis period, and policy makers need to take appropriate actions for smooth functioning of domestic financial market and economy during crisis. "How much portfolio asset allocation should be change to diversify portfolio during crisis" is the main issue for portfolio managers. Therefore, it is needed to investigate the linkages between international and domestic markets during normal (full sample) and crisis periods. Moreover, it is also needed for investors to calculate the optimal weights of portfolios during crisis and full sample period to get maximum benefit of diversification.

1.3 Research Questions

These are the four main questions of the study that are needed to be examined empirically.

- Do return and volatility transmit from the China, and USA to emerging Asian (India, Korea, Indonesia, Pakistan, Malaysia, Philippine, Thailand and Taiwan) and Latin American stock markets during different periods?
- Whether return and risk transmission exist from the world oil markets to the emerging (Asian and Latin American) stock markets during different periods or not?
- Whether return and risk transmit from the world Gold markets to emerging (Asian and Latin American) stock markets during different periods?
- How can investors manage the portfolio (stock-stock, oil-stock, and gold-stock) risk during crisis periods?

1.4 Objective of the Study

The study aims to examine the mean and the volatility spillover between different markets (Stock, Oil and Gold) during US financial crisis and Chinese stock market crash. It also computes the optimal weights and hedge ratios for different portfolios to diversify risk during US financial crisis and Chinese stock market crash. Following are the specific objectives of the study:

- To examine the spillover from USA and China to Asian and Latin American stock markets.
- To estimate the spillover from USA to Asian and Latin American Stock markets during US financial crisis.
- To investigate the spillover from China to Asian and Latin American Markets during Chinese stock market crash.
- To explore the spillover from Oil to Asian and Latin American Stock markets.
- To examine the spillover from Oil to Asian and Latin American markets during US financial crisis and Chinese stock market crash.

- To investigate the spillover from Gold to Asian and Latin American Stock markets.
- To estimate the spillover from Gold to Asian and Latin American markets during US financial crisis and Chinese stock market crash.
- To calculate the optimal weights and hedge ratios for different pairs of portfolios during full sample period, US financial crisis, and Chinese stock market crash.

1.5 Contribution of Study

The analysis of spillover between markets is crucial for investors because international portfolio diversification is also dependent upon the spillover between the international markets. According to modern portfolio theory, the gains of international portfolio diversification reduces when the correlation of security returns increases and vice versa. Michaud et al. (1996) discuss the advantages of low correlation between the developed and emerging markets with respect to international portfolio diversification. Thus, investors can get benefit by investing in emerging markets which are weakly interconnected with developed markets. Therefore, spillover between markets is the important area of study.

This analysis is different from the prevailing studies in six aspects. First, this study examines the mean and the volatility spillover from china and USA to other Asian and Latin American Countries instead of just USA to Asian and Latin American markets. Previous studies focus on examining the impact of US market on other markets, whereas this study also examines the impact of Chinese stock market on other markets. Second, this study measures the return and volatility transmission from China to Asian and Latin American stock markets during the period of Chinese crash. Third, this study estimates the spillovers from oil to stock markets during both crises (US financial crisis and Chinese crash). Fourth, this study estimates the spillovers from Gold to stock markets during both crises. The area of "spillovers during Chinese stock market crash" is not explored in literature. Therefore, it is the main uniqueness of this study. Fifth, this study investigates the spillover during long run periods (on full sample period) as well as short run periods (US financial crisis and Chinese crash). Lastly, this study provides the insights to investors about "How to optimally change the portfolio assets allocation during crises periods" and "How to hedge the risk of portfolio during crisis period".

This study is be useful for researchers, investors (individual and institutional) and policy makers of the economy. Investors need to make appropriate portfolios and this study is helpful for the portfolio managers in asset allocation and portfolio risk management in crisis period (short run) and long run period. This study is also useful for policy makers to take decision regarding sustainability of financial markets during financial crisis.

1.6 Organization of the Study

This study examines the spillover between different markets during crises. This paper has been structured as follows: Section 1 consists of introduction. Section 2 provides the Theoretical background and Section 3 provides the overview of existing literature on the subject. Section 4 describes the data and methodology used during empirical work. Section 5 consists of the empirical findings of the study. Finally, Section 6 briefly conclude the whole discussion.

Chapter 2

Theoretical Background and Literature Review

2.1 Theoretical Background

Two theories are used to explain the theoretical linkages between the pairs of stock-stock, oil-stock and gold-stock markets. The oil and stock market link can be explained through both economic and international diversification theories. Whereas the theoretical link between the market pairs of stock-stock and gold-stock can be explained through the theory of "international portfolio diversification theory". In following sub-sections, both theories are explained in detail.

2.1.1 Oil and Stock Nexus - Economic Theory

The link between the oil and stock returns can be established by using different channels, the most recommended one concerns the financial channel (Kilian and Park, 2009). This channel is built upon the idea of discounted cash flow method. According to this method, the stock value is equal to the present value of future cash flows at different investment horizons. According to this channel, high oil prices leads towards the increase in cost of production, and ultimately net income (or earnings) of company decreases due high cost of production. At the same time, level of inflation becomes high due to high oil prices; and ultimately discount rates and interest become high. Consequently, either high discount rate or low expected earning leads towards the lower stock prices.

Another channel explains about the association between oil and equity prices through consumers. When international oil prices increase then domestic oil prices also increase. Ultimately consumers spend more money on gasoline and consumers left with less to consume on other goods. After that, consumer's aggregate demand decreases because of having less amount to consume on other goods. Due to low demand/sales, corporate earning decreases as well.

Crude oil is the influential commodity which effects the financial markets and real economy. Oil prices shocks negatively effects the macro economy (Hamilton, 1983). When crude oil prices increase then it effects the firm's cash flows (negatively or positively but depend upon its oil dependence) and discount factor of cash flows (linked with the influence of international oil prices on the macro economy, particularly interest rates, inflation and monetary policy).

Hence, corporate earnings decrease due to two reasons (1) due to decrease in sales (demand) and (2) due to increase in production cost because oil uses as the input for companies. Finally, stock prices are affected due to decrease in corporate earnings.

Investors tried to adjust/change the portfolio asset allocation to make portfolios better resistant to crisis or turmoil periods (Bouri et al., 2013). Therefore, the transmission effect from the international oil prices to equity market during crises is very important for investors. Several crises were already studied, but the spillovers during Chinese crisis is also important to study.

2.1.2 Stock Market to Stock Market Nexus - International Portfolio Diversification Theory

The analysis of transmissions between markets is crucial for investors because international portfolio diversification is also dependent upon the spillover between the international markets. According to modern portfolio theory, the gains of international portfolio diversification reduces when the correlation of security returns increases and vice versa. Michaud et al. (1996) discuss the advantages of low correlation between the emerging and developed markets for international portfolio diversification. Thus, investors can get benefit by investing in emerging markets which are weakly interconnected with developed markets. If there is strong spillover from one market to another, then diversification benefits are reduced by making portfolio comprises on sectors of these countries.

This international portfolio theory explains about the theoretical linkage between the different stock markets. When investors make portfolio of different stock of different countries then they choose such stocks from different countries which are negatively correlated or uncorrelated with each other for diversification to reduce their risk. That's how there is a link between the stocks of different countries. The extreme time moments like crisis or turmoil period is also very important because the link between different stock markets changes during the crisis period, therefore investors are always curious about the return and volatility spillover from one market to another stock market during crisis.

2.1.3 Gold to Stock market Nexis - International Portfolio Diversification Theory

Portfolio can consist of the combination of gold and international stock markets. According to international portfolio theory, investors need assets which are uncorrelated or negatively correlated with each other to reduce risk through diversification. Thus, diversification benefit is higher for portfolio investors, when gold and stock markets are negatively correlated or uncorrelated with each other.

The negative and uncorrelated association between gold and stock markets is also important during crisis. Because Gold is generally considered safe haven asset from ancient periods and gold is even valuable during war, recession, or crisis period. "Safe Haven" is define as the asset which don't loses its value during market crash. When stock market goes down during crisis then investors invest more in Gold, because this is safe investment at that time. That's how Gold and stock markets link can also explained through 'safe haven' characteristics of gold during crisis.

Several studies are also evident of negative association between the gold and stock markets. Baur and Lucey (2010) find that gold market normally considers as a safe haven for stock markets during crisis. Kumar (2014) investigates the mean and volatility transmissions between stock and Gold market and finds a negative association between Gold and Stock markets especially during crisis or recession. Investors make portfolio of Gold and stocks, when these markets don't co-move in same direction to diversify risk. Therefore, gold and stock link can be explained through 'diversification' and 'safe haven' characteristics. This study investigates the transmission effect from Gold to stock market during crisis and non-crisis periods.

2.2 Literature Review

2.2.1 Spillover between Stock Markets

Several studies have investigated the association between different stock markets during the last four decades. Neal (1987) finds that London and Amsterdam stock markets are well-integrated from the second quarter of eighteen century. Eun and Shim (1989) investigate the transmission between stock markets of Japan, Australia, France, Hong Kong, Germany, Switzerland, UK, Canada, and USA during 1979 to 1985. It finds that integration between all these stock markets are found to be significant. The results of both above-mentioned studies are different regarding the integration between US, Germany, Japan, and UK stock markets, suggesting a time varying integration in equity markets.

Hamao et al. (1990) examine the interdependence between Japan, UK, and USA stock markets. It finds a significant volatility spillover from UK to Japan, US to Japan, and US to UK stock market for the pre-October 1987 period. Mathur and Subrahmanyam (1990) investigate the interdependencies between USA and Nordic stock markets during 1974 to 1985. The causal association from US to

Danish stock market is evident, but not to the Finish, Norwegian or Swedish stock markets.

Cheung and Mak (1992) estimate the causal links among USA , Japan and Asia Pacific stock markets during 1977-1988. It provides an evidence of the significant and dominant impact of USA on Asia Pacific stock markets as compared to the impact of Japan on Asia pacific. Theodossiou and Lee (1993) investigate the mean and volatility transmission between stock markets of USA, Japan, UK, Germany, and Canada. It finds a positive mean transmission from the US to Germany, UK and Canada, whereas negative return spillover from Japan to German stock market. Moreover, volatility is transmitted from the US to all four stock markets, from Germany to Japan, and from UK to Canada stock markets.

Palac-McMiken (1997) examines the association stock markets of ASEAN stock markets (Malaysia, Philippine, Thailand, Indonesia, and Singapore) by using data from 1987 to 1995. It finds a significant link between ASEAN stock markets except for Indonesia. Booth et al. (1997) look at the return and the risk transmission between the Norwegian, Swedish, Danish and Finnish stock markets. This study finds that the spillover effect is asymmetric and spillover being more pronounced for bad news as compared to the good news. Furthermore, there is a presence of spillover between these markets.

Janakiramanan and Lamba (1998) investigate the associations between developed (Australia, Singapore, Hong Kong, Japan, US, the New Zealand) and the developing stock markets (Thailand, Indonesia, and Malaysia) during 1988 to 1996. It finds a significant affect of US on other stock markets except Indonesia. Wu and Su (1998) examine the association between stock markets of US, Hong Kong, Japan and UK during 1982 to 1991. It finds that the association between these markets become stronger after the 1987 market crash. It suggests that financial crises may influence the integration between markets.

Liu et al. (1998) estimate the return transmission between stock markets of US, Singapore, Hong Kong, Japan, Taiwan, and Thailand during 1985-1990. It finds that US significantly influences the five Asia Pacific markets, and return transmission between stock markets becomes stronger after 1987 market crash. Christofi and Pericli (1999) estimate the mean and volatility transmission between stock markets of Latin America (Brazil, Chile, Colombia, Argentina, and Mexico). It finds a significant return and volatility transmission between these Latin American stock markets. Moreover, the volatility transmission is stronger as compared to the return spillover effect in these markets. Masih and Masih (1999) examine the interdependencies between US, UK, OECD, and emerging Asian markets. It finds a significant impact of US and UK on OECD and emerging Asian stock markets.

Ng (2000) compares the volatility transmission from the equity markets of USA and Japan to the Pacific Basin. It finds a significant volatility transmission from the stock markets of US (global) and Japan (regional) to Pacific Basin and reports the strong impact of US on Pacific Basin markets as compared to the impact of Japan. Darrat et al. (2000) examine the global and regional integration of three Middle East stock markets. It reports a significant influence of US on Middle East stock markets. Huang et al. (2000) investigate the link between US, South China, and Japan growth triangle during 1992-1997. The return of US market significantly and dominantly influences the south Chinese growth triangle as compared to the influence of Japan on Chinese stock market. The return transmission is significant from US to Taiwan and Hong Kong, and from Hong Kong to Taiwan stock market.

In et al. (2001) study the interdependence between the Korea, Hong Kong and Thailand stock markets in Asian financial crises of 1997-1998. This study finds a bidirectional volatility transmission between Korea and Hong Kong, and unidirectional from Korea to Thailand in Asian crises. Overall, these three markets are highly integrated during crises. Scheicher (2001) finds a limited integration between Poland, Hungary, and Czech Republic stock markets. Chen et al., (2002) investigate the spillover between Brazil, Mexico, Venezuela, Columbia, Chile and Argentina stock markets from 1995 to 2000. It finds an insignificant volatility spillover between Latin American stock markets. Moreover, the dependencies between Latin American stock markets are not found different during the dramatic shortfall between 1997-1998.

Yang et al. (2003) investigate the long and short run relationship between USA, Japan and ten Asian equity markets particularly focusing on financial crisis of Asia during 1997-1998. This study reports a strengthen long run co-integration among these stock markets during Asian financial crises period. Post-crises integration is higher than the Pre-crises integration between equity markets. The degree of integration is found to be changed during all crises and non-crises periods. Miyakoshi (2003) estimates the mean and volatility transmission between the stock markets of US, Japan, and Asia (Thailand, Korea, Indonesia, Singapore, Taiwan,and Hong Kong) from 1998 to 2000. The return spillover is found to be significant from US to Asian markets, whereas no return spillover is found from Japanese to Asian markets. Moreover, volatility transmission from Japan to Asian stock markets is evident to be dominant as compared to the volatility transmission from USA to Asian markets.

Balasubramanyan (2004) estimate the volatility transmission between US, UK, and Japan. It finds a significant volatility transmission between the stock markets of US, UK, and Japan. Choudhry (2004) examines the risk and return transmission between the stock markets of friends and foe countries. In foe countries, the return and volatility spillovers are found to be significant. The return spillover is dominant from the small to large stock markets, while volatility transmission is found from large markets to small markets. In friendly countries, the mean and volatility transmissions are also evident between the US and other six stock markets. Moreover, the returns spillover is significant from US to other six stock markets, but six stock markets are not significantly impacted the US stock market.

Shik Lee (2004) examines the spillover between US and Korea stock market and find a significant unidirectional spillover from US to Korean stock market. Kim (2005) reports a significant spillover from US to Asia pacific stock markets, whereas the spillover effect from Japan to Asia Pacific stock markets is found to be relatively weaker than US. Sharkasi et al. (2005) estimate the spillover between US, Brazil, Hong Kong, Japan, UK and Irish and Portugal stock markets. This study finds an intra-Asian and intra-European co-movements of stock markets. Moreover, comovements between stock markets of the US and Brazil are also found significant. Egert and Kocenda (2005) examine the link between the central and eastern European countries' stock markets. It reports a significant return and volatility transmission between European stock markets.

Hiang Liow et al. (2005) estimate the short and long run linkages between the property stock market of four European markets (Germany, France, UK, Italy), four Asian stock markets (Japan, Singapore, Hong Kong, and Malaysia). This study reports a weak return transmission, whereas insignificant volatility spillover between property stock markets.

Chancharoenchai and Dibooglu (2006) estimate the volatility transmission between emerging stock markets of south Asia during Asian crisis of 1997. It finds a significant volatility spillover from Thailand to Malaysia and Korea; Philippine to Thailand, Taiwan, and Korea; Taiwan to Indonesia and Philippine stock markets during 1997 Asian crisis period.

Al-Deehani and Moosa (2006) examine the spillover between three stock markets of Saudi Arabia, Bahrain and Kuwait. First, it finds that Kuwait market transmits strong volatility effect in Bahrain and Saudi Arabia. Second, Saudi Arabia transmits a volatility effect to the Kuwait stock market. Third, Bahrain stock market significantly transmits a positive volatility effect on the Kuwait stock market. Égert and Kočenda (2007) estimate the short run spillover between the western and eastern European stock markets from 2003 to 2005. It finds a significant return and volatility transmission between the western and eastern European stock markets.

Qiao et al. (2008) find that China and Hong stock markets are fractionally integrated. Johansson and Ljungwall (2009) analyse the association between China, Thailand, and Hong Kong stock markets by using data from 1994 to 2005. It finds a significant return spillover from Taiwan to Hong Kong, and China stock market, whereas volatility effect run from Hong Kong to Taiwan and Taiwan to China stock market. Li and Majerowska (2008) examine the volatility transmission between Poland, Hungary, Germany, and US stock markets. It finds that volatility transmission run from stock markets of developed countries to emerging countries.

Yu and Hassan (2008) estimate the volatility spillover between US and MENA markets, and find a significant influence of US on MENA stock markets. Koulakiotis et al. (2009) estimate volatility spillover between Scandinaviaan, German and French stock markets during 1987 to 2006. It finds an insignificant bidirectional volatility transmission accross these three European markets. Hammoudeh et al. (2009) investigate the shock and volatility transmission across three sectors of Saudi Arabia, UAE, Qatar, and Kuwait stock markets. It finds that not past own-shocks, but past own-volatility significantly impact the current conditional volatility of four gulf stock markets.

Nath Mukherjee and Mishra (2010) estimate the integration and volatility transmission between India and its 12 Asian counterparts during 1997 to 2008. First, it finds a bidirectional return transmission between India and majority Asian counterparts stock markets. Second, the majority Asian markets strongly transmit the volatility effect to the Indian stock market. Third, India stock market significantly influences the Pakistan and Sri Lanka stock market. Nishimura and Men (2010) investigate the risk spillover between the stock markets of China and G5 countries from 2004 to 2007. It finds a significant short run risk transmission from China to US, UK, French and German stock markets.

Singh et al. (2010) analyse the spillover between 15 Asian, European and North American stock markets during 2000 to 2008. This study reports a significant return and volatility transmission from US to Japan and Taiwan to Hong Kong and Korea to Singapore and Hong Kong to Europe and Europe to US stock market. Yilmaz (2010) investigate the return and risk transmission between 10 east Asian markets of Indonesia, Japan, Hong Kong, Malaysia, Korea, Singapore, Philippine, Australia, Thailand, and Taiwan from 1992 to 2009. It finds that return and volatility spillovers are different between stock markets during the periods of crisis and non-crisis.

Beirne et al. (2010) estimate the spillovers from global and regional to local stock markets. It uses 41 markets from the regions of Latin America, Europe, Asia, and

Middle East. It finds a significant spillover from global and regional to the majority local stock markets. However, these linkages vary across regions and countries. Moreover, return spillover is dominant in Latin American and Asian region, whereas volatility spillover is dominant in European region. Regional spillover is found to be dominant in Latin American and Middle East, whereas global spillover is found to be dominant in Asia.

Moon and Yu (2010) estimate the risk spillover between US and China stock markets from 1999 to 2007. After the structural break of December 2005, asymmetric and symmetric volatility spillover is significant from US to Chinese equity market, whereas the asymmetric volatility effect is also run from China to US stock market. Abou-Zaid (2011) investigates the volatility spillover from US and UK to the MENA (Turkey, Israel, and Egypt) stock markets during US financial crisis of 2008. It finds that US significantly transmits the volatility effect to the Israel and Egypt stock markets during US financial crises of 2008.

Joshi (2011) examines the mean and volatility transmission between six Asian stock markets (China, Korea, Hong Kong, India, Indonesia, and Japan). It finds a bidirectional mean and volatility spillover between majority pairs of stock markets. Sakthivel et al. (2012) empirically estimate the volatility spillover between five stock markets of US, India, UK, Australia, and Japan. It provides evidence of bi-directional volatility spillover between US stock and Indian stock markets. Moreover, volatility also transmitted from stock markets of UK and Japan to India.

Korkmaz et al. (2012) examine the causal link between the Indonesia, Columbia, Egypt, Vietnam, South Africa and Turkey stock markets. It provides an evidence causal link between 10 pairs out of 30 pairs of stock markets. Moreover, inter-regional and intra-regional spillover effects are also observed. Zhou et al. (2012) estimate the spillover between Chinese and international (US, France, UK, Germany, Hong Kong, Japan, India, Taiwan, Korea, and Singapore) stock markets from 1996 to 2009. Before 2005, Chinese stock markets are affected by the spillover from other international markets. After 2005, volatility spillover is significantly transmitted from China to majority other international stock markets.

Li and Zhang (2013) analyse the risk spillover between the US and Chinese stock markets and find no risk transmission between both markets. Moreover, US returns significantly influence the returns of the Chinese equity market. Beirne et al. (2013) examine the mean and volatility transmission from developed to emerging stock markets during turbulence in mature stock markets. It reports that volatility in mature markets affects the conditional variances in emerging stock markets. Moreover, the spillover effect from developed to emerging markets is also changed during time of turbulence in mature markets. In most of emerging markets, the conditional correlation between mature and local markets increases during the time of turbulence. Further, conditional variance also increases in local markets during turbulence episode.

Sugimoto et al. (2014) examine the global, regional, commodity, exchange rate spillover effect on the African counties during European debt crisis and the US subprime crisis of 2008. The study finds that the spillover effect from the global market to African financial markets is significant. And regional spillover effect to African countries is weaker as compared to Global markets. So, the Global crisis affects a lot to the African financial markets. Further, spillover from European markets to African markets is stronger as compared to the effect from US to African Markets. Majdoub and Mansour (2014) test the volatility transmission between US stock market and sharia-compliant Islamic equity markets (Pakistan, Malaysia, Qatar, Indonesia, and Turkey). This study reports an insignificant spillover from US to sharia compliant markets.

Tsai (2014) investigates the spillover effect between the US,France, UK, Japan, and Germany. It estimates the spillover indices of these major stock markets; and finds that transmission of information is significantly increased after 1998. Germany mainly influences the UK stock markets and US largely effects the other stock markets. The net spillover of US stock market is exceeded zero during three periods: before 1997, from 2000 to 2002 (the dot com bubble) and during subprime crisis from 2007-2008.

Taşdemir and Yalama (2014) investigate the spillover effect between Brazil and Turkey. The results reveal that there is a presence of spillover effect from stock market of Brazil to Turkey. Moreover, the spillover effect also exists from Turkey to Brazil during financial crises. Jin (2015) examines the mean and the volatility transmission among China, Taiwan, and Hong Kong. The study finds that financial crises have a large and positive effect on expected conditional variances, but the size and dynamics of influence vary from market to market.

Hwang (2014) provide the evidence of stronger connection between US and Latin American markets in US financial crisis of 2008. Alotaibi and Mishra (2015) investigate the mean spillover effect from US and Saudi Arabia to GCC (UAE, Qatar, Kuwait, Oman and Bahrain) stock markets. The study finds that the return spillover effect from US and Saudi Arabia to GCC stock markets.

Natarajan et al. (2014) examines the spillover between Australia, US, Brazil, Germany, and Hong Kong stock markets from 2001 to 2011. The return spillover is significant from US to Australia and Germany stock markets. Moreover, volatility spillover is significant between US, Australia, and Germany stock markets. Dungey and Gajurel (2014) investigates the stock market contagion between the emerging and advanced countries. This study reports a strong equity contagion between emerging and advanced equity markets. Overall, there is an existence of a significant contagion effect from US to the emerging and advanced country equity market.

Li and Giles (2015) investigate the volatility transmission across the US, Japan and four Asian developing economies such as India, China, Malaysia, Indonesia, Thailand, and Philippines. The result reveals that there is a presence of volatility spillover effect from USA to Asian developing economies and Japan. This study also finds a bidirectional volatility spillover effect between USA, Japan and Asian Developing economies during financial Crisis.

Syriopoulos et al. (2015) analyse the mean and volatility spillover across US and BRICS economies. This study finds that a significant return and risk transmission is existed accross US and BRICS stock markets as well as in the business sector. Kim et al. (2015) investigate the volatility transmission effect from US to the five emerging Asian equity markets during the US financial crisis of 2008. The findings show a significant volatility spillover between the US and Asian equity markets. Liow (2015) investigate the volatility transmission mechanism among the seven asset classes (Stock, public real estate, bond, currency, and money) by using domestic as well as international market data from G7 countries. The volatility spillover is evident in general equity portfolios.

Golosnoy et al. (2015) estimate the spillover effect between stock markets of US, Japan, and German Stock markets during the financial crisis of 2008. This study finds that there is an existence of volatility transmission from one stock market to the next trading market in short run, and this spillover effect becomes more strengthened during financial crisis. Hence, global volatility contagion comes from US stock market during subprime crisis. Before crisis, this study is observed a strong volatility contagion come to and from Japanese stock market. So, volatility contagion is different during crisis or turmoil of crisis news.

Mensi et al. (2016) estimate the spillover effect among USA and emerging stock markets of BRICS during global financial crisis of 2008. The results show that strong dynamic correlation exist between US and BRICS emerging stock markets. Further, the study finds that the global financial crisis strongly affects the four economies of Brazil, Indian, China and South Africa.

Baruník et al. (2016) examine the spillover between most liquid stocks from seven sectors of US. This study also quantifies the asymmetry of volatility and this asymmetry exists due to the bad and good volatility. The study finds that the magnitude of bad and good volatility transmission is different between different sectors. Further, positive spillover dominates as compared to negative spillovers between different stocks. Moreover, the interconnectivity of US stocks significantly increased during a financial crisis.

Rejeb and Arfaoui (2016) find a significant presence of volatility spillover between US and LAS markets. Moreover, the structure of interdependence is asymmetric for both Latin American and Asian stock markets. Yarovaya and Lau (2016) analyze the co-movements of equity markets during the financial crisis. The study reports a presence of higher conditional correlation between the stock markets when it is compelled by negative shocks to the financial market. Abbas et al. (2013) investigate the volatility spillover between regional equity markets to India, China, Pakistan, and Sri Lanka. This study also chooses some countries of USA, UK, Japan, and Singapore for spillover analysis. These results reveal a significant presence of volatility spillover between friendly countries of different regions.

Kumar and Kamaiah (2017) examine the mean and the volatility transmission across Asian equity markets including India, Japan, Hong Kong, Amman, Korea, and Singapore. The study finds a significant integration among markets in long run. Moreover, the spillover effect across these markets is relatively low at the high frequency, so the possibility of diversification is existed at daily to intraweek scale. Gamba-Santamaria et al. (2017) empirically estimate the risk spillover between stock markets of USA and Latin America, especially during US financial crisis of 2008. This study finds a significant volatility transmission from Brazil to Columbia, Chile, and Mexico stock markets. Moreover, the shock spillover becomes strong from US to LA stock markets during the International financial crisis. Chow (2017) estimates the volatility transmission across US and Asian stock markets. It finds a dominant volatility spillover effect from US to Asian markets as compared to the effect from China and Japan to Asian equity markets.

Mensi et al. (2018) estimate spillover between global, regional and GIPSI (Greek, Ireland, Portugal, Spain, and Italy) equity markets during the US financial crisis. It finds that regional Europe, Ireland, Portugal, Spain and Italy are significantly transmitted the shock spillover to other stock markets. Moreover, volatility spillover among pairs becomes intensified during global financial crisis. Ji et al. (2018) empirically estimate the risk spillover between stock markets of US and G7 countries. It finds a larger magnitude of risk transmission from G7 to US as compared to the risk transmission from stock markets of US to G7 countries. Wang et al. (2018) examine the volatility transmission from US to International (Japan, Germany, France, UK, and Canada) stock markets during 1991 to 2015. It finds a significant risk transmission from US to five international stock markets.Lien et al. (2018) examine the risk transmission across US and eight east Asian equity markets during Asian currency crisis, and US subprime crisis. It finds a significant risk spillover from US to Asian markets during both crises.

Joyo and Lefen (2019) investigate the integration among stock markets of Pakistan and its trading partners (China, Indonesia, Malaysia, UK, and US) from 2005 to 2018. It finds that Pakistani stock market is strongly integrated with other trading partner's stock markets during global financial crisis, whereas this integration becomes weaker after the global financial crisis. Hung (2019) empirically estimates the return and risk transmission from USA and China to four Asian stock markets of Thailand, Vietnam, Malaysia, and Singapore. It finds a significant risk transmission from USA to four Asian stock markets during full sample. However, the return is also found significant China to four Asian markets during global financial crisis.

Vo and Tran (2020) investigate the volatility transmission from the US to ASEAN equity markets and find a significant volatility spillover from the US to ASEAN equity markets. Xiao (2020) find that volatility transmission from China to East Asian equity markets is different during crisis and non-crisis periods. Based on the literature as mentioned above, it is observed that the interactions between stock markets are rarely investigated during Chinese crash. Therefore, the current study addresses this literature gap by examining the spillovers between stock markets during Chinese crash of 2015.

2.2.2 Spillover between Oil and Stock Markets

Sadorsky (1999) finds that oil price volatility significantly affects stock returns. Faff and Brailsford (1999) investigate the effect of oil prices on equity returns of different sectors in Australia. It finds a significant effect of international oil prices on equity returns of some sectors (Oil and Gas, Paper and Packaging, and Transport) in Australia. Ciner (2001) examines the association between energy shocks and US equity returns and reports the significant influence of oil price shocks on equity returns of US.

Hammoudeh and Aleisa (2004) examine the relationship between crude oil prices and equity returns in Gulf countries (Bahrain, Oman, Saudi Arabia, Kuwait, and UAE). This study reports a bidirectional linkage between international crude oil prices and stock prices of Saudi Arabia. Hayo and Kutan (2005) study the effect of news and oil prices on the returns of the stock and bond market of Russia. This study finds that energy-related news affects the returns, however, news related to war insignificantly affect the returns. Moreover, growth in oil prices is significantly affected stock returns.

Maghyereh (2006) investigates the dynamic relationship between international oil price shocks and equity returns of 21 emerging markets during 1998 to 2004. It reports a weak association between oil price shocks and equity returns of emerging markets. Basher and Sadorsky (2006) find a significant influence of oil price risk on stock returns of emerging markets. Ågren (2006) examines the volatility spillover between Norway, Japan, Swedish, UK, and US stock markets. It reports significant transmission of volatility between all markets except Sweden. Maghyereh and Al-Kandari (2007) study the association between oil prices and equity prices of GCC countries. It finds a non-linear impact of international oil prices on GCC equity markets.

Cong et al. (2008) investigate the link between oil price shocks and Chinese equity market. It reports an insignificant influence of oil price shocks on majority Chinese indices except for oil and manufacturing sector index. Nandha and Faff (2008) examine the effect of oil price shocks on equity returns of different sectors. It finds that stock returns of all sectors (Except Mining, oil, and gas) are adversely affected due to the rise in oil prices. Park and Ratti (2008) examine the effect of oil prices shocks on the stock returns of the US and 13 European countries. There is a significant positive effect of the real stock returns on the oil prices in oil-exporting country of Norway. The increase in the oil price volatility reduces the real stock returns in most of European countries, but not in US.

Diebold and Yilmaz (2009) provide a measure of interdependence of asset returns and/or volatilities. Further, it provides us a mechanism to measure mean and the volatility spillovers during crisis and non-crisis period; and, study bursts and trends in spillover. The results indicate that mean spillover show increasing trend but no bursts while volatility spillovers show no trend but clear bursts.

Malik and Ewing (2009) investigate the return and the volatility spillover between five US sectors indexes and oil prices. The study reports and evidence of volatility and shocks transmission between the oil prices and some US sector indexes. Lake and Katrakilidis (2009) investigate the spillover between UK, Greece, German and US stock markets. It reports that oil price returns do not affect the stock market returns of Greece, US, and UK stock markets.

Bhar and Nikolova (2010) study the effect of changes in oil prices on the equity market in Russia. These results show that global oil prices significantly affect the returns and volatility of Russian equity market. Arouri et al. (2011a) investigate the volatility spillover between oil and stock markets in the USA and Europe at the sector level. This study finds that volatility spillover exists between the oil price returns and sector-wise stock returns. Further, there is a presence of spillover from oil to sector stock returns in Europe, while bidirectional spillover exists oil and stock returns in US. Arouri et al. (2011b) examine the mean and the volatility transmission between the oil and stock markets. The results show that there is a presence of mean and the volatility spillover between the world oil prices and GCC stock prices.

Fayyad and Daly (2011) investigate the volatility transmission from oil prices to stock returns for the seven countries (USA, UK, Kuwait, Oman, UAE, and Bahrain). The study finds that the predictive power of oil for the stock returns improved for the period of global financial crisis. Further, UAE, UK, and the Qatar showed high responsiveness to oil shocks as compare to USA, Bahrain, Oman, and Kuwait. Filis et al. (2011) examine the dynamic correlation between the stock and oil prices for oil-exporting and oil-importing countries. The study Uses Mexico, Canada, and Brazil as an Oil exporting countries; while Germany, USA, and Netherland as oil-importing countries. The study finds that there is no difference between the time-varying correlation of oil exporting and importing countries.

Arouri et al. (2012) examine the volatility spillover between the oil and stock markets in Europe. This study finds that different industries are not equally affected by the oil price changes. Moreover, there is evidence of the volatility spillover from oil prices to sector level stock returns. Sadorsky (2012) examines the conditional correlation and volatility transmission between the oil and stock prices of the technology companies and the clean energy companies. The study finds that there is a high correlation between stock prices of the technology-based companies and the clean energy companies as compared to oil prices.

Aloui et al. (2013) investigate the association between crude oil prices and the stock markets using data from the central and the eastern European economies. The results show that there is a presence of contagion between the six CEE countries. So, there is a presence of positive dependence between and stock markets.

Chang et al. (2013) examine the volatility spillover and conditional correlation between stock and crude oil price returns. The results shows that conditional correlation is low across the markets; and statistically insignificant in some markets as well. However, there is a presence of volatility spillover between stock and crude oil returns. Degiannakis et al. (2013) examine the association between the oil prices and European industrial sector indices returns. The study finds that the association between the oil prices returns and stock indices returns changes over the time and it's also industry-specific. Lin et al. (2014) investigate the volatility spillover transmission mechanism between oil and Ghanian stock market. The study finds a significant presence of volatility spillover among the oil and stock market of Ghana. Further, the volatility spillover effect from oil to stock market greater as compare to spillover from stock to oil markets.

Reboredo and Rivera-Castro (2014) examine the association between oil and the stock markets in USA, Europe at aggregate and Sector level. The results demonstrate that change in oil prices is not significantly affecting the stock market returns at both aggregate and sectoral levels in pre-crisis period. Moreover, there is evidence of financial contagion between the oil and stock markets during financial crisis period. Ajmi et al. (2014) study the non-linear causal association between oil prices and stock markets of MENA countries during a black swan periods. The results show that the oil prices and stock prices of MENA stock markets interact in non-linear manners.

Du and He (2015) examines the spillover effect between the crude oil and stock returns by using the daily data of S&P 500 and the World Texas intermediate crude oil future returns. The result shows that there is a presence of risk spillover between stock index and oil future returns. There is evidence of positive risk spillover from stock to the oil market, whereas negative spillover oil market to the stock market during a recent financial crisis. There is a presence of bidirectional positive risk spillover and become strengthen after financial crisis.

Khalfaoui et al. (2015) examine the association between crude oil markets and stock markets of Japan, Canada, Germany, France, Italy, US, and UK. The results show that there is an evidence of mean and the volatility spillover between the oil and stock market returns. Salisu and Oloko (2015) examine the association between the oil prices and US stock prices. The results find that there is a presence of positive mean spillover from US stock market to oil market. Further, there is evidence of bidirectional shock spillover between stock and oil markets. Serletis and Xu (2018) analyse the mean and the volatility spillover between the oil, stock, debt and foreign exchange markets. The study finds that there is a presence of strong interconnectedness between crude oil and three financial markets.

Liu et al. (2017) estimate the mean and the volatility spillover between oil and stock market returns during three-time phase's before during and after crisis period. The results show that there is evidence of the weakening association between the oil and USA stock market in the long term, while the association between the oil and the Russian stock market is strengthening in all time scales. Moreover, Russian stock index and US stock index shows the opposite trend falling oil prices during post crisis period. Bouri et al. (2017b) study the link between oil, gold and Indian stock market. It reports that oil price volatility significantly affects the volatility of Indian equity market. Noor and Dutta (2017) empirically find an insignificant volatility spillover between crude oil and south Asian stock markets.

Basta and Molnar (2018) detect a strong co-movement between the volatility of Stocks and oil prices. Wong and El Massah (2018) empirically estimate the impact of oil price shock on stock markets of Gulf council countries (Kuwait, Qatar, Oman, Bahrain, UAE, and Saudi Arabia from 2005 to 2015. It reports that changes in oil prices significantly affect the stock markets of Saudi Arabia, Kuwait, and UAE. Moreover, the stock markets of Bahrain, Kuwait, and Qatar significantly affect the oil prices. Uzo-Peters et al. (2018) find that oil price shocks negatively affect the oil and gas sector of Nigeria.

Wen et al. (2019) examine the non-linear causal association between crude oil and Chinese stock markets. It finds a non-linear causality between oil prices and Chinese stock market. Khalfaoui et al. (2019) investigate the volatility spillover between oil and stock markets of oil-importing/exporting countries. It provides evidence of bidirectional volatility spillover between oil and stock markets. Xu et al. (2019) report an asymmetric volatility spillover between oil and two international (US and China) stock markets.

Sarwar et al. (2020) examine the volatility linkages between the crude oil and Asian stock markets including Chinese, Indian, and Pakistani equity markets. The results reveal that there is a no significant difference between the risk spillover between crude oil and Asian stock markets during non-crisis and crisis periods. In contrast, various above mentioned studies find a significantly different spillover between oil and stock markets during the crisis and non-crisis periods. Based on the literature as mentioned above, it is observed that none of the study has investigated the linkages between oil and equity markets during the Chinese crash of 2015. Therefore, the current study addresses this literature gap by examining the linkages between oil and equity markets during the Chinese crash.

2.2.3 Spillover between Gold and Stock Markets

Smith (2001) study the causal association between gold returns and US stock market returns by using data from 1991 to 2001. It reports a significant unidirectional causal impact from US stock returns to Gold returns. Smith (2002) examine the association between gold price and equity markets of Japan and Europe. It provides an evidence negative relationship between gold returns and stock returns of majority series, whereas a few series of stock returns show an insignificant and positive relationship with gold returns. Lawrence (2003) investigates the association between Standard and Poor 500 index, gold and other commodities. It finds that gold returns are weakly associated with S&P 500 returns as compared to the association between S&P 500 and other commodities.

Gilmore et al. (2009) explore the link between gold mining company stocks and gold prices. It finds a significant causal effect of stock returns of gold mining company to the gold returns. Mishra et al. (2010) examine the link between the volatility of gold price and stock market returns of India from 1991 to 2009. This study finds a bidirectional causal link between local gold prices and stock market returns of India. Choi and Hammoudeh (2010) empirically find a low correlation between the returns of gold and S&P 500 index.

Chan et al. (2011) examine the relationship between financial assets, commodities, and real estate assets returns. Financial assets include treasury bonds and US stocks while commodities like Gold and oil. This study finds that there is a presence of flight from gold to stock market during the crisis period. Mulyadi and Anwar (2012) conduct a comparison between gold and stock investment. Many past studies show that Gold is used to diversify risk during extreme stock market conditions. This study finds that gold investment has more advantages as compared to stock investments. Mensi et al. (2013) examine mean and the volatility spillover across the commodity idices (Gold, food, energy) and S&P 500. The study results show that mean and the volatility spillover effect is significant between commodity price indices (Gold, food, energy) and S&P 500. Moreover, the highest correlation exists between S&P 500 and Gold index.

Miyazaki and Hamori (2013) investigate the relationship between stock and gold market performance. This study finds unidirectional causality from stock to Gold but there is an absence of causality in variance from stock to Gold market. Before the crisis, there is a presence of bidirectional causality while unidirectional causality in mean and variance exists from stock to gold market after crisis period.

Souček (2013) examines the co-movements between equity, gold futures, and crude oil. The study finds that the correlation between equity and gold future becomes weak negative. Thuraisamy et al. (2013) investigate the volatility transmission from Asia stock market to the two commodities gold futures and crude oil markets. This study uses 14 Asian countries for analysis. The study finds that spillover results of mature and immature markets are different from each other. In mature markets like Japan, there is a presence of spillover effect from Japanese equity market to gold future and crude oil markets. While in immature markets, there is a presence of spillover effect from commodity futures to the equity markets. Moreover, there is a presence of a bidirectional volatility transmission during a financial crisis.

Lucey et al. (2014) examine the mean and the volatility spillover between four major gold located in London, Tokyo, New York, and Shanghai. The study finds that highly integrated pair of the market is COMEX and London cash market. Moreover, the mean spillover effect is stronger as compared to volatility spillover between these markets. Arouri et al. (2015) investigate the mean and the volatility spillover effect between the Gold and stock prices in China by using the data from 2004 to 2011. The study finds a significant presence of mean and the volatility spillover between Gold and stock markets. Moreover, past gold returns help in forecasting future gold price and gold ia a safe haven for Chinese stocks during global financial crisis.

Wong et al. (2015) investigate the role of gold while making portfolios. The study finds that risk-averse investors do not prefer to gold while risk seeker investors prefer to include gold in their stocks-bonds portfolios during financial crisis especially. Raza et al. (2016) finds that gold positively influence the equity market prices in BRICS economies. Moreover, gold negatively influence the equity prices in counties like Malaysia, Chile, Thailand, Indonesia, and Mexico. Thus, the relationships between gold and stock markets vary across countries.

Wang et al. (2016) study the risk transmission between the major gold markets (New York, London, Shanghai, and Tokyo) during pre and post-financial crisis. This study finds that there is an evidence of risk spillover transmission between New York and London, and Shanghai and London. Moreover, the extreme risk transmission from New York to Tokyo and Shanghai is much stronger as compared to risk transmission from London to Tokyo and Shanghai. While extreme risk spillover transmission from Shanghai and Tokyo to New York is limited.

Bouri et al. (2017a) investigate the link between oil, gold and Indian stock market from 2009 to 2016. It reports a positive and non-linear impact of gold volatility on Indian stock volatility. Shahzad et al. (2017) find that the dependence between gold and stock markets is time-varying (Bullish and bearish) and country-specific. Bouri et al. (2017b) look at the link between the gold and stock markets of China and India. It finds a bidirectional causality link between gold and stock markets of China and India during low and high frequencies.

Tursoy and Faisal (2018) analyse the association between gold, oil and stock market of Turkey from 1986 to 2016. It reports a negative long-run relationship between gold and stock prices in Turkey. Piñeiro-Chousa et al. (2018) find a unidirectional causality between US and gold market returns. Rahman and Mustafa (2018) empirically examine the relationship between gold, crude oil and US stock market from 1986 to 2016. It finds a negative association between gold and US equity market.

Akkoc and Civcir (2019) investigate the volatility spillover from gold and oil to Turkish stock market from 2009 to 2017. It finds a significant volatility spillover from gold and oil to Turkish stock market. Singhal et al. (2019) empirically investigate the relationship between gold and Mexican stock market. It reports a significant positive impact of international gold prices on the stock prices of Mexico. Akbar et al. (2019) finds a negative association between gold and stock prices in Pakistan from 2001 to 2014. Based on the literature as mentioned above, it is observed that none of the study has examined the linkages between gold and equity markets during the Chinese crash of 2015. Therefore, the current study addresses this literature gap by examining the linkages between gold and equity markets during the Chinese crash.

Chapter 3

Data and Research Methodology

3.1 Data Description

The daily data of nine Asian, four Latin American, and the US stock indices are used in this study. The emerging Asian equity markets include China, India, Korea, Indonesia, Pakistan, Malaysia, Philippine, Thailand, and Taiwan. The emerging Latin American markets comprise of the Brazil, Mexico, Chile, and Peru. This study selects emerging economies of Asia and Latin America by using a list of countries including in MSCI emerging market index. The data of stock markets is taken from the S&P Capital IQ database.

The one of study's objective is to examine the spillover from US and China to emerging Asian and Latin-American stock markets. The selection of the markets is based upon the trade flows between these countries, as Singh et al. (2010) also explain the price and volatility linkages between stock markets through trade flows. The US and China are the biggest trading partners with Latin-American region. From 2000 to 2014, the trade volume of China with Latin-American region has increased from $12 billion to $260 billion. It shows a 22 folds increase in trade volume from 2000 to 2014. However, trade volume was significantly decreased during 2015. From 2000 to 2014, the trade volume of US with Latin-American region has increased from $378 billion to $757 billion[1]. It shows that trade volume

[1] https://wits.worldbank.org/

became double from 2000 to 2014. China has become the second largest trading partner of Latin-American countries in 2019 having trading volume of $307 billion[2]. Moreover, US and China are the biggest trading partners of emerging Asian economies. As these trade flows between US, China, emerging Asia and Latin-America are higher, therefore it is appropriate to examine the link between the stock markets of these countries. When trade between different countries and regions increases/decreases, then spillover between financial markets might also be changed.

To examine spillover between the oil and stock returns, the data of daily oil prices is taken from the "Energy Information Administration (EIA)". This study uses the Brent spot prices as an indicator of international oil prices. To examine spillover between Gold and Stock returns, the data of daily London gold spot prices (in the US dollars per troy ounce) is taken from the London Bullion Market Association Homepage. To cover both periods of US financial crisis and Chinese equity market crash, this study uses a sample period from January 2000 to June 2018. The stock, oil and gold markets are closed on Saturday and Sunday, thus this study used daily data from Monday to Friday.

This study estimate spillover during three periods i.e. full sample period (from Jan 2000 to June 2018), US financial crisis (August 2007 to July 2010), and Chinese stock market crash (June 2015 to May 2018). Li and Giles (2015) use the same time frame for two crises to examine the spillover effect from the USA and Japan to six Asian markets during the Asian financial crisis and the US financial crisis.

The summary statistics of all stock indices, oil and gold returns are reported in Table 3.1. The average return of the Pakistani stock market is highest, while lowest for the US stock market during full sample period. Thus, the Pakistani stock market is a good market for return sensitive international portfolio investors. The standard deviation of Malaysia, Chile, US and gold markets are lowest, while highest in oil market. The US stock market exhibits the lowest return and risk in all stock, gold and oil markets. The volatility of Indonesia, Pakistan, Taiwan

[2]https://www.scmp.com/news/china/diplomacy/article/3020246/latin-america-trade-grows-china-and-us-tussle-influence

and Peru is almost equal, but the returns of Pakistani stock market are highest among all stock, gold and oil markets. Therefore, Pakistani stock market provides a high return with relatively low risk during the full sample period. Skewness is positive in most cases and kurtosis is higher than 3 in gold, oil and stock markets. Jarque-Bera statistics do not accept the hypothesis of the normality of all series. Moreover, there is significant evidence of autocorrelation for all series. Lastly, there is strong evidence of ARCH effect in all series. Table 3.2 presents the results of the unit root test for all series. This study applies the Augmented Dickey Fuller (ADF) test and Phillip-Perron test to check the stationarity of all series. Each test is applied three times, with “no constant and trend”, “constant”and “constant and trend”. The results depict that all series are significant while applying ADF and Phillip-Perron test, thus there is no evidence of stationarity in any series.

3.2 Research Methodology

Financial asset returns exhibit volatility clustering (Mandelbrot, 1963), thus it is better to use time-varying second-order moments-based modeling. To model second-order moments, (Engle, 1982) has introduced autoregressive conditional heterosckedasticity models. Bollerslev (1986) introduces the Generalized Autoregressive conditional heterosckedasticity based models for second-order moments.

Bollerslev et al. (1988) introduce a general vector error correction (VEC) model, which is a direct generalization of the univariate GARCH model. The drawback of this model is that a large number of the parameters are required to be estimated. i.e if n=3 then 78 parameters are required to be estimated. Moreover, it’s difficult to fulfill the condition of positive conditional variance without imposing restrictions on parameters (Gourieroux, 1997).

Because the number of parameters are high in the VEC model, therefore Bollerslev et al. (1988) suggest a Diagonal Vector Error correction (DVEC) model. In this model, A and G matrices are assumed to be diagonal, whereas restrictions reduce the number of parameters. According to this model, if n=3 then 12 parameters are required to be estimated.

TABLE 3.1: Summary Statistics.

	Mean	**Med**	**Max**	**Min**	**SD**	**Skew**	**Kurt**	**JB**	**Q-Stat**	**ARCH**
USA	0.00016	0.00055	0.10958	-0.09470	0.01200	-0.20353	11.5720	14802.7***	37.24***	206.42***
CHN	0.00045	0.00096	0.09401	-0.09256	0.01570	-0.31725	8.2151	5547.4***	54.64***	180.10***
IND	0.00050	0.00094	0.15990	-0.11809	0.01472	-0.22234	10.5424	11474.1***	84.62***	283.89***
INDO	0.00046	0.00113	0.07623	-0.10954	0.01357	-0.85402	10.9238	13206.3***	154.0***	457.66***
KOR	0.00028	0.00080	0.11284	-0.12805	0.01509	-0.57337	9.6486	9149.3***	24.06***	210.02***
MYS	0.00020	0.00041	0.04503	-0.09979	0.00816	-0.85496	13.3307	22038.9***	226.8***	267.36***
PAK	0.00081	0.00109	0.08507	-0.07741	0.01359	-0.34875	6.8376	3058.01***	165.5***	594.62***
PHL	0.00038	0.00055	0.16178	-0.13089	0.01309	0.23024	19.7830	5665.3***	96.40***	161.15***
TAIW	0.00018	0.00070	0.06525	-0.09936	0.01356	-0.27454	6.5959	2659.6***	77.68***	201.54***
THA	0.00044	0.00064	0.10577	-0.16063	0.01316	-0.70520	12.8619	19948.5***	70.19***	656.27***
BRAZ	0.00046	0.00090	0.13678	-0.14116	0.01790	-0.17721	7.1763	3531.0***	16.815***	120.56***
MEXI	0.00031	0.00069	0.10440	-0.08267	0.01288	-0.03744	8.4611	5995.5***	98.708***	139.59***
CHIL	0.00041	0.00060	0.11784	-0.08490	0.00979	-0.10695	12.9329	19828***	184.18***	191.18***
PERU	0.00057	0.00041	0.12815	-0.13291	0.01355	-0.43896	14.7773	28023***	290.68***	657.11***
OIL	0.00029	0.00070	0.18129	-0.19891	0.02266	-0.14565	7.9882	5018.2***	23.99***	108.20***
GOLD	0.00035	0.00048	0.06841	-0.09596	0.01119	-0.24309	8.2175	5519.26***	22.883***	109.13***

Table 3.2: Unit Root Tests.

	ADF (t-test)			Phillips-Perron test		
	None	**Constant**	**Constant and Trend**	**None**	**Constant**	**Constant and Trend**
USA	-53.316	-53.33	-53.357	-73.788	-73.834	-73.929
CHN	-30.991	-31.038	-31.047	-66.482	-66.401	-66.394
IND	-61.457	-61.511	-61.512	-61.336	-61.327	-61.326
KOR	-64.997	-65.01	-65.004	-64.899	-64.908	-64.902
INDO	-58.437	-58.486	-58.481	-58.461	-58.535	-58.529
MYS	-56.326	-56.349	-56.343	-56.611	-56.607	-56.601
PAK	-34.616	-34.793	-34.791	-62.501	-62.258	-62.254
PHL	-60.84	-60.878	-60.877	-60.659	-60.76	-60.759
THA	-44.099	-44.16	-44.159	-64.137	-64.163	-64.157
TAIW	-33.808	-33.815	-33.819	-63.935	-63.937	-63.935
BRAZ	-66.352	-66.39	-66.388	-66.287	-66.3303	-66.328
MEXI	-47.81	-47.844	-47.84	-60.31	-60.3353	-60.329
CHIL	-57.259	-57.34	-57.336	-56.931	-56.9878	-56.982
PERU	-29.73	-29.818	-29.833	-57.468	-57.2741	-57.259
OIL	-65.262	-65.265	-65.264	-65.273	-65.2824	-65.281
GOLD	-66.741	-66.801	-66.811	-66.743	-66.8028	-66.8142

Engle and Kroner (1995) suggest the BEKK model to overcome these two problems of large number of parameters and condition of positive h_t. This model introduces a new parametrization of h_t. The conditional covariance matrix of BEKK (1,1) model is defined as follows:

$$H_t = \acute{C}C + \acute{A}e_{t-1}e_{t-1}^{\prime}A + \acute{G}H_{t-1}G$$

Kroner and Ng (1998) presented another version of the BEKK model which allows for an asymmetric property of volatility in the BEKK model as a new addition:

$$H_t = \acute{C}C + \acute{A}e_{t-1}e_{t-1}^{\prime}A + \acute{G}H_{t-1}G + \acute{D}e_{t-1}e_{t-1}^{\prime}D$$

The parameters of matrix D shows asymmetric responses to bad news or negative shocks. However, the number of parameters increases exponentially in the BEKK model, when the number of variables is increased. Moreover, the BEKK model has a convergence issue as well.

As all previously discussed models have excessive parameters and convergence issues, thus Ling and McAleer (2003) propose the multivariate VAR-GARCH Model to solve these issues. This model is suitable to examine the spillover between the different series; it is also easier to compute as compared to other volatility models. This study uses the AIC and BIC model selection criteria to select the most parsimonious specifications. In VAR-GARCH model, following are the specifications of the conditional mean equation for two series:

$$R_t = \mu + \phi R_{t-1} + e_t \tag{3.1}$$

$$e_t = D_t^{1/2}\eta_t$$

where $R_t = (R_t^a, R_t^b)^{\prime}$ is the vector of returns on the two series of 'a' (i.e. oil) and 'b' (i.e. stock), at time t. It is a 2×2 matrix of parameters giving the impacts of own lagged and cross mean spillover between two series,$e_t = (e_t^a, e_t^b)^{\prime}$ is the vector of error terms of the conditional mean equations for 'a' and 'b' series returns, respectively, at time t, and $\eta_t = (\eta_t^a, \eta_t^b)^{\prime}$ is a sequence of identically and independently distributed random vectors.$D_t^{1/2}$ = diag ($\sqrt{h_t^a}$, $\sqrt{h_t^b}$), where h_t^a , h_t^b are the conditional variances of returns of two series 'a' and 'b', given as:

$$h_a^t = c_2^a + c_{11}^2(e_{t-1}^a)^2 + c_{21}^2(e_{t-1}^b)^2 + b_{11}^2 h_{t-1}^a + b_{21}^2 h_{t-1}^b \tag{3.2}$$

$$h_b^t = c_2^b + c_{12}^2(e_{t-1}^a)^2 + c_{22}^2(e_{t-1}^b)^2 + b_{12}^2 h_{t-1}^a + b_{22}^2 h_{t-1}^b \tag{3.3}$$

These two equations are used to estimate volatility and shock transmittion across time and across the relevant return series. The conditional covariance between 'a' and 'b' series returns can be estimated as:

$$h_t^{ab} = \rho \times \sqrt{h_t^a} \times \sqrt{h_t^b} \tag{3.4}$$

In the above equation, h_t^{ab} refers to the conditional covariance between the returns of two series 'a' and 'b' at time t. ρ shows the constant conditional correlation (CCC). h_t^a , h_t^b are the conditional variances of returns of two series 'a' and 'b' at time t. This study estimates spillovers by employing the VAR-AGARCH model proposed by McAleer et al. (2009), which incorporates the asymmetry. Specifically, the conditional variance is defined as follows for VAR-AGARCH model:

$$h_a^t = c_2^a + c_{11}^2 A(e_{t-1}^a)^2 + c_{21}^2 A(e_{t-1}^b)^2 + b_{11}^2 h_{t-1}^a + b_{21}^2 h_{t-1}^b + a_{11}^2 B[e_{t-1}^a e_{t-1}^a < 0] \tag{3.5}$$

$$h_b^t = c_2^b + c_{12}^2 A(e_{t-1}^a)^2 + c_{22}^2 A(e_{t-1}^b)^2 + b_{12}^2 h_{t-1}^a + b_{22}^2 h_{t-1}^b + a_{22}^2 B[e_{t-1}^b e_{t-1}^b < 0] \tag{3.6}$$

Here "$A(e_{t-1}^a)^2$ and $B[e_{t-1}^a e_{t-1}^a < 0]$ as well as $A(e_{t-1}^b)^2$ and $B[e_{t-1}^b e_{t-1}^b < 0]$ reveal the association between a volatility of market and its own lagged positive and negative returns Lin et al. (2014). Equations (5) and (6) show the conditional variance of each series and how it depends on its own past shock and past volatility, as well as the past shock and past volatility of other (cross) series. In equation (5), $(e_{t-1}^a)^2$ and $(e_{t-1}^b)^2$ show how own past series shocks and 'b' series shocks, respectively, affect the current conditional volatility of 'a' series returns. Here, h_{t-1}^a and h_{t-1}^b are measures of how own past volatility and 'b' series volatility affect current conditional volatility in the 'a' series. This study estimates the mean and volatility transmissions of the three pairs of stock-stock, oil-stock, and gold stock."In each of these three pairs, 1st asset can consider as 'a' series and 2nd asset consider as 'b' series for the understanding of above-mentioned VAR-AGARCH model.

Chapter 4

Data Analysis and Discussion

Chapter 4 reports the results of two major categories (1) return and volatility spillovers between markets, (2) optimal portfolio weights and hedge ratios. Moreover, this study additionally provides the dynamic conditional correlation in table 4.21 and 4.22, because constant conditional correlations are not time varying. Lastly, this study summarises the all results of return and volatility spillovers in Table 4.23 and 4.24.

4.1 Spillovers between USA-Asia and China-Asia Stock Markets

This section provides the results of spillovers between (a) US and Asian stock markets, (b) China and Asian equity markets during all sample periods.

4.1.1 Stock Market Linkages between USA and Asia during the Full Sample Period [Jan 2001-Jul 2018]

Table 4.1 presents the findings of transmissions between US and Asian stock markets in full sample period. The difference in opening time of US and Asian stock markets has been adjusted by taking lag where necessary. The current returns are significantly influenced by the past returns of Asian equity markets except for Korea. These findings are similar to the results of Sok-Gee et al. (2010). This shows the short-term predictability in stock price changes in the Asian equity markets. Moreover, the autoregressive term of USA stock market is found to be significant as well. This depicts that past returns help to predict current returns in USA stock market.

The estimate of mean spillover from one market to another market is estimated by the coefficient of lagged return of one market (i.e. USA) on another market (i.e. India) and vice versa. The return spillover from USA to all Asian stock markets is significant. These findings are in line with the results of Sok-Gee et al. (2010) and Huyghebaert and Wang (2010), which find a significant return spillover from USA to Asian markets. This shows that the returns effect of USA stock market is significantly transmitted to the Asian stock markets. However, the mean spillover from all Asian stock markets to USA is highly insignificant.

ARCH coefficient captures the shock dependence, while the GARCH coefficient captures the persistence of volatility in conditional variance equations. The findings reveal that the sensitivity of past own shocks (ARCH term) is significantly positive for all Asian Stock Markets in the short run. Moreover, the sensitivity of lagged own volatility (GARCH term) is statistically significant for all equity markets (including Asian and USA Markets), thus ARCH (1) volatility model is more appropriate in this case.

The conditional volatility (h_t) of India, Korea, Philippine, Pakistan, Thailand stock markets are significantly affected by the Shocks in USA stock market. These findings are similar to the results of Syriopoulos et al. (2015), which shows that lagged shocks of USA market significantly affect the volatility of India, Brazil, and Russia from BRICS countries. Therefore, it implies that shock in USA stock market leads to increase the volatility of majority Asian Markets. The past volatility (h_{t-1}) of USA stock market is significantly influenced the conditional volatility of the India, Philippine, Pakistan, Thailand stock markets. These results confirm the previous findings of Li and Giles (2015). Further Syriopoulos et al. (2015) find a significant volatility transmission from USA to India, but not from USA to

China. In addition, the past volatility of majority Asian Markets (Except India and Taiwan) does not significantly transmit to the USA Stock market. Asymmetric coefficients of all Asian stock markets are significant and positive, showing that negative news (or unexpected shock) of USA stock market has more ability to increase the volatility of all Asian Stock markets as compared to positive news.

Besides, the asymmetric coefficient of USA stock market is positively significant, demonstrating that negative unexpected shock of Asian Stock markets will increase the volatility more in USA Stock market as compared to the positive shock. Constant conditional correlation is positively significant for all pairs of stock markets. But cross-market correlation is weak in almost all pairs, indicate that investors can get substantial gain by having these pairs in the same portfolio. Moreover, the investor can get maximum gain by investing in portfolio of USA-Pakistan stock markets, because this pair shows the lowest correlation among all pairs of markets during full sample period. The diagnostic tests on residuals are performed to check the adequacy of the model. AIC and SIC tests are used to measure the relative goodness of fit of the estimated model. Jarque -Bera test is used for the normality based on kurtosis and skewness. Q-statistics test is used to check the autocorrelation in standardized residuals and squared standardized residuals respectively, results reveal that there is no evidence of autocorrelation in majority estimations.

4.1.2 Stock Market Linkages between China and Asia from the Full Sample Period[Jan 2001-Jul 2018]

Table 4.2 reports the findings of spillovers among Chinese and Asian equity markets for the full sample period. The findings reveal that the current returns of Asian Stock markets are affected by their own lagged stock returns. Moreover, Chinese stock returns are also impacted by their one period own lagged returns. These findings depict that stock prices can be predicted in the short term in Asian Markets.

Table 4.1: Estimates of VAR(1)-AGARCH(1,1) Model for USA and Asian Stock Markets during Full Sample Period.

	IND	**USA**	**INDO**	**USA**	**KOR**	**USA**	**MYS**	**USA**
Panel A. Mean Equation								
Constant	4e-04***	2e-04*	5e-04***	2e-04**	2E-04	2e-04*	1E-04	2e-04**
	[0.001]	[0.023]	[0.001]	[0.022]	[0.252]	[0.059]	[0.195]	[0.026]
r^s_{t-1}	0.100***	-8E-04	0.136***	-0.01	0.017	0.016	0.168***	-0.022
	[0.000]	[0.933]	[0.000]	[0.260]	[0.241]	[0.126]	[0.000]	[0.232]
r^u_{t-1}	0.231***	-0.041***	0.301***	-0.032**	0.420***	-0.037**	0.201***	-0.034**
	[0.000]	[0.009]	[0.000]	[0.031]	[0.000]	[0.017]	[0.000]	[0.035]
Panel B. Variance Equation								
Constant	2-06***	1-06***	1e-05***	1e-06***	1e-06***	1e-06***	6e-07***	1e-06***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$(e^s_{t-1})^2$	0.056***	0.038***	0.118***	0.057***	0.053***	0.020***	0.090***	7e-03***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.001]	[0.000]	[0.002]
$(e^u_{t-1})^2$	8e-03***	-6E-03	2E-03	-0.011*	6e-03**	-0.011	5E-03	-0.011*
	[0.001]	[0.401]	[0.538]	[0.052]	[0.032]	[0.108]	[0.524]	[0.073]
h^s_{t-1}	0.877***	-0.030***	0.579***	0.085	0.906***	-0.018	0.853***	3E-03
	[0.000]	[0.000]	[0.000]	[0.130]	[0.000]	[0.290]	[0.000]	[0.378]
h^u_{t-1}	(-4e-03**	0.896***	7E-04	0.908***	-3E-03	0.900***	0.01	0.894***
	[0.031]	[0.000]	[0.915]	[0.000]	[0.407]	[0.000]	[0.355]	[0.000]
Asymmetry	0.098***	0.172***	0.199***	0.164***	0.068***	0.173***	0.060***	0.183***
	[0.000]	[0.001]	[0.000]	[0.000]	[0.001]	[0.000]	[0.000]	[0.000]
Panel C. Correlations								
$\rho^{s,u}$	0.198***		0.104***		0.185***		0.082***	
	[0.000]		[0.000]		[0.000]		[0.000]	
Panel D. Diagnostic Tests								
LogL	30500.4		30678.8		30692		33342.3	

Aic	-9.52		-9.912		-10.06		-11.074	
Sic	-9.126		-9.518		-9.671		-10.68	
JB	533.87***	381.11***	688.36***	528.06***	870.23***	391.04***	1921.2***	500.41***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	16.143	22.788	9.012	15.021	5.829	18.049	13.179	14.149
	[0.185]	[0.303]	[0.702]	[0.240]	[0.924]	[0.114]	[0.356]	[0.291]
$Q^2[12]$	13.026	9.413	19.566*	8.416	5.242	9.919	14.799	10.027
	[0.367]	[0.667]	[0.076]	[0.752]	[0.949]	[0.623]	[0.253]	[0.614]

	PAK	**USA**	**PHL**	**USA**	**TAIW**	**USA**	**THA**	**USA**
Panel A. Mean Equation								
Constant	8e-04***	2e-04**	3e-04**	2e-04***	1E-04	2e-04**	6e-04***	2e-04*
	[0.000]	[0.048]	[0.030]	[0.001]	[0.296]	[0.016]	[0.000]	[0.010]
r^s_{t-1}	0.168***	-5E-03	0.118***	-2E-03	0.054***	0.014	0.093***	-9E-03
	[0.000]	[0.648]	[0.000]	[0.132]	[0.000]	[0.232]	[0.000]	[0.423]
r^u_{t-1}	6e-03**	-0.030**	0.421***	-0.030**	0.386***	-0.037**	0.224***	-0.037**
	[0.017]	[0.040]	[0.000]	[0.014]	[0.000]	[0.021]	[0.000]	[0.021]
Panel B. Variance Equation								
Constant	7e-06***	2e-06***	3e-05***	-1e-06***	1e-06***	1e-06***	4e-06***	1e-06***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$(e^s_{t-1})^2$	0.100***	-1e-03***	0.125***	0.041***	0.037***	0.035***	0.080***	9E-03
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.315]
$(e^u_{t-1})^2$	5e-03***	(-6e-03*	-4e-03***	-0.014***	7E-03	-9E-03	7e-03**	-9E-03
	[0.000]	[0.083]	[0.000]	[0.000]	[0.110]	[0.228]	[0.012]	[0.119]
h^s_{t-1}	0.791***	2E-04	0.506***	-0.029	0.925***	-0.030***	0.813***	5E-03
	[0.000]	[0.369]	[0.000]	[0.142]	[0.000]	[0.000]	[0.000]	[0.599]

h^u_{t-1}	(-7e-03***	0.892***	0.036***	0.903***	2E-04	0.897***	(-4e-03*	0.900***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.968]	[0.000]	[0.076]	[0.000]
Asymmetry	0.143***	0.193***	0.143***	0.167***	0.051***	0.167***	0.157***	0.175***
	[0.000]	[0.000]	[0.001]	[0.000]	[0.000]	[0.001]	[0.000]	[0.000]
Panel C. Correlations								
$\rho^{s,u}$	0.031**		0.054***		0.142***		0.134***	
	[0.030]		[0.000]		[0.001]		[0.000]	
Panel D. Diagnostic Tests								
LogL	30597		30633		30931		30683	
Aic	-10.044		-10.537		-10.03		-10.174	
Sic	-9.04		-10.143		-9.78		-9.779	
JB	3442.1***	508.01***	1084.7***	438.39***	295.38***	462.68***	2033.6***	560.99***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	55.870*	15.244	21.845**	15.008	18.533*	19.566*	33.450*	16.279
	[0.097]	[0.228]	[0.039]	[0.241]	[0.100]	[0.076]	[0.087]	[0.179]
Q^2[12]	5.973	0.000***	1.823	0.000***	16.456	10.976	0.928	11.617
	[0.918]	[0.000]	[0.923]	[0.000]	[0.171]	[0.531]	[0.965]	[0.477]

Notes: ^{s}, ^{u} and [ ] denote the Asian stock, USA stock and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level

TABLE 4.2: Estimates of VAR(1)-AGARCH(1,1) Model for China and Asian Stock Markets during Full Sample Period.

	IND	CHN	INDO	CHN	KOR	CHN	MYS	CHN
Panel A. Mean Equation								
Constant	5e-04***	3e-04*	5e-04***	3e-04**	2e-04*	3e-04**	1e-04**	3e-04**
	[0.000]	[0.053]	[0.000]	[0.022]	[0.065]	[0.043]	[0.036]	[0.023]
r^s_{t-1}	0.137***	0.036***	0.152***	0.017	0.083***	0.011	0.191***	0.018
	[0.000]	[0.004]	[0.000]	[0.237]	[0.000]	[0.345]	[0.000]	[0.456]
r^c_{t-1}	-0.018*	0.049***	-0.00605	0.050***	-0.013	0.055***	0.00711	0.053***
	[0.096]	[0.001]	[0.603]	[0.000]	[0.269]	[0.000]	[0.295]	[0.000]
Panel B. Variance Equation								
Constant	2e-06***	1e-06***	4e-06***	1e-06***	1e-06***	1e-06***	5e-07***	1e-06***
	[0.000]	[0.001]	[0.000]	[0.002]	[0.000]	[0.000]	[0.000]	[0.000]
$(e^s_{t-1})^2$	0.051***	-0.001	0.074***	-0.0001	0.031***	0.00703	0.074***	0.0003
	[0.000]	[0.413]	[0.000]	[0.950]	[0.000]	[0.241]	[0.000]	[0.668]
$(e^c_{t-1})^2$	(-5e-03*	0.069***	9e-03*	0.066***	-0.001	0.070***	-0.006	0.069***
	[0.081]	[0.000]	[0.099]	[0.000]	[0.551]	[0.000]	[0.422]	[0.000]
h^s_{t-1}	0.876***	9e-03***	0.840***	0.011**	0.929***	-6e-03***	0.871***	2.9e-03**
	[0.000]	[0.001]	[0.000]	[0.041]	[0.000]	[0.000]	[0.000]	[0.022]
h^c_{t-1}	7e-03**	0.920***	-0.004	0.923***	0.002	0.918***	0.01	0.921***
	[0.033]	[0.000]	[0.482]	[0.000]	[0.314]	[0.000]	[0.278]	[0.000]
Asymmetry	0.105***	0.016**	0.096***	0.012	0.067***	0.019**	0.073***	0.016*
	[0.000]	[0.048]	[0.000]	[0.138]	[0.000]	[0.023]	[0.000]	[0.055]
Panel C. Correlations								
$\rho^{s,c}$	0.158***		0.164***		0.211***		0.170***	
	[0.000]		[0.001]		[0.000]		[0.000]	
Panel D. Diagnostic Tests								
LogL	28559.5		28690.5		28584.3		31339.5	

Aic	9.191		-9.543		-9.621		-10.762	
Sic	-8.797		-9.149		-9.227		-10.368	
JB	574.75***	1348.9***	1310.0***	1391.7***	1385.2***	705.97***	1651.1***	1428.9***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	17.399	48.803***	10.709	45.754***	9.252	46.376***	15.229	44.283***
	[0.135]	[0.000]	[0.554]	[0.000]	[0.681]	[0.000]	[0.229]	[0.000]
$Q^2[12]$	11.249	11.647	17.033	9.322	5.203	11.672	20.075*	11.915
	[0.508]	[0.474]	[0.148]	[0.675]	[0.951]	[0.472]	[0.066]	[0.453]

	PAK	**CHN**	**PHL**	**CHN**	**TAIW**	**CHN**	**THA**	**CHN**
Panel A. Mean Equation								
Constant	8e-04***	3e-04**	3e-04**	3e-04**	2e-04*	3e-04**	5e-04***	0.0002
	[0.000]	[0.029]	[0.031]	[0.030]	[0.089]	[0.027]	[0.000]	[0.139]
r^s_{t-1}	0.167***	0.00627	0.144***	-0.028**	0.100***	0.017	0.125***	0.018
	[0.000]	[0.576]	[0.000]	[0.048]	[0.000]	[0.241]	[0.000]	[0.183]
r^c_{t-1}	0.01	0.055***	0.025**	0.055***	0.00226	0.051***	-0.02	0.049***
	[0.272]	[0.000]	[0.043]	[0.000]	[0.841]	[0.000]	[0.103]	[0.001]
Panel B. Variance Equation								
Constant	7e-06***	1e-06***	1e-05***	1e-06**	9e-07***	1e-06***	1e-06***	1e-06***
	[0.000]	[0.002]	[0.000]	[0.048]	[0.000]	[0.000]	[0.001]	[0.001]
$(e^s_{t-1})^2$	0.100***	-0.0009	0.053***	8e-03**	0.033***	3e-03**	0.070***	0.023***
	[0.000]	[0.509]	[0.000]	[0.016]	[0.000]	[0.034]	[0.000]	[0.000]
$(e^c_{t-1})^2$	0.0035	0.064***	0.0008	0.068***	9e-03***	0.069***	7e-03**	0.062***
	[0.453]	[0.000]	[0.754]	[0.000]	[0.000]	[0.000]	[0.025]	[0.000]
h^s_{t-1}	0.792***	0.001	0.797***	0.0022	0.922***	-0.0013	0.878***	-8e-03***
	[0.000]	[0.458]	[0.000]	[0.656]	[0.000]	[0.508]	[0.000]	[0.001]

h^c_{t-1}	-0.001	0.923***	0.0015	0.921***	-8e-03***	0.921***	-0.003	0.919***
	[0.816]	[0.000]	[0.816]	[0.000]	[0.002]	[0.000]	[0.497]	[0.000]
Asymmetry	0.139***	0.019**	0.096***	0.018**	0.072***	0.016**	0.073***	0.030***
	[0.000]	[0.012]	[0.000]	[0.035]	[0.000]	[0.050]	[0.000]	[0.001]
Panel C. Correlations								
$\rho^{s,c}$	0.047***		0.131***		0.218***		0.146***	
	[0.001]		[0.000]		[0.001]		[0.000]	
Panel D. Diagnostic Tests								
LogL	28776.2		28564.8		28882.9		28821.9	
Aic	-9.824		-9.92		-9.766		-9.77	
Sic	-9.43		-9.52		-9.372		-9.375	
JB	3079.5***	1424.8***	1248.2***	1408.7***	464.07***	1238.5***	56026***	1380.1***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	54.789***	51.513***	14.166	50.473***	24.449**	39.022***	31.740***	48.687***
	[0.000]	[0.000]	[0.290]	[0.000]	[0.018]	[0.000]	[0.002]	[0.000]
$Q^2[12]$	6.182	12.065	4.715	10.218	11.938	13.649	2.396	10.561
	[0.907]	[0.440]	[0.967]	[0.597]	[0.451]	[0.324]	[0.999]	[0.567]

Notes: ^{s}, ^{c} and [ ] denote the Asian stock, China stock and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

The mean spillover from China to the majority Asian Markets is found to be insignificant except India, Philippine, and Thailand stock markets. Besides, mean transmission from Asian markets to Chinese market is highly insignificant except Indian Stock market. These results are supported by the findings of Joshi (2011). Moreover, there is a presence of bi-directional mean transmission between India and China stock market. The coefficient of past own shock of all Asian markets (including China) is significant, thus past shocks affect current conditional volatility in Asian stock markets. Furthermore, the sensitivity of past own volatility of all Asian markets is significant as well.

The conditional volatility of India, Indonesia, Taiwan and Thailand is significantly impacted the shock in Chinese market. Also, the conditional volatility of Chinese market is significantly impacted by the shocks in Philippine, Taiwan, and Thailand equity markets. The past volatility of the China does not affect the conditional volatility of majority Asian equity markets except India and Taiwan equity markets. These findings corroborate with the results of Joshi (2011), which reports a significant volatility spillover from China to India stock market. Moreover, (Zhou et al., 2012) find a significant transmission from China to Taiwan equity market. However, the past volatility of most of the Asian markets (except Pakistan, Philippine and Taiwan) is significantly affected the conditional volatility of the Chinese equity market.

The asymmetric coefficients of all Asian equity markets are significant and positive, showing that negative news of Chinese equity market has more ability to increase the volatility of all Asian Stock markets as compared to positive news. Moreover, the asymmetric coefficient of Chinese stock market is significant and positive, showing that negative news in Asian markets (except Indonesia) has more ability to increase the volatility of Chinese market as compared to positive news. Constant conditional correlation is positively significant for all pairs of equity markets, but CCC is weak in majority pairs.

4.1.3 Stock Market Linkages between USA and Asia during US Financial Crisis [Aug 2007- July 2010]

Table 4.3 presents the findings of spillovers between USA and Asian stock markets during US financial crisis. The difference in opening time of USA and Asian stock markets has been adjusted by taking lag where necessary. In Asian Stock markets (except Indonesia), past lagged returns are significantly influenced the current returns. While USA stock returns are also significantly influenced by their one period own lagged returns in majority cases.

The mean spillover effect from USA to all Asian markets is significant during the US financial crisis. These results confirm the previous findings of Glick and Hutchison (2013), which reports a significant impact of USA equity returns on Asian equity returns during US financial crisis. Moreover, no single Asian stock market transmits the mean effect to the USA market during US financial crisis. The sensitivity of past own shock is significant for half of the Asian markets. The coefficient of past own shocks of USA stock market is not significant in majority estimations. Besides, the coefficient of past own volatility all Asian markets is significant except Philippine.

The past shock in USA stock market significantly influences the conditional volatility of the Indonesia, Philippine and Taiwan during US financial crisis. However, past shocks of majority Asian stock markets (Except India and Korea) insignificantly affect the conditional volatility of the USA stock market. The effect of past volatility of USA on conditional volatility of the Asian stock markets (except Indonesia) is not significant. These results match with the findings of Li and Giles (2015). In contarst, (Lien et al., 2018) report a unidirectional risk transmission from the US to majority of the Asian stock markets during the global financial crisis.Moreover, the past volatility of half of the Asian stock significantly affects the USA stock market volatility.. The asymmetric coefficient of all Asian markets is significant and positive. Moreover, the asymmetric coefficient of US market is significant and positive in all cases. Constant conditional correlation is positively significant for all pairs of stock markets.

Table 4.3: Estimates of VAR(1)-AGARCH(1,1) Model for USA and Asian Stock Markets during US Financial Crisis.

	IND	**USA**	**INDO**	**USA**	**KOR**	**USA**	**MYS**	**USA**
Panel A. Mean Equation								
Constant	7-04	3e-05	-2e-05	-8e-05	8e-04*	-7e-05	4.e-04	-1.e-04
	[0.138]	[0.936]	[0.957]	[0.834]	[0.080]	[0.8650]	[0.123]	[0.742]
r^s_{t-1}	0.0814**	0.016	-0.031	-0.024	0.094***	-0.010	0.145***	-0.046
	[0.031]	[0.510]	[0.360]	[0.455]	[0.007]	[0.713]	[0.000]	[0.409]
r^u_{t-1}	0.293***	-0.093**	0.423***	-0.062*	0.325***	-0.079**	0.187***	-0.080**
	[0.000]	[0.016]	[0.000]	[0.091]	[0.000]	[0.041]	[0.000]	[0.042]
Panel B. Variance Equation								
Constant	2e-06	3e-06***	1e-05***	5e-06***	3e-05***	4e-06***	1e-06**	3e-06***
	[0.161]	[0.001]	[0.000]	[0.001]	[0.000]	[0.004]	[0.038]	[0.001]
$(e^s_{t-1})^2$	0.086***	0.075**	-0.019	0.001	-0.012	0.077*	0.119***	-7.E-04
	[0.000]	[0.016]	[0.401]	[0.877]	[0.674]	[0.078]	[0.000]	[0.879]
$(e^u_{t-1})^2$	6e-03	-0.016	0.051**	-0.029**	7e-03	0.001	0.051	-0.013
	[0.530]	[0.337]	[0.011]	[0.014]	[0.505]	[0.917]	[0.213]	[0.361]
h^s_{t-1}	0.868***	-0.048	0.750***	0.060	0.426***	-0.121**	0.755***	0.013*
	[0.000]	[0.123]	[0.000]	[0.208]	[0.000]	[0.033]	[0.000]	[0.090]
h^u_{t-1}	2e-03	0.894***	-0.076**	0.945***	-0.017	0.906***	-0.035	0.915***
	[0.874]	[0.000]	[0.012]	[0.000]	[0.394]	[0.000]	[0.312]	[0.000]
Asymmetry	0.064*	0.179***	0.265***	0.159***	0.446***	0.161***	0.163***	0.154***
	[0.091]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.004]	[0.000]
Panel C. Correlations								
$\rho^{s,u}$	0.172***		0.280***		0.220***		0.195***	
	[0.000]		[0.000]		[0.001]		[0.000]	
Panel D. Diagnostic Tests								
LogL	4369.8		4230.2		4436.3		4843.96	

Aic	-10.066		-10.502		-10.394		-11.482	
Sic	-9.773		-10.209		-10.101		-11.187	
JB	513.31***	372.23***	679.01***	512.65***	843.87***	399.86***	321.22***	627.41
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	14.588	8.939	11.706	6.002	12.006	7.401	11.897	6.28
	[0.264]	[0.708]	[0.469]	[0.915]	[0.445]	[0.829]	[0.454]	[0.901]
$Q^2[12]$	7.779	13.979	5.3030	14.983	6.336	13.673	5.422	14.54
	[0.802]	[0.301]	[0.947]	[0.242]	[0.898]	[0.322]	[0.942]	[0.268]

	PAK	**USA**	**PHL**	**USA**	**TAIW**	**USA**	**THA**	**USA**
Panel A. Mean Equation								
Constant	9e-04***	4.E-04	9e-04***	4e-04***	2.E-04	-3.E-05	6.E-04	-6.E-05
	[0.005]	[0.262]	[0.001]	[0.066]	[0.684]	[0.955]	[0.194]	[0.886]
r^s_{t-1}	0.125***	0.015	0.101***	0.016	0.063*	0.02	0.065**	-0.012
	[0.001]	[0.648]	[0.000]	[0.523]	[0.076]	[0.565]	[0.027]	[0.663]
r^u_{t-1}	0.175***	0.016	0.489***	1.60E-03	0.383***	-0.103**	0.249***	-0.077**
	[0.000]	[0.706]	[0.000]	[0.963]	[0.000]	[0.011]	[0.000]	[0.034]
Panel B. Variance Equation								
Constant	4e-06***	3e-06***	3e-05***	2e-06***	1.E-06	3e-06***	3e-05***	5.E-08
	[0.007]	[0.000]	[0.000]	[0.000]	[0.352]	[0.009]	[0.000]	[0.984]
$(e^s_{t-1})^2$	0.036**	8.E-03	0.283	0.051**	5.E-03	0.029	0.151***	0.015
	[0.034]	[0.439]	[0.140]	[0.044]	[0.761]	[0.230]	[0.000]	[0.678]
$(e^u_{t-1})^2$	0.018	-0.060***	(-4e-03**	-0.061***	0.026*	-0.022	-5.E-03	-6.E-03
	[0.146]	[0.001]	[0.033]	[0.000]	[0.056]	[0.113]	[0.690]	[0.661]
h^s_{t-1}	0.854***	8.E-03	0.099	0.043	0.951***	-0.029*	0.449***	0.110**
	[0.000]	[0.470]	[0.196]	[0.171]	[0.000]	[0.062]	[0.000]	[0.024]

h^u_{t-1}	-0.021	0.907***	8.E-03	0.906***	-0.017	0.910***	0.031	0.905***
	[0.322]	[0.000]	[0.115]	[0.000]	[0.382]	[0.000]	[0.299]	[0.000]
Asymmetry	0.101***	0.237***	0.523***	0.233***	0.075***	0.169***	0.187***	0.147***
	[0.004]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Panel C. Correlations								
$\rho^{s,u}$	0.016*		0.065**		0.187***		0.218***	
	[0.086]		[0.044]		[0.000]		[0.001]	
Panel D. Diagnostic Tests								
LogL	4850.88		6628.56		4391.36		4399.67	
Aic	-11.499		-11.518		-10.601		-10.71	
Sic	-11.205		-11.224		-10.308		-10.417	
JB	676.08***	654.37***	1598.2***	629.47***	352.58***	635.28***	330.04***	643.32***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	17.579	9.78	9.776	7.878	14.047	5.797	13.234	5.468
	[0.129]	[0.635]	[0.636]	[0.795]	[0.298]	[0.926]	[0.352]	[0.941]
$Q^2[12]$	6.417	32.448***	2.113	20.023*	6.158	13.94	8.596	14.294
	[0.894]	[0.001]	[0.999]	[0.067]	[0.908]	[0.305]	[0.737]	[0.282]

Notes: ^{s}, ^{u} and [ ] denote the Asian stock, USA stock and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level

4.1.4 Stock Market Linkages between China and Asia from the Chinese Stock Market Crash [Jun 2015-May 2018]

Table 4.4 reports the findings of spillovers between Chinese and Asian stock markets during Chinese crash. There is significant evidence that the current stock returns of Asian Stock markets (Except Korea, Philippine, and Taiwan) are influenced by their own lagged returns. Moreover, Chinese equity market returns do not affect by their lags during Chinese Crisis in majority cases.

The return spillover effect from China to all Asian markets is insignificant. However, the mean spillover from majority Asian markets to Chinese is insignificant except India and Taiwan during Chinese crisis. The coefficient of past own shock is not significantly influenced the conditional variance of the majority Asian stock markets except India, Malaysia, and Thailand. Moreover, the sensitivity of past own shock of Chinese equity market is insignificant during Chinese crash. However, the sensitivity of past own volatility is found to be significant for all Asian equity markets.

The conditional volatility of India, Indonesia, Taiwan, and Thailand is significantly affected by the shocks in Chinese equity market. However, the shocks in the majority of Asian equity markets (except India and Philippine) do not influence the Chinese stock markets. The volatility of China influences the conditional volatility of the stock markets of India, Indonesia, Taiwan, and Thailand. However, volatility spillover from majority Asian equity markets (except India, Taiwan, and Thailand) to the Chinese stock market is insignificant during Chinese crisis. Asymmetric coefficients of all Asian stock markets (except Malaysia and Philippine) are significant and positive, showing that negative news of USA stock market has more ability to increase the volatility of Asian Stock markets as compared to positive news. Asymmetric coefficients of China are significant and positive in all pairs, demonstrating that negative news of Asian stock markets except India has more ability to increase the volatility of Chinese Stock markets as compared to positive news in Chinese crash. Constant conditional correlation is positively significant for all pairs of stock markets, but CCC is weak in most of the pairs.

Table 4.4: Estimates of VAR(1)-AGARCH(1,1) Model for China and Asian Stock Markets during Chinese Stock Market Crash.

	IND	**CHN**	**INDO**	**CHN**	**KOR**	**CHN**	**MYS**	**CHN**
Panel A. Mean Equation								
Constant	3.E-04	6.E-05	1.E-05	1.E-04	3.E-04	8.E-05	-1.E-05	1.E-04
	[0.168]	[0.835]	[0.964]	[0.615]	[0.147]	[0.715]	[0.933]	[0.715]
r^s_{t-1}	0.167***	0.106**	0.144***	-0.034	0.084	-0.014	0.125***	0.062
	[0.000]	[0.022]	[0.000]	[0.500]	[0.350]	[0.715]	[0.000]	[0.322]
r^c_{t-1}	-0.029	0.037	-0.012	0.069	-0.019	0.062*	0.021	0.053
	[0.185]	[0.356]	[0.550]	[0.330]	[0.361]	[0.077]	[0.222]	[0.181]
Panel B. Variance Equation								
Constant	3e-06***	1e-06**	4e-06*	-4.E-08	3.E-06	1.E-06	1.E-06	-2.E-07
	[0.000]	[0.012]	[0.010]	[0.930]	[0.139]	[0.425]	[0.126]	[0.768]
$(e^s_{t-1})^2$	-0.063***	-5e-03***	0.052	6.E-04	0.024	5.E-03	0.102***	-9.E-04
	[0.000]	[0.002]	[0.119]	[0.901]	[0.413]	[0.107]	[0.003]	[0.677]
$(e^c_{t-1})^2$	0.070***	0.035**	-0.018***	0.012	9.E-03	0.023	-0.013	1.E-02
	[0.000]	[0.031]	[0.007]	[0.567]	[0.618]	[0.290]	[0.780]	[0.611]
h^s_{t-1}	0.880***	0.016***	0.789***	8.85E-03	0.879***	-2.E-03	0.768***	9.E-03
	[0.000]	[0.000]	[0.000]	[0.176]	[0.000]	[0.665]	[0.000]	[0.283]
h^c_{t-1}	-0.096***	0.945***	0.039**	0.940***	-0.014	0.944***	0.1	0.934***
	[0.000]	[0.000]	[0.025]	[0.000]	[0.742]	[0.000]	[0.343]	[0.000]
Asymmetry	0.171***	0.029	0.163***	0.059**	0.044*	0.045*	0.087	0.065**
	[0.000]	[0.145]	[0.000]	[0.021]	[0.077]	[0.058]	[0.112]	[0.015]
Panel C. Correlations								
$\rho^{s,c}$	0.204***		0.151***		0.282***		0.166***	
	[0.000]		[0.000]		[0.001]		[0.000]	
Panel D. Diagnostic Tests								
LogL	5216.7		5157.8		5258.4		5520	

Aic	-12.108		-12.093		-12.437		-12.929	
Sic	-11.814		-11.799		-12.143		-12.635	
JB	245.34***	365.25***	212.59***	369.93***	325.49***	305.71***	214.27***	342.42***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	31.405***	16.802	10.948	15.522	27.305***	16.59	15.069	16.94
	[0.002]	[0.157]	[0.533]	[0.214]	[0.007]	[0.166]	[0.238]	[0.152]
$Q^2[12]$	55.871***	17.976	47.212***	21.484**	48.551***	17.416	70.480***	21.463**
	[0.000]	[0.116]	[0.000]	[0.044]	[0.000]	[0.135]	[0.000]	[0.044]

	PAK	**CHN**	**PHL**	**CHN**	**TAIW**	**CHN**	**THA**	**CHN**
Panel A. Mean Equation								
Constant	4.E-04	1.E-04	6.E-05	1.E-04	3.E-04	1.E-04	2.E-04	2.E-04
	[0.145]	[0.663]	[0.875]	[0.699]	[0.310]	[0.714]	[0.359]	[0.561]
r^s_{t-1}	0.288***	-0.012	0.056	-1.E-04	0.086	0.106**	0.155***	0.021*
	[0.000]	[0.660]	[0.141]	[0.997]	[0.280]	[0.014]	[0.000]	[0.620]
r^c_{t-1}	0.014	0.062	0.033	0.062	5.E-03	0.021	-9.E-04	0.070**
	[0.452]	[0.120]	[0.274]	[0.113]	[0.836]	[0.580]	[0.965]	[0.052]
Panel B. Variance Equation								
Constant	4e-06***	8e-07***	6e-06**	1.E-06	9e-06***	3e-06**	2e-06***	-8e-07**
	[0.000]	[0.005]	[0.032]	[0.259]	[0.000]	[0.017]	[0.001]	[0.031]
$(e^s_{t-1})^2$	-0.013	-3.E-05	0.058	0.018**	-0.028	6.E-03	-0.039**	-3.E-03
	[0.560]	[0.986]	[0.144]	[0.022]	[0.209]	[0.347]	[0.021]	[0.364]
$(e^c_{t-1})^2$	5.E-03	9.E-03	0.021	0.02	0.062***	0.027	-0.033***	0.017
	[0.180]	[0.656]	[0.137]	[0.342]	[0.008]	[0.176]	[0.000]	[0.355]
h^s_{t-1}	0.841***	-1.E-03	0.824***	-9.E-03	0.659***	0.021**	0.818***	0.015**
	[0.000]	[0.517]	[0.000]	[0.137]	[0.000]	[0.038]	[0.000]	[0.028]

h^c_{t-1}	-6.E-03	0.949***	-0.026	0.943***	-0.118**	0.944***	0.112***	0.933***
	[0.109]	[0.000]	[0.341]	[0.000]	[0.017]	[0.000]	[0.000]	[0.000]
Asymmetry	0.263***	0.058*	0.061	0.048**	0.276***	0.047**	0.229***	0.049**
	[0.000]	[0.010]	[0.210]	[0.045]	[0.000]	[0.040]	[0.000]	[0.029]
Panel C. Correlations								
$\rho^{s,c}$	0.109***		0.179***		0.319***		0.202***	
	[0.003]		[0.000]		[0.001]		[0.000]	
Panel D. Diagnostic Tests								
LogL	5143.3		5026.7		5246.5		5354.3	
Aic	-11.856		-11.866		-12.268		-12.364	
Sic	-11.562		-11.573		-11.975		-12.07	
JB	156.23***	422.30***	216.09***	338.66***	301.33***	269.37***	227.03***	329.20***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	46.439***	20.284*	26.154*	15.115	13.912	11.123	24.373**	15.957
	[0.000]	[0.062]	[0.010]	[0.235]	[0.306]	[0.518]	[0.018]	[0.193]
$Q^2[12]$	70.632***	30.028***	50.180***	23.783**	44.260***	16.31	88.957***	31.358***
	[0.000]	[0.003]	[0.000]	[0.022]	[0.000]	[0.177]	[0.000]	[0.002]

Notes: ^{s}, ^{c} and [ ] denote the Asian stock, China stock and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

4.1.5 Spillover Patterns during US Financial Crisis and Chinese Stock Market Crash for Asian Stock Markets

The return spillover is evident from the US to Asian stock markets in full sample period. Whereas, volatility transmission is significant from US to India, Philippine, Pakistan, and Thailand stock markets. Moreover, no return spillover is existed between China and majority Asian stock markets. Whereas, volatility is not transmitted from China to majority Asian stock (except India and Taiwan) markets during full sample period.

The return spillover is evident from USA to Asian stock markets, whereas the volatility effect is not transmitted from US to Asian stock markets (except India) during US financial crisis. No returns spillover finds from China to Asian stock markets, whereas volatility spillover exists from China to four Asian markets (India, Indonesia Taiwan, and Thailand) during Chinese crash. Overall, volatility transmission patterns across markets are vary during full sample, US financial crisis and Chinese crash. These different patterns of spillover can be explained through the sensitivity of different markets to same crisis. Some markets are severely affected from the one crisis, while others are not.Thus spillover can be different across countries and crises. Therefore, investors need to adjust portfolio asset allocations to diversify the portfolio risk during both crises.

4.2 Spillover between USA-Latin America and China-Latin America Stock Markets

This section provides the results of return and volatility spillovers between (a) US and Latin American stock (LAS) markets, (b) China and LAS markets during all sample periods.

4.2.1 Stock Market Linkages between USA and Latin America during Full Sample Period [Jan 2001-Jul 2018]

Table 4.5 represents the findings of spillovers between US and LAS markets during the full sample period. The past returns of USA and LAS markets significantly influence the current returns, similar to findings of Syriopoulos et al. (2015). It highlights the possibility of short-term prediction of current returns through past returns, The return spillover is significant from USA to Chile, Mexico, and Peru stock markets during the full sample period. However, return spillover is significant from Brazil to USA stock markets during the full sample period.

The sensitivity of past own shocks (ARCH term) is found to be significantly positive for LAS markets, whereas insignificant for USA stock market. Moreover, the coefficients of lagged own volatility (GARCH term) are significant for USA and LAS markets. The USA stock market shocks significantly influence the conditional volatility of the Brazil and Chile equity markets. These findings validate the results of Syriopoulos et al. (2015), which reveals that the past shock in US market significantly influences the volatility of Brazil stock market. Despite this, the shocks in brazil and Mexico have a significant effect on the conditional volatility of the USA stock markets.

Regarding cross-market volatility spillover, the volatility is significantly transmitted from USA to brazil stock market during full sample period. These findings match with the results of Nikkinen et al. (2013), which report a significant volatility transmission from USA to Brazil stock market. Moreover, Brazil and Mexico transmit volatility spillover to the USA stock market. Overall, there is a bidirectional risk transmission between Brazil and USA, which is similar to the results of Cardona et al. (2017).

The asymmetric coefficients of LAS markets are positively significant, which infers that negative news (or unexpected shock) of USA stock market has more ability to increase the volatility of LAS markets as compared to positive news. Also, the asymmetric coefficient of USA stock market is positively significant, which implies that negative unexpected shock of LAS markets will increase the volatility more in USA Stock market as compared to the positive shock. Constant conditional correlation is positively significant for all pairs USA and LAS markets. However, cross-market correlation is not weak in almost all pairs, indicate that investors can't get substantial gain by having these pairs in the same portfolio.

4.2.2 Stock Market Linkages between China and Latin America during the Full Sample Period [Jan 2001-Jul 2018]

Table 4.6 reports the findings of spillovers between China and LAS markets during full sample period. The difference in opening time of China and LAS markets has been adjusted by taking lag where necessary. The current stock returns of LAS markets are significantly affected by their own lagged stock returns. While Chinese stock returns are also significantly influenced by their one period own lagged returns. These findings reveal that stock prices might be predicted in the short term in China and LAS markets. The return spillover from China to LAS markets is found to be insignificant, consistent with the findings of Aktan et al. (2009). However, the return spillover from LAS markets to Chinese stock market is found to be highly significant during full sample period.

The coefficient of past own shocks is significantly positive for Chinese and LAS markets. Also, the coefficients of lagged own volatility are significant for China and LAS markets. The conditional volatility of Brazil and Peru are significantly influenced by the shock in Chinese equity market. The volatility of Chinese market is not significantly influenced by the shocks in LAS markets. The past volatility of the Chinese stock market does not impact the conditional volatility of the LAS markets. However, the past volatility of the Brazil stock markets is significantly affected the conditional volatility of the Chinese Stock market during full sample period.

TABLE 4.5: Estimates of VAR(1)-AGARCH(1,1) Model for USA and Latin American Markets during Full Sample Period.

	BRAZ	**USA**	**CHIL**	**USA**	**MEXI**	**USA**	**PERU**	**USA**
Panel A. Mean Equation								
Constant	0.001**	2e-04**	3e-04***	2e-04***	3e-04**	2e-04**	4e-04***	2.E-04
	[0.016]	[0.019]	[0.000]	[0.008]	[0.014]	[0.020]	[0.001]	[0.066]
r^s_{t-1}	0.047***	0.016*	0.177***	-0.01	0.081***	1.E-03	0.230***	-0.025
	[0.016]	[0.059]	[0.000]	[0.429]	[0.000]	[0.929]	[0.000]	[0.110]
r^u_{t-1}	0.028	-0.049***	0.063***	-0.032**	0.039**	-0.041**	0.081***	-0.024*
	[0.254]	[0.001]	[0.000]	[0.026]	[0.029]	[0.012]	[0.000]	[0.093]
Panel B. Variance Equation								
Constant	1e-05***	2e-06***	3e-06***	1e-06***	2e-06***	2e-06***	5e-06***	1e-06***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$(e^s_{t-1})^2$	0.042***	0.029*	0.057***	4.E-03	0.030***	9e-03*	0.107***	7.E-03
	[0.000]	[0.079]	[0.000]	[0.380]	[0.000]	[0.073]	[0.000]	[0.162]
$(e^u_{t-1})^2$	3e-03**	-4.E-03	-4e-03***	-6.E-03	3.E-03	4.E-03	-1.E-03	-5.E-03
	[0.044]	[0.582]	[0.006]	[0.383]	[0.242]	[0.549]	[0.470]	[0.461]
h^s_{t-1}	0.866***	(-4e-03*	0.835***	2.E-03	0.909***	-0.011*	0.821***	-0.012
	[0.000]	[0.081]	[0.000]	[0.625]	[0.000]	[0.052]	[0.000]	[0.280]
h^u_{t-1}	(-5e-03**	0.905***	6.E-03	0.899***	-3.E-03	0.899***	2.74E-03	0.893***

	[0.020]	[0.000]	[0.133]	[0.000]	[0.272]	[0.000]	[0.204]	[0.000]
Asymmetry	0.086***	0.159***	0.113***	0.167***	0.091***	0.146***	0.088***	0.178***
	[0.000]	[0.001]	[0.000]	[0.000]	[0.001]	[0.000]	[0.000]	[0.000]
Panel C. Correlations								
$\rho^{s,u}$	0.533***		0.414***		0.599***		0.357***	
	[0.000]		[0.000]		[0.000]		[0.000]	
Panel D. Diagnostic Tests								
LogL	29623		32475.1		31882.4		31312.2	
Aic	-10.03		-10.855		-10.707		-9.86	
Sic	-9.342		-10.461		-10.313		-9.466	
JB	293.51***	237.87***	6749.0***	376.92***	377.74***	127.60***	802.71	293.05***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	10.991***	28.256	15.852	14.521	7.883	18.881*	54.316***	17.397
	[0.530]	[0.005]***	[0.198]	[0.269]	[0.794]	[0.091]	[0.000]	[0.135]
Q^2[12]	17.629	21.533	4.16	5.99	9.093	35.620***	12.035	3.563
	[0.127]	[0.043]	[0.980]	[0.917]	[0.695]	[0.000]	[0.443]	[0.990]

Notes: ^{s}, ^{u} and [ ] denote the LA stock, USA stock and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level

TABLE 4.6: Estimates of VAR(1)-AGARCH(1,1) Model for China and Latin American Markets during Full Sample Period.

	BRAZ	**CHN**	**CHIL**	**CHN**	**MEXI**	**CHN**	**PERU**	**CHN**
Panel A. Mean Equation								
Constant	3e-04*	3e-04**	3e-04***	2e-04**	2e-04**	3e-04**	4e-04***	2e-04*
	[0.066]	[0.048]	[0.001]	[0.052]	[0.051]	[0.033]	[0.001]	[0.099]
r^s_{t-1}	0.056***	0.076***	0.212***	0.123***	0.109***	0.077***	0.251***	0.092***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
r^c_{t-1}	0.016	0.045***	-7.E-04	0.046***	7.E-03	0.048***	-8.E-03	0.046***
	[0.298]	[0.002]	[0.931]	[0.003]	[0.389]	[0.001]	[0.394]	[0.002]
Panel B. Variance Equation								
Constant	7e-06***	1e-06**	2e-06***	1e-06***	1e-06***	1e-06***	3e-06***	1e-06***
	[0.000]	[0.023]	[0.000]	[0.009]	[0.000]	[0.000]	[0.000]	[0.000]
$(e^s_{t-1})^2$	0.030***	-5.E-03	0.051***	1.E-03	0.021***	1.E-03	0.108***	-7.E-04
	[0.000]	[0.207]	[0.000]	[0.468]	[0.002]	[0.207]	[0.000]	[0.516]
$(e^c_{t-1})^2$	5e-03*	0.064***	6.E-03	0.066***	-3.E-03	0.067***	5.49e-03*	0.064***
	[0.058]	[0.000]	[0.248]	[0.000]	[0.378]	[0.000]	[0.097]	[0.000]
h^s_{t-1}	0.892***	0.012**	0.853***	2.E-03	0.914***	7.E-04	0.820***	5.E-03
	[0.000]	[0.021]	[0.000]	[0.181]	[0.000]	[0.514]	[0.000]	[0.301]
h^c_{t-1}	-4.E-03	0.925***	-2.E-03	0.923***	4.E-03	0.922***	-4.E-03	0.922***

	[0.271]	[0.000]	[0.830]	[0.000]	[0.329]	[0.000]	[0.224]	[0.000]
Asymmetry	0.093***	0.016*	0.118***	0.018**	0.108***	0.019**	0.086***	0.022***
	[0.000]	[0.062]	[0.000]	[0.033]	[0.001]	[0.018]	[0.000]	[0.007]
Panel C. Correlations								
$\rho^{s,c}$	0.110***		0.077***		0.094***		0.086***	
	[0.000]		[0.000]		[0.000]		[0.000]	
Panel D. Diagnostic Tests								
LogL	27066.7		30247.8		29051		29200.4	
Aic	-8.994		-10.186		-9.575		-9.337	
Sic	-8.6		-9.923		-9.181		-8.943	
JB	302.04***	1355.2***	7331.3***	1354.8***	351.52***	1416.0***	823.14***	1562.8***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	10.46	49.731***	16.623	47.711	6.973	52.283***	49.446***	50.295***
	[0.576]	[0.000]	[0.164]	[0.000]	[0.859]	[0.000]	[0.000]	[0.000]
Q^2[12]	16.089	13.159	3.902	11.372	9.831	10.502	12.642	10.877
	[0.187]	[0.358]	[0.985]	[0.497]	[0.631]	[0.572]	[0.396]	[0.539]

Notes: ^{s}, ^{c} and [ ] denote the LA stock, China stock and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

The asymmetric coefficients of LAS markets are significant and positive, revealing that negative news of Chinese stock market has more ability to increase the volatility of LAS markets as compared to positive news. Moreover, the asymmetric coefficient of Chinese stock market is significant and positive, showing that negative news in LAS markets has more ability to increase the volatility of Chinese market as compared to positive news. Constant conditional correlation is positively significant for all pairs of stock markets. However, CCC is weak in majority pairs, indicate that investors can get substantial gain by having these pairs in the same portfolio.

4.2.3 Stock Market Linkages between USA and Latin America during the US Financial Crisis Period [Aug 2007- July 2010]

Table 4.7 presents the findings of spillovers between USA and LAS markets during the US financial crisis. Results indicate that the past lagged returns are significantly influenced the current returns in Brazil and Peru stock markets. While USA stock returns are also significantly affected by their one-period lagged returns in majority cases. Mean spillover from USA to LAS markets (except Peru) is insignificant during US financial crisis. Moreover, no single LAS markets transmits the mean effect to the USA market during US financial crisis.

The sensitivity of past own shock is insignificant for majority LAS markets except for Peru. Moreover, the coefficient of past own shocks of USA stock market is highly insignificant. The past shocks in USA stock market do not influence the conditional volatility of the LAS markets during US financial crisis. However, past shocks of majority LAS markets (Except Mexico) do not affect the conditional volatility of the USA stock market. The effect of past volatility of USA on conditional volatility of the LAS markets is insignificant. These findings are supported by the results of Wang et al. (2017), which report an insignificant volatility spillover from USA to Brazil stock market during global financial crisis. Moreover, the past volatility of majority LAS markets (except Mexico) does not significantly affect the USA stock market volatility. The asymmetric coefficients of LAS markets are significant and positive. Moreover, the asymmetric coefficient of US market is significant and positive. Constant conditional correlation is positively significant for all pairs of stock markets. However, CCC is not weak in majority pairs, thus there will be a lesser benefit of diversification by having these pairs in the same portfolio during US financial crisis.

4.2.4 Stock Market Linkages between China and Latin America during the Chinese Stock Market Crash [Jun 2015-May 2018]

Table 4.8 reports the findings of spillovers between Chinese and Latin American stock(LAS) markets during Chinese crash. "The difference in opening time of China and LAS markets has been adjusted by taking lag where necessary." The current stock returns of majority LAS markets (Except Brazil) are influenced by their lagged returns. Moreover, Chinese stock market returns do not affect by their lags during Chinese Crisis. The return spillover effect from China to all LAS markets is insignificant. However, the mean spillover from all LA-stock markets to China is significant during Chinese crash.

The coefficient of past own shock is significantly influenced the conditional variance of the majority LAS markets except for Brazil. Moreover, the sensitivity of past own shock of Chinese equity market is insignificant during Chinese crash. However, past own volatility significantly affects the current volatility of all LAS markets.

The conditional volatility of the majority LAS markets (except Chile) is significantly affected by the shocks in Chinese stock market. However, the shocks in majority LAS markets do not affect the Chinese stock markets.

The past volatility of China does not significantly influence the conditional volatility of the majority LAS markets (except Peru). However, volatility spillover from majority LAS markets (except Brazil) to the Chinese stock market is insignificant during Chinese crash. The asymmetric coefficients of Chile and Mexico stock markets are insignificant.

TABLE 4.7: Estimates of VAR(1)-AGARCH(1,1) Model for USA and Latin American Stock Markets during US Financial Crisis.

	BRAZ	**USA**	**CHIL**	**USA**	**MEXI**	**USA**	**PERU**	**USA**
Panel A. Mean Equation								
Constant	1.E-04	-2.E-04	6.E-04	-1.E-04	-2.E-04	4.E-05	0.001**	0
	[0.855]	[0.623]	[0.066]	[0.811]	[0.697]	[0.924]	[0.011]	[0.605]
r^s_{t-1}	0.057	1.E-03	0.183***	0.035	0.019	0.027	0.204***	-0.043
	[0.224]	[0.973]	[0.000]	[0.383]	[0.650]	[0.493]	[0.000]	[0.190]
r^u_{t-1}	-0.012	-0.085*	0.031	-0.097***	0.057	-0.120***	0.131***	-0.046
	[0.836]	[0.054]	[0.138]	[0.006]	[0.151]	[0.003]	[0.000]	[0.125]
Panel B. Variance Equation								
Constant	1e-05***	3e-06**	8e-06***	6e-06***	2e-06***	3e-06**	2E-05***	0.000***
	[0.010]	[0.042]	[0.000]	[0.000]	[0.009]	[0.014]	[0.000]	[0.000]
$(e^s_{t-1})^2$	0.014	-0.036	0.047	-5.E-03	-0.013	0.042***	0.159***	0.1
	[0.476]	[0.134]	[0.110]	[0.533]	[0.317]	[0.000]	[0.000]	[0.210]
$(e^u_{t-1})^2$	-4.E-04	-4.E-03	1.E-02	-9.E-03	-6.E-03	0.011	0	-0.008
	[0.958]	[0.808]	[0.607]	[0.539]	[0.673]	[0.536]	[0.768]	[0.472]
h^s_{t-1}	0.803***	0.108	0.744***	0.013	0.960***	-0.044***	0.680***	-0.056
	[0.000]	[0.128]	[0.000]	[0.192]	[0.000]	[0.008]	[0.000]	[0.139]
h^u_{t-1}	0.022	0.875***	-0.03	0.908***	0.038	0.861***	0	0.911***

	[0.200]	[0.000]	[0.270]	[0.000]	[0.153]	[0.000]	[0.719]	[0.000]
Asymmetry	0.232***	0.153***	0.257***	0.165***	0.097***	0.163***	0.181***	0.157***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Panel C. Correlations								
$\rho^{s,u}$	0.702***		0.576***		0.740***		0.414***	
	[0.000]		[0.000]		[0.001]		[0.000]	
Panel D. Diagnostic Tests								
LogL	4392.6		4767.6		4662.9		6791	
Aic	-10.525		-11.209		-11.18		-10.644	
Sic	-10.232		-10.916		-10.887		-10.41	
JB	320.46***	651.48***	314.47***	600.05***	363.74***	654.49***	120.408	40.019
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.144]	[0.284]
Q[12]	11.87	8.64	10.129	7.104	11.851	7.169	17.157	14.269
	[0.456]	[0.733]	[0.605]	[0.851]	[0.458]	[0.846]	[0.396]	[0.525]
Q^2[12]	9.851	14.994	8.184	14.968	11.16	20.329*	12.630***	11.049***
	[0.629]	[0.242]	[0.771]	[0.243]	[0.515]	[0.061]	[0.000]	[0.000]

Notes: ^{s}, ^{u} and [ ] denote the LA stock, USA stock and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

TABLE 4.8: Estimates of VAR(1)-AGARCH(1,1) Model for China and Latin American Stock Markets during Chinese Stock Market Crash.

	BRAZ	**CHN**	**CHIL**	**CHN**	**MEXI**	**CHN**	**PERU**	**CHN**
Panel A. Mean Equation								
Constant	7.E-04	1.E-04	4.E-04	2.E-05	4.E-05	1.E-04	0	0.001**
	[0.189]	[0.679]	[0.105]	[0.929]	[0.869]	[0.610]	[0.675]	[0.018]
r^s_{t-1}	0.05	0.093***	0.210***	0.141***	0.111***	0.108***	0.240***	0.059*
	[0.181]	[0.000]	[0.000]	[0.000]	[0.006]	[0.008]	[0.000]	[0.087]
r^c_{t-1}	6.E-03	0.064	-6.E-03	0.055	-0.013	0.035	-0.009	0.057
	[0.874]	[0.108]	[0.763]	[0.135]	[0.586]	[0.399]	[0.650]	[0.125]
Panel B. Variance Equation								
Constant	6e-05***	1.E-06	9e-06**	8.E-07	1e-05***	3.E-06	0.000**	0.000***
	[0.000]	[0.215]	[0.011]	[0.170]	[0.000]	[0.180]	[0.028]	[0.000]
$(e^s_{t-1})^2$	0.04	-0.021	0.354***	7.E-03	0.186***	1.E-02	0.063**	-0.009
	[0.271]	[0.408]	[0.000]	[0.267]	[0.002]	[0.157]	[0.023]	[0.181]
$(e^c_{t-1})^2$	0.012***	-4.E-03	0.022***	0.017	0.039**	0.01	-0.026***	0.1
	[0.003]	[0.813]	[0.118]	[0.386]	[0.046]	[0.633]	[0.000]	[0.132]
h^s_{t-1}	0.375***	0.160***	0.528***	5.E-03	0.410***	1.E-02	0.757***	0.023
	[0.000]	[0.004]	[0.000]	[0.583]	[0.000]	[0.254]	[0.000]	[0.301]

h^c_{t-1}	-0.014	0.955***	-0.028	0.951***	-0.089	0.950***	0.072***	0.920***
	[0.111]	[0.000]	[0.228]	[0.000]	[0.168]	[0.000]	[0.000]	[0.000]
Asymmetry	0.333***	0.068***	-0.161	0.044**	0.015	0.058**	0.146***	-0.044***
	[0.001]	[0.000]	[0.144]	[0.029]	[0.843]	[0.013]	[0.001]	[0.005]
Panel C. Correlations								
$\rho^{s,c}$	0.109***		0.121***		0.137***		0.109***	
	[0.001]		[0.000]		[0.000]		[0.002]	
Panel D. Diagnostic Tests								
LogL	4733.9		5285.5		5210.7		4722	
Aic	-11.042		-12.326		-12.267		-11.524	
Sic	-10.748		-12.033		-11.974		-11.2	
JB	152.46***	347.11***	340.96***	314.80***	35.281	519.59***	120.40***	40.019***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	8.762	20.398*	13.935	17.958	13.219	19.159*	10.266	13.351
	[0.723]	[0.060]	[0.305]	[0.117]	[0.353]	[0.085]	[0.593]	[0.344]
$Q^2[12]$	4.317	13.281	12.086	17.513	15.364	10.601	7.489	12.775
	[0.977]	[0.349]	[0.439]	[0.131]	[0.222]	[0.563]	[0.824]	[0.386]

Notes: ^{s}, ^{c} and [ ] denote the LA stock, China stock and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

The asymmetric coefficients of China are significant and positive in all pairs, showing that negative news of Latin American stock market has more ability to increase the volatility of Chinese stock markets as compared to positive news during Chinese crash. Constant conditional correlation is positively significant for all pairs of stock markets, however, CCC is weak in majority pairs.

4.2.5 Spillover Patterns during US Financial Crisis and Chinese Stock Market Crash for Latin American Stock Markets

The return spillover is not significant from USA to the majority LAS markets, whereas volatility is not transmitted from USA to majority LAS markets during full sample period. Moreover, return and volatility spillover from China to LAS markets are highly insignificant during the full sample period.

During US financial crisis, the return and volatility do not transmit from USA to the LAS markets. In addition, the return and volatility is also not transmitted from China to LAS markets during Chinese crash. It implies that LAS markets are good to diversify risk of USA and Chinese stocks during both crises.

4.3 Spillover between Oil and Asian Stock Markets

This section provides the results of spillovers between oil and Asian equity markets during all sample periods.

4.3.1 Linkages between Oil and Asian Stock Markets during the Full Sample Period [Jan 2001-Jul 2018]

Table 4.9 represents the findings of spillovers between oil and Asian emerging stock market during the full sample period. The current stock returns of all Asian markets (except Taiwan) are significantly influenced by the past own stock returns. It suggests that the changes in past stock prices help to predict current stock prices in the short run for emerging Asian stock markets. Furthermore, one period lagged oil returns significantly affect the current oil returns during the full sample period. It implies that future oil price can also be predicted through past oil prices in the short run.

The return spillover from oil to all Asian stock markets (except India) is found to be significant. These findings are similar to the results of (Bhar and Nikolova, 2010), they report a significant effect of oil prices on stock market returns. However, the mean spillover from all Asian stock markets to the oil market is highly insignificant during the full sample period. It infers that return spillover is unidirectional from oil to Asian markets during the full sample period.

The results reveal that the sensitivity of past own shocks is significantly positive for all Asian stock markets in the short run. Furthermore, the sensitivity of past own volatility is also significant for all Asian emerging stock markets, therefore ARCH (1) model is more appropriate for estimation purpose as well. The coefficient of past own shock is smaller as compared to the coefficient of the past own volatility in all Asian emerging stock markets, proposing that past own volatility is a more important factor to predict future volatility as compare to past own shocks. Besides, the sensitivity of past own shocks and volatility is significant for oil markets in the short run. Conditional Volatility of India, Korea, Malaysia, and Pakistan stock markets is significantly affected by the shocks in oil market. Therefore, oil market shocks lead to an increase in the volatility of the majority Asian markets. Moreover, the conditional volatility of the oil market is significantly affected by the shocks in Indonesia, Malaysia, and Thailand stock markets. It infers that shock spillover is bidirectional between the oil and Malaysia stock market during a full sample period.

Table 4.9: Estimates of VAR(1)-AGARCH(1,1) Model for Oil and Asian Stock Markets during Full Sample Period.

	CHN	OIL	IND	OIL	INDO	OIL	KOR	OIL	MYS	OIL
Panel A. Mean Equation										
Constant	3e-04***	7.E-05	4e-04***	9.E-05	5e-04***	9.E-05	2e-04**	2.E-04	1e-04**	1.E-04
	[0.039]	[0.777]	[0.001]	[0.715]	[0.000]	[0.714]	[0.047]	[0.554]	[0.046]	[0.662]
r^s_{t-1}	0.051***	0.018	0.137***	0.042**	0.151***	0.026	0.073***	0.004***	0.188***	0.028
	[0.001]	[0.361]	[0.000]	[0.029]	[0.000]	[0.242]	[0.000]	[0.042]	[0.000]	[0.469]
r^o_{t-1}	0.023***	0.063***	3.E-03	0.060***	0.016**	0.062*	0.034***	0.060*	0.024***	0.062***
	[0.002]	[0.000]	[0.630]	[0.000]	[0.024]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Panel B. Variance Equation										
Constant	1e-06***	6.E-07	2e-06***	9e-07*	5e-06***	8.E-07	1e-06***	1e-06***	8e-07***	1e-06**
	[0.004]	[0.225]	[0.000]	[0.071]	[0.000]	[0.198]	[0.000]	[0.006]	[0.000]	[0.014]
$(e^s_{t-1})^2$	0.068***	-2.E-04	0.052***	3.E-03	0.070***	0.007***	0.032***	2.E-03	0.081***	1e-03***
	[0.000]	[0.833]	[0.000]	[0.120]	[0.000]	[0.000]	[0.000]	[0.189]	[0.001]	[0.003]
$(e^o_{t-1})^2$	-4.E-04	0.018***	0.021***	0.016***	0.005	0.020***	0.027***	0.019***	0.105***	0.016***
	[0.951]	[0.001]	[0.008]	[0.001]	[0.654]	[0.000]	[0.001]	[0.000]	[0.000]	[0.001]
h^s_{t-1}	0.920***	1.E-03	0.868***	4.E-04	0.814***	3.E-04	0.922***	-1.E-03	0.854***	-7.E-05
	[0.000]	[0.282]	[0.000]	[0.839]	[0.000]	[0.868]	[0.000]	[0.304]	[0.000]	[0.893]
h^o_{t-1}	8.E-03	0.953***	-0.014**	0.955***	-0.094**	0.954***	-0.015*	0.950***	-0.077***	0.956***
	[0.226]	[0.000]	[0.046]	[0.000]	[0.093]	[0.000]	[0.061]	[0.000]	[0.002]	[0.000]
Asymmetry	0.019**	0.051***	0.118***	0.051***	0.129***	0.047***	0.079***	0.051***	0.094***	0.047***
	[0.025]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Panel C. Correlations										
$\rho^{s,o}$	0.070***		0.110***		0.100***		0.105***		0.083***	
	[0.000]		[0.000]		[0.000]		[0.000]		[0.000]	
Panel D. Diagnostic Tests										
LogL	25950		26536		25332		26526		29316	

Aic	-8.593		-8.558		-8.971		-8.334		-10.126	
Sic	-8.199		-8.164		-8.577		-7.939		10.024	
JB	1468.6***	503.26***	723.68***	425.89***	1346.22***	503.07***	726.56***	326.05***	1601.0***	301.08***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	52.640***	5.379	17.07	5.733	12.535	4.789	9.591	5.246	15.176	5.768
	[0.000]	[0.944]	[0.147]	[0.929]	[0.404]	[0.965]	[0.652]	[0.949]	[0.232]	[0.927]
Q^2[12]	11.325	15.645	9.937	16.135	11.387	17.188	4.636	9.296	16.677	13.283
	[0.501]	[0.208]	[0.622]	[0.185]	[0.496]	[0.143]	[0.969]	[0.678]	[0.162]	[0.349]

	PAK	**OIL**	**PHL**	**OIL**	**TAIW**	**OIL**	**THA**	**OIL**
Panel A. Mean Equation								
Constant	9e-04***	1.E-04	3e-04**	7.E-05	2.E-04	1.E-04	6e-04***	1.E-04
	[0.000]	[0.673]	[0.031]	[0.766]	[0.102]	[0.646]	[0.000]	[0.613]
r^s_{t-1}	0.165***	-6.E-03	0.143***	-0.016	0.096	0.027	0.108***	-0.014
	[0.000]	[0.790]	[0.000]	[0.516]	[0.119]	[0.299]	[0.000]	[0.519]
r^o_{t-1}	0.016**	0.065***	0.027***	0.061*	0.039***	0.063***	0.028***	0.071
	[0.025]	[0.000]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Panel B. Variance Equation								
Constant	5e-06***	9e-07*	8e-06***	-8.E-09	1e-06***	9e-07*	2e-06***	4.E-07
	[0.000]	[0.079]	[0.000]	[0.992]	[0.000]	[0.061]	[0.000]	[0.358]
$(e^s_{t-1})^2$	0.096***	-1.E-03	0.062***	-2.E-03	0.032***	-1.E-03	0.068***	-3.E-03
	[0.000]	[0.550]	[0.000]	[0.330]	[0.000]	[0.392]	[0.000]	[0.005]
$(e^o_{t-1})^2$	0.019*	0.018***	-2.E-03	0.014***	0.015	0.018***	0.014	0.012
	[0.071]	[0.002]	[0.744]	[0.003]	[0.143]	[0.000]	[0.217]	[0.007]
h^s_{t-1}	0.788***	5.E-03	0.772***	0.019***	0.919***	2.E-03	0.831***	0.01
	[0.000]	[0.197]	[0.000]	[0.000]	[0.000]	[0.141]	[0.000]	[0.160]

h^{o}_{t-1}	-0.01	0.954***	0.015	0.958***	4.E-04	0.953*	-5.E-03	0.963
	[0.380]	[0.000]	[0.326]	[0.000]	[0.170]	[0.052]	[0.694]	[0.000]
Asymmetry	0.148***	0.050***	0.115***	0.051***	0.078	0.046***	0.143***	0.044
	[0.000]	[0.000]	[0.000]	[0.000]	[0.079]	[0.000]	[0.000]	[0.000]
Panel C. Correlations								
$\rho^{s,o}$	0.024		0.071***		0.078***		0.099***	
	[0.115]		[0.000]		[0.000]		[0.000]	
Panel D. Diagnostic Tests								
LogL	26797		26577		26800		26780	
Aic	-9.26		-9.332		-9.177		-9.184	
Sic	-8.866		-8.938		-8.783		-8.79	
JB	2131.7***	405.21***	5481.4***	504.14***	482.57***	441.10***	1392.7***	455.57***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	54.140***	5.437	15.554	6.073	25.302**	5.264	35.047***	4.901
	[0.000]	[0.942]	[0.213]	[0.912]	[0.013]	[0.949]	[0.000]	[0.961]
$Q^2[12]$	6.2	14.658	8.244	19.828*	12.703	15.093	6.073	18.630*
	[0.906]	[0.261]	[0.766]	[0.070]	[0.391]	[0.236]	[0.812]	[0.098]

Notes: ^{s}, ^{o} and [ ] denote the Asian stock, oil market and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

The findings indicate that volatility is significantly transmitted from the oil market to India, Indonesia, Korea, and Malaysia stock markets. These findings confirm the results of (Basher and Sadorsky, 2006), they find a significant volatility spillover from the oil to emerging equity markets. Furthermore, the past volatility of the majority Asian stock markets (Except the Philippine) does not transmit to the Oil markets. It suggests that risk spillover is unidirectional from oil to India, Indonesia, Korea, and Malaysia stock markets during the full sample period.

The asymmetric coefficients of all Asian equity markets are positively significant, demonstrating that negative news (or unexpected shock) of the oil market has more ability to increase the volatility of all Asian Stock markets as compared to positive news. In addition, the asymmetric coefficient of the oil market is positively significant, showing that negative unexpected shock of the majority Asian Stock markets will increase the volatility more in oil markets as compared to the positive shock. Constant conditional correlation (CCC) is positively significant for all pairs of oil and stock markets. But cross-market correlation is weak in almost all pairs, indicate that investors can get substantial gain by having these pairs in the same portfolio.

4.3.2 Linkages between Oil and Asian Stock Markets during the US Financial Crisis [Aug 2007-July 2010]

Table 4.10 reports the findings of spillovers between Oil and Asian emerging stock markets during the US financial crisis. The lag returns significantly affect the current returns of majority Asian emerging markets (except China and Korea). Moreover, current oil returns are significantly affected by the past own oil returns in the majority cases during the US financial crisis. It implies that past stock prices and oil prices help to predict future prices in the short run.

The mean spillover from oil to majority Asian markets (except India and Pakistan) is highly significant. In addition, the mean transmission effect from the majority Asian markets (except India) to oil markets is highly insignificant. Therefore, there is evidence of unidirectional return spillover from oil to the majority emerging Asian stock markets during the US financial crisis.

The coefficients of past own shocks of majority Asian markets (except China and Taiwan) are significant, therefore past shocks affect the current conditional volatility in Asian stock markets. Furthermore, the sensitivity of past own shocks of oil prices is not significant in majority cases during the US financial crisis. The sensitivity of past own volatility is significant for all Asian stock markets. Moreover, the coefficient of past own volatility is also significant and positive for the oil market during the US financial crisis. The coefficient of past own volatility is higher than the coefficient of the past own shock in all Asian stock markets, suggesting that past own volatility is a more important factor to predict future volatility as compare to past own shocks.

The oil market shocks significantly affect the conditional volatility of the Pakistan, Philippine and Taiwan stock markets. Moreover, the conditional volatility of the oil market is not affected by shocks in Asian stock markets (except Korea and Taiwan) during the US financial crisis. It implies that shock spillover is unidirectional from oil to Pakistan and Philippine stock markets, whereas shock spillover is bidirectional between oil and Taiwan stock market in the US financial crisis.

The volatility spillover is evident from oil to Korea, Taiwan, and Thailand stock markets. These findings are similar to the results of (Fayyad and Daly, 2011), which find a significant volatility spillover from oil to equity markets during the global financial crisis. However, the conditional volatility of oil markets is not influenced by the past volatility of majority Asian stock markets (except Taiwan and Indonesia). It implies that volatility spillover is bidirectional between the oil and Taiwan stock market during the US financial crisis. The asymmetric coefficients of all Asian equity markets are positively significant, revealing that negative news (or unexpected shock) of the oil market has more ability to increase the volatility of all Asian Stock markets as compared to positive news. Constant conditional correlation is positively significant for all pairs of oil and stock markets.

TABLE 4.10: Estimates of VAR(1)-AGARCH(1,1) Model for Oil and Asian Stock Markets during US Financial Crisis.

	CHN	**OIL**	**IND**	**OIL**	**INDO**	**OIL**	**KOR**	**OIL**	**MYS**	**OIL**
Panel A. Mean Equation										
Constant	-6.E-06	7.E-04	9.E-04	1.E-03	4.E-04	1.E-03	-9.E-05	1.E-03	4.E-04	1.E-03
	[0.993]	[0.382]	[0.113]	[0.233]	[0.452]	[0.220]	[0.836]	[0.206]	[0.140]	[0.239]
r^s_{t-1}	0.041	0.051	0.143***	0.083*	0.133***	0.037	0.046	0.04	0.157***	0.013
	[0.290]	[0.186]	[0.000]	[0.056]	[0.001]	[0.480]	[0.241]	[0.485]	[0.000]	[0.874]
r^o_{t-1}	0.070***	0.076**	-0.023	0.058	0.054***	0.032**	0.046**	0.075**	0.053***	0.071*
	[0.007]	[0.027]	[0.353]	[0.113]	[0.007]	[0.042]	[0.037]	[0.040]	[0.000]	[0.055]
Panel B. Variance Equation										
Constant	1e-05***	5.E-06	5.E-06	9e-06*	3e-05***	1.E-05	5e-06*	8e-06**	2e-06*	1e-05**
	[0.002]	[0.258]	[0.112]	[0.068]	[0.000]	[0.131]	[0.071]	[0.016]	[0.084]	[0.026]
$(e^s_{t-1})^2$	0.016	0.011	0.090***	0.011	-0.048*	8.E-04	-0.030*	0.019***	0.102***	1.E-04
	[0.407]	[0.183]	[0.000]	[0.197]	[0.059]	[0.872]	[0.052]	[0.007]	[0.000]	[0.930]
$(e^o_{t-1})^2$	0.012	1.E-03	0.011	0.012	-2.E-03	0.067**	0.046	8.E-03	0.032	0.015
	[0.443	[0.929]	[0.612]	[0.433]	[0.953]	[0.011]	[0.123]	[0.557]	[0.681]	[0.288]
h^s_{t-1}	0.863***	-5.E-03	0.867***	-0.013	0.581***	0.041***	0.862***	-3.E-03	0.777***	3.E-03
	[0.000]	[0.658]	[0.000]	[0.318]	[0.000]	[0.002]	[0.000]	[0.672]	[0.000]	[0.257]
h^o_{t-1}	-7.E-03	0.957***	4.37E-03	0.924***	0.019	0.874***	-0.054*	0.947***	-0.03	0.936***
	[0.734]	[0.000]	[0.851]	[0.000]	[0.721]	[0.000]	[0.074]	[0.000]	[0.694]	[0.000]
Asymmetry	0.141***	0.060***	0.097***	0.080**	0.456***	0.082**	0.205***	0.068***	0.175***	0.067***
	[0.000]	[0.001]	[0.009]	[0.022]	[0.000]	[0.024]	[0.000]	[0.004]	[0.004]	[0.009]
Panel C. Correlations										
$\rho^{s,o}$	0.166***		0.242***		0.184***		0.190***		0.206***	
	[0.000]		[0.000]		[0.000]		[0.000]		[0.000]	
Panel D. Diagnostic Tests										
LogL	3729.843		3792.372		3888.261		3951.892		4392.589	

Aic	-8.904		-9.075		-9.143		-9.411		-10.469	
Sic	-8.611		-8.782		-8.85		-9.118		-10.175	
JB	372.81***	683.46***	505.90***	707.35***	641.22***	636.45***	347.74***	695.30***	591.30***	655.21***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	12.91	5.531	13.998	5.525	12.347	4.892	12.056	5.469	11.343	6.007
	[0.376]	[0.938]	[0.301]	[0.938]	[0.418]	[0.961]	[0.441]	[0.940]	[0.500]	[0.916]
Q^2[12]	9.86	13.77	9.287	13.609	6.729	12.77	5.781	14.214	5.987	14.787
	[0.628]	[0.316]	[0.678]	[0.326]	[0.875]	[0.386]	[0.927]	[0.287]	[0.917]	[0.253]

	PAK	**OIL**	**PHL**	**OIL**	**TAIW**	**OIL**	**THA**	**OIL**
Panel A. Mean Equation								
Constant	-4e-04*	1e-03**	4.E-04	1e-03*	2.E-04	1.E-03	5.E-04	1.E-03
	[0.056]	[0.021]	[0.266]	[0.088]	[0.757]	[0.498]	[0.347]	[0.146]
r^s_{t-1}	0.228***	-0.055	0.131***	4.E-03	0.078**	0.035	0.081**	0.013
	[0.000]	[0.254]	[0.000]	[0.906]	[0.039]	[0.522]	[0.035]	[0.805]
r^o_{t-1}	2.E-03	0.047***	0.078***	0.027**	0.067***	0.077**	0.045**	0.080**
	[0.379]	[0.000]	[0.000]	[0.044]	[0.001]	[0.032]	[0.029]	[0.030]
Panel B. Variance Equation								
Constant	4e-05***	4e-05***	6e-05***	1e-05***	4e-06**	1e-05**	2e-05***	-7.E-06
	[0.000]	[0.000]	[0.000]	[0.000]	[0.041]	[0.057]	[0.007]	[0.339]
$(e^s_{t-1})^2$	0.115***	-2.E-03	0.074***	2.E-03	0.025	0.017**	0.124***	6.E-03
	[0.007]	[0.229]	[0.000]	[0.278]	[0.141]	[0.012]	[0.007]	[0.131]
$(e^o_{t-1})^2$	0.055**	0.293***	(-9e-03**	0.079***	-0.046*	0.011	-0.08	0.018
	[0.019]	[0.000]	[0.035]	[0.000]	[0.061]	[0.441]	[0.103]	[0.241]
h^s_{t-1}	0.550***	-4.E-03	0.611***	-5.E-03	0.911***	-0.013*	0.538***	0.032
	[0.000]	[0.230]	[0.000]	[0.141]	[0.000]	[0.065]	[0.000]	[0.102]

h^o_{t-1}	-0.057	0.702***	9.E-03	0.872***	0.059*	0.919*	0.196**	0.937***
	[0.221]	[0.000]	[0.352]	[0.000]	[0.098]	[0.000]	[0.045]	[0.000]
Asymmetry	0.506***	0.015***	0.235***	0.073***	0.077***	0.092*	0.266***	0.017**
	[0.000]	[0.000]	[0.000]	[0.000]	[0.006]	[0.005]	[0.001]	[0.045]
Panel C. Correlations								
$\rho^{s,o}$	0.055**		0.070*		0.217***		0.256***	
	[0.023]		[0.060]		[0.000]		[0.000]	
Panel D. Diagnostic Tests								
LogL	3990.862		3889.633		3929.026		3977.646	
Aic	-9.52		-9.361		-9.61		-9.667	
Sic	-9.227		-9.067		-9.317		-9.374	
JB	631.11***	680.07***	211.20***	665.80***	329.48***	698.10***	347.50***	673.40***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	14.387	5.199	11.364	5.345	14.639	4.925	14.713	5.483
	[0.277]	[0.951]	[0.498]	[0.945]	[0.262]	[0.960]	[0.258]	[0.940]
$Q^2[12]$	6.314	13.240***	25.369**	13.438	6.094	14.412	7.67	14.045
	[0.899]	[0.000]	[0.013]	[0.338]	[0.911]	[0.275]	[0.810]	[0.298]

Notes: ^{s}, ^{o} and [ ] denote the Asian stock, oil market and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

4.3.3 Linkages between Oil and Asian Stock Markets during the Chinese Stock Market Crash [Jun 2015-May 2018]

Table 4.11 reports the findings of spillovers between oil and emerging Asian stock markets during the Chinese crash. The one period lagged stock returns do not affect the current stock returns of China, Korea, and Philippine stock market returns during the Chinese crash. Therefore, returns become unpredictable for the short run in China, Korea and Philippine stock market during the Chinese crash. Moreover, past returns of the oil market significantly affect the current returns. It suggests that the change in past oil prices helps to predict future oil prices in the short run.

The mean transmission from oil to Korea, Malaysia, Philippine, and Taiwan stock markets is significant during the Chinese crash. However, all Asian markets do not transmit return spillovers to the oil market. It implies that return spillover is unidirectional from oil to Korea, Malaysia, Philippine, and Taiwan stock markets during the Chinese crash. The coefficient of past own shock is significant in India, Indonesia, Malaysia, and Thailand stock markets. However, the sensitivity of past own volatility is significant in the majority Asian stock markets except for Korea. The coefficient of past own volatility is higher than the coefficient of past own shocks, thus past own volatility plays an important role in predicting future volatility in Asian Stock Markets.

The past shocks of the oil market do not significantly affect the volatility of majority Asian stock markets except Korea and Taiwan during the Chinese crash. The past shocks of just the Chinese equity market significantly affect the volatility of the Oil market during the Chinese crash. It implies that shock spillover is unidirectional from oil to Korea and Taiwan stock exchange, whereas unidirectional from the Chinese stock market to the oil market during the Chinese crash.

Volatility is transmitted from oil to Indian and Korean stock market during the Chinese crisis. However, there is significant evidence of volatility spillover from China, India, Korea, and Thailand stock markets to the oil Market. It implies that volatility spillover is bidirectional between oil-India and oil-Korea during the Chinese crash. The asymmetric coefficient of majority Asian markets is significant and positive except the Malaysian stock market, demonstrating that negative news of the oil market has more ability to increase the volatility of all emerging Asian Stock markets as compared to positive news. Furthermore, the majority asymmetric coefficients of the oil market are also positively significant, showing that negative unexpected shocks of majority Asian Stock markets will increase the volatility more in oil markets as compared to the positive shocks. Constant conditional correlation is positively significant for all pairs of oil and stock market.

4.3.4 Spillover Patterns during US Financial Crisis and Chinese Stock Market Crash

The return spillover is evident from oil to the majority emerging Asian stock markets, whereas the volatility is transmitted from oil to four Asian markets during full sample period. During US financial crisis, the return spillover is significant, whereas volatility transmission is insignificant from oil to majority Asian stock markets.

The return spillover is significant from oil to majority Asian markets, whereas volatility is not transmitted from oil to most of the Asian stock markets during Chinese crash. Overall, the risk of few emerging Asian stocks are sensitive to international oil prices during both crisis. Therefore, investors need to adjust the asset allocation of few stocks in oil-stock portfolio during the both crisis.

TABLE 4.11: Estimates of VAR(1)-AGARCH(1,1) Model for Oil and Asian Stock Markets during Chinese Stock Market Crash.

	CHN	**OIL**	**IND**	**OIL**	**INDO**	**OIL**	**KOR**	**OIL**	**MYS**	**OIL**
Panel A. Mean Equation										
Constant	0	4.E-04	4.E-04	2.E-04	-4.E-05	2.E-05	0	-0.001	0	-0.002
	[0.478]	[0.579]	[0.147]	[0.766]	[0.865]	[0.979]	[0.531]	[0.232]	[0.488]	[0.195]
r^s_{t-1}	0.049	0.088	0.153***	0.11	0.136**	2.51E-03	0.024	0.02	0.081*	-0.064
	[0.201]	[0.139]	[0.000]	[0.220]	[0.001]	[0.976]	[0.629]	[0.908]	[0.085]	[0.755]
r^o_{t-1}	0.032**	0.070**	0.017	0.022	0.021	0.060*	0.053***	0.087*	0.035***	0.095*
	[0.017]	[0.043]	[0.163]	[0.537]	[0.117]	[0.098]	[0.000]	[0.077]	[0.000]	[0.070]
Panel B. Variance Equation										
Constant	1e-06***	3.E-06	3e-06***	3.E-06	3.E-06	1.E-07	0.002	0	0	0
	[0.001]	[0.220]	[0.000]	[0.365]	[0.124]	[0.986]	[0.427]	[0.721]	[0.822]	[0.367]
$(e^s_{t-1})^2$	0.014	2e-03*	-0.082***	9E-04	0.053*	-2E-03	-0.028	0.004	0.100***	-0.002
	[0.383]	[0.053]	[0.000]	[0.638]	[0.096]	[0.313]	[0.504]	[0.270]	[0.009]	[0.122]
$(e^o_{t-1})^2$	0.026	0.027	0.257**	-0.011	-0.018	-6.66E-03	0.913**	0.028	0.021	0.025
	[0.134]	[0.141]	[0.022]	[0.257]	[0.911]	[0.772]	[0.020]	[0.294]	[0.977]	[0.553]
h^s_{t-1}	0.962***	(-5e-03**	0.856***	6e-03**	0.764***	0.011	-0.427	0.087***	0.822***	0.006
	[0.000]	[0.014]	[0.000]	[0.030]	[0.000]	[0.150]	[0.116]	[0.007]	[0.000]	[0.176]
h^o_{t-1}	-0.017	0.949***	-0.233*	0.960***	0.143	0.948***	0.289**	0.551**	2.22	0.675***
	[0.386]	[0.000]	[0.091]	[0.000]	[0.646]	[0.000]	[0.045]	[0.017]	[0.386]	[0.005]
Asymmetry	0.033*	0.029	0.202***	0.087***	0.173***	0.085	0.212***	0.197**	-0.001	0.297*
	[0.091]	[0.166]	[0.000]	[0.000]	[0.002]	[0.129]	[0.001]	[0.022]	[0.977]	[0.056]
Panel C. Correlations										
$\rho^{s,o}$	0.086**		0.100***		0.097***		0.185***		0.161***	
	[0.016]		[0.002]		[0.002]		[0.000]		[0.001]	
Panel D. Diagnostic Tests										
LogL	4383.5		4641.7		4641.7		2502.3		2618.8	

Aic	-9.939		-11.088		-11.215		-11.19		-11.603	
Sic	-9.645		-10.795		-10.921		-10.79		-11.203	
JB	414.28***	466.08***	249.89***	331..79***	663.56***	855.23***	167.27***	198.40***	40.767***	68.018***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	17.168	8.073	13.966	9.565	15.588	9.431	10.556	10.627	9.491	7.131
	[0.143]	[0.779]	[0.303]	[0.654]	[0.211]	[0.666]	[0.567]	[0.561]	[0.661]	[0.849]
$Q^2[12]$	20.263*	13.811	4.153	3.92	10.745	16.411	12.726	9.883	6.358	18.003
	[0.062]	[0.313]	[0.981]	[0.985]	[0.551]	[0.173]	[0.389]	[0.626]	[0.897]	[0.116]

	PAK	**OIL**	**PHL**	**OIL**	**TAIW**	**OIL**	**THA**	**OIL**
Panel A. Mean Equation								
Constant	4.E-04	3.E-04	-5.E-05	-7.E-05	2.E-05	5.E-04	7.E-05	1.E-04
	[0.177]	[0.706]	[0.898]	[0.918]	[0.941]	[0.453]	[0.710]	[0.879]
r^s_{t-1}	0.289***	-0.015	0.044	0.113	0.094**	-0.014	0.158***	0.196
	[0.000]	[0.845]	[0.291]	[0.125]	[0.015]	[0.880]	[0.000]	[0.524]
r^o_{t-1}	0.016	0.077**	0.062***	0.069**	0.057***	0.037**	0.015	0.070*
	[0.161]	[0.046]	[0.000]	[0.049]	[0.000]	[0.021]	[0.138]	[0.053]
Panel B. Variance Equation								
Constant	5e-06***	5E-06	5E-06	-7E-06	5e-06***	3E-06	1e-06**	6E-07
	[0.001]	[0.110]	[0.255]	[0.459]	[0.004]	[0.534]	[0.042]	[0.758]
$(e^s_{t-1})^2$	-0.011	1.1E-03	0.018	-2E-03	-0.031	9E-04	-0.036*	-2E-03
	[0.581]	[0.415]	[0.687]	[0.541]	[0.150]	[0.696]	[0.074]	[0.124]
$(e^o_{t-1})^2$	0.012	2E-03	7E-03	-0.017	0.185*	-7E-03	0.086	6E-03
	[0.746]	[0.877]	[0.966]	[0.142]	[0.097]	[0.354]	[0.477]	[0.642]
h^s_{t-1}	0.835***	-3E-03	0.845***	7E-03	0.722***	8E-03	0.777***	0.010**
	[0.000]	[0.184]	[0.000]	[0.577]	[0.000]	[0.164]	[0.000]	[0.015]

h^{o}_{t-1}	-0.033	0.957***	0.138	0.968***	-0.205	0.971***	0.193	0.946***
	[0.299]	[0.000]	[0.708]	[0.000]	[0.310]	[0.000]	[0.434]	[0.000]
Asymmetry	0.264***	0.073***	0.103***	0.078***	0.264***	0.064***	0.266***	0.042**
	[0.000]	[0.001]	[0.004]	[0.000]	[0.000]	[0.000]	[0.000]	[0.025]
Panel C. Correlations								
$\rho^{s,o}$	0.086**		0.083**		0.098***		0.107***	
	[0.013]		[0.019]		[0.004]		[0.002]	
Panel D. Diagnostic Tests								
LogL	4568.1		4449.7		4645.5		4768.2	
Aic	-11.022		-11.059		-11.236		-11.491	
Sic	-10.728		-10.765		-10.942		-11.197	
JB	38.763***	54.888***	275.08***	122.36***	127.50***	152.30***	71.062***	82.969***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	12.165	9.165	9.654	8.827	12.048	9.824	5.066	10.443
	[0.433]	[0.689]	[0.646]	[0.718]	[0.442]	[0.631]	[0.956]	[0.577]
Q^2[12]	8.133	14.74	3.033	15.671	8.341	3.014	24.439**	13.386
	[0.775]	[0.256]	[0.995]	[0.207]	[0.758]	[0.995]	[0.018]	[0.342]

Notes: ^{s}, ^{o} and [ ] denote the Asian stock, oil market and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

4.4 Spillover between Oil and Latin American Stock Markets

This section provides the results of spillovers between oil and LAS markets during all sample periods.

4.4.1 Linkages between Oil and Latin American Stock Markets during the Full Sample Period [Jan 2001-Jul 2018]

Table 4.12 represents the findings of spillovers between oil and Latin American stock(LAS) market during the full sample period. The current stock returns of LAS markets are significantly affected by the past own stock returns. It suggests that the change in past stock price helps to predict current stock prices in the short run for emerging LAS markets. Furthermore, one period lagged oil returns significantly affect the current oil returns during the full sample period. It implies that future oil price can also be predicted through past oil prices in the short run. The return spillover from oil to Brazil and Peru markets is found to be significant. However, the mean spillover from Brazil and Mexico to oil market is found to be significant during the full sample period.

The results reveal that the sensitivity of past own shocks is significantly positive for all LAS markets in the short run. Furthermore, the sensitivity of past own volatility is also significant for all LAS markets. The coefficient of past own shock is smaller as compared to the coefficient of the past own volatility in all LAS markets, suggesting that past own volatility is a more important factor to predict future volatility as compared to past own shocks. In addition, the sensitivity of past own shocks and volatility is significant for oil markets in the short run.

The conditional volatility of Brazil stock markets is significantly affected by the shocks in the oil market. Therefore, oil market shocks lead to an increase in the volatility of Brazil stock market. Moreover, the conditional volatility of the oil market is not significantly affected by the shocks in LAS markets. It infers that shock spillover is unidirectional from oil to Brazil stock market during a full sample period.

The findings reveal that volatility is not significantly transmitted from the oil market to LAS markets. In contrast, (Fayyad and Daly, 2011) find a significant volatility spillover between oil and stock markets. Furthermore, the past volatility of the majority LAS markets (Except the Brazil) does not transmit to the oil markets. It suggests that risk spillover is unidirectional from Brazil to oil market during the full sample period.

The asymmetric coefficients of all LAS markets are significant and positive, revealing that negative news (or unexpected shock) of the oil market has more ability to increase the volatility of all LAS markets as compared to positive news. In addition, the asymmetric coefficient of the oil market is positively significant, showing that negative unexpected shock of the majority LAS markets will increase the volatility more in oil markets as compared to the positive shock. Constant conditional correlation (CCC) is positively significant for all pairs of oil and stock markets. But cross-market correlation is weak in almost all pairs, indicate that investors can get substantial gain by having these pairs in the same portfolio.

4.4.2 Linkages between Oil and Latin American Stock Markets during the US Financial Crisis [Aug 2007-July 2010]

Table 4.13 reports the findings of spillovers between oil and Latin American stock markets(LAS) during the US financial crisis. The lag returns significantly affects the current returns of majority LAS markets (except Mexico). Moreover, current oil returns are significantly affected by the past own oil returns in majority cases during the US financial crisis. It implies that past stock prices and oil prices help to predict future prices in the short run.

Table 4.12: Estimates of VAR(1)-AGARCH(1,1) Model for Oil and Latin American Stock Markets during Full Sample Period.

	BRAZ	OIL	CHIL	OIL	MEXI	OIL	PERU	OIL
Panel A. Mean Equation								
Constant	4E-04	1E-04	3e-04***	7E-05	2e-04**	1E-04	4E-04	6E-05
	[0.121]	[0.674]	[0.003]	[0.789]	[0.039]	[0.695]	[0.001]	[0.831]
r^s_{t-1}	0.056***	0.097***	0.206***	0.043	0.108***	0.081***	0.241***	0.082
	[0.000]	[0.000]	[0.000]	[0.134]	[0.000]	[0.001]	[0.000]	[0.110]
r^o_{t-1}	0.020*	0.050***	8E-03	0.066***	3E-03	0.057***	0.017***	0.055***
	[0.053]	[0.001]	[0.137]	[0.000]	[0.694]	[0.000]	[0.009]	[0.000]
Panel B. Variance Equation								
Constant	9e-06***	7E-07	2e-06***	6E-07	1e-06***	9E-07	4e-06***	1e-06**
	[0.000]	[0.356]	[0.000]	[0.374]	[0.000]	[0.104]	[0.000]	[0.017]
$(e^s_{t-1})^2$	0.024***	3E-03	0.050***	-1e-03***	0.019***	-1E-03	0.116***	2E-03
	[0.005]	[0.337]	[0.000]	[0.193]	[0.005]	[0.214]	[0.000]	[0.140]
$(e^o_{t-1})^2$	0.020***	0.023***	-0.011	0.018***	0.015	0.021***	9E-03	0.024***
	[0.001]	[0.000]	[0.412]	[0.000]	[0.135]	[0.000]	[0.302]	[0.000]
h^s_{t-1}	0.858***	0.012**	0.851***	4E-03	0.905***	3E-03	0.809***	-1E-03
	[0.000]	[0.013]	[0.000]	[0.108]	[0.000]	[0.110]	[0.000]	[0.403]
h^o_{t-1}	-0.013	0.954***	0.02	0.957***	-5E-04	0.951***	-9E-03	0.952***

	[0.144]	[0.000]	[0.232]	[0.000]	[0.970]	[0.000]	[0.396]	[0.000]
Asymmetry	0.123***	0.039***	0.124***	0.047***	0.120***	0.046***	0.084***	0.045***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Panel C. Correlations								
$\rho^{s,o}$	0.153***		0.091***		0.123***		0.192***	
	[0.000]		[0.000]		[0.000]		[0.000]	
Panel D. Diagnostic Tests								
LogL	2511.33		2825.46		2707.72		2727.5	
Aic	-9.86		-9.638		-9.054		-8.877	
Sic	-9.466		-9.244		-8.66		-8.482	
JB	275.52***	440.39***	2444.7***	550.66***	347.38***	492.30***	785.82***	587.31***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	10.416	5.61	17.192	4.405	7.156	4.56	51.996***	4.075
	[0.580]	[0.934]	[0.143]	[0.975]	[0.847]	[0.971]	[0.000]	[0.982]
Q^2[12]	17.115	19.062*	5.683	24.584**	11.272	18.325	9.433	22.652**
	[0.145]	[0.087]	[0.931]	[0.017]	[0.506]	[0.106]	[0.666]	[0.031]

Notes: ^{s}, ^{o} and [ ] denote the LA stock, oil market and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

Table 4.13: Estimates of VAR(1)-AGARCH(1,1) Model for Oil and Latin American Stock Markets during US Financial Crisis.

	BRAZ	**OIL**	**CHIL**	**OIL**	**MEXI**	**OIL**	**PERU**	**OIL**
Panel A. Mean Equation								
Constant	1E-04	6E-04	5E-04	7E-04	-5E-04	6E-04	-3E-04	7E-04
	[0.865]	[0.458]	[0.187]	[0.387]	[0.280]	[0.411]	[0.600]	[0.375]
r^s_{t-1}	0.072**	0.203***	0.214***	0.043	0.05	0.183***	0.227***	0.075
	[0.047]	[0.000]	[0.000]	[0.544]	[0.177]	[0.001]	[0.000]	[0.117]
r^o_{t-1}	4E-03	0.044***	-0.012	0.079**	-6E-03	0.051	-8E-03	0.070*
	[0.886]	[0.023]	[0.366]	[0.027]	[0.774]	[0.141]	[0.708]	[0.067]
Panel B. Variance Equation								
Constant	1E-06	3E-06	4e-06**	8E-06	-1E-06	5E-06	1e-05***	9e-06*
	[0.784]	[0.153]	[0.012]	[0.121]	[0.544]	[0.293]	[0.000]	[0.060]
$(e^s_{t-1})^2$	-2E-03	-9E-03	0.041	-3E-04	-0.03	-5E-03	0.153***	0.015
	[0.892]	[0.217]	[0.171]	[0.840]	[0.170]	[0.130]	[0.000]	[0.139]
$(e^o_{t-1})^2$	9E-03	8E-03	-0.015	0.012	-0.044	0.016	-3E-03	0.02
	[0.443]	[0.588]	[0.610]	[0.330]	[0.118]	[0.326]	[0.863]	[0.173]
h^s_{t-1}	0.844***	0.041**	0.804***	3E-03	0.908***	0.021*	0.741***	-0.013
	[0.000]	[0.024]	[0.000]	[0.199]	[0.000]	[0.076]	[0.000]	[0.183]
h^o_{t-1}	0.013	0.963***	0.022	0.945***	0.109*	0.939***	9E-03	0.935***

	[0.423]	[0.000]	[0.639]	[0.000]	[0.079]	[0.000]	[0.720]	[0.000]
Asymmetry	0.227***	0.012**	0.213***	0.059***	0.175***	0.025***	0.167***	0.056**
	[0.000]	[0.049]	[0.000]	[0.008]	[0.000]	[0.026]	[0.003]	[0.021]
Panel C. Correlations								
$\rho^{s,o}$	0.253***		0.177***		0.221***		0.367***	
	[0.000]		[0.000]		[0.000]		[0.000]	
Panel D. Diagnostic Tests								
LogL	3765.7		4221.1		3977.7		3944.2	
Aic	-8.942		-9.98		-9.511		-9.247	
Sic	-8.649		-9.699		-9.217		-8.954	
JB	437.09***	409.46***	502.90***	489.81***	434.01***	654.32***	598.20***	656.09***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	4.73	11.54	5.973	9.511	4.28	8.751	13.119	15.45
	[0.966]	[0.483]	[0.917]	[0.659]	[0.978]	[0.724]	[0.360]	[0.218]
$Q^2[12]$	10.344	15.852	8.042	10.62	22.908**	12.575	6.562	16.448
	[0.586]	[0.198]	[0.782]	[0.562]	[0.029]	[0.401]	[0.885]	[0.172]

Notes: ^{s}, ^{o} and [ ] denote the LA stock, oil market and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

Mean spillover from oil to LAS markets is highly insignificant. In addition, the mean transmission effect from Brazil and Mexico stock markets to oil markets is highly significant. Thus, there is evidence of unidirectional return spillover from Brazil and Mexico to the oil market during the US financial crisis.

The coefficients of past own shocks of majority Latin American markets (except Peru) are insignificant. Furthermore, the sensitivity of past own shocks of oil prices is not significant during the US financial crisis. The sensitivity of past own volatility is significant for all LAS markets. Moreover, the coefficient of past own volatility is also significant and positive for the oil market during the US financial crisis. The coefficient of past own volatility is higher than the coefficient of the past own shock in all LAS markets, suggesting that past own volatility is a more important factor to predict future volatility as compared to past own shocks.

The shocks in oil markets do not significantly affect the conditional volatility of the LAS markets. Moreover, the conditional volatility of the oil market is not affected by the shocks in LAS markets during the US financial crisis. The volatility spillover is evident from oil to Mexico stock market. However, the conditional volatility of oil markets is significantly affected by the past volatility of Brazil and Mexico. It implies that volatility spillover is bidirectional between the oil and Mexico stock market during the US financial crisis.

The asymmetric coefficients of all LAS markets are positively significant, showing that negative news (or unexpected shock) of the oil market has more ability to increase the volatility of all LAS markets as compared to positive news. Constant conditional correlation (CCC) is positively significant for all pairs of oil and stock markets.

4.4.3 Linkages between Oil and Latin American Stock Markets during the Chinese Stock Market Crash [Jun 2015-May 2018]

Table 4.14 represents the findings of spillovers between oil and emerging Latin American stock(LAS) markets during the Chinese crash. The one period lagged stock returns significantly affect the current stock returns of majority LAS markets (except Brazil). Therefore, returns become unpredictable for the short run in majority LAS markets during the Chinese crash. Moreover, past returns of the oil market significantly affect the current returns in majority cases. It suggests that the change in past oil prices helps to predict future oil prices in the short run.

The mean transmission from oil to LAS markets is not significant during the Chinese crash. However, majority LAS markets (except Brazil) do not transmit return spillover to the oil market. It implies that return spillover is unidirectional from brazil to oil markets during the Chinese crash.

The coefficient of past own shock is significant in Chile and Mexico stock markets. However, the sensitivity of past own volatility is significant in the Latin American stock markets. The coefficient of past own volatility is higher than the coefficient of past own shocks, thus past own volatility plays an important role in predicting future volatility in Latin American Stock Markets. The past shocks of the oil market do not significantly affect the volatility of LAS markets during the Chinese crash. The past shocks of the LAS markets do not significantly affect the volatility of the oil market during the Chinese crash.

The volatility is not transmitted from oil to LAS markets during the Chinese crisis. However, there is significant evidence of volatility spillover from Brazil and Mexico stock markets to the oil Market during the Chinese crash. It implies that volatility spillover is unidirectional from Brazil and Mexico to oil markets during Chinese crash. The asymmetric coefficients of majority LAS markets are positively significant, showing that negative news of the oil market has more ability to increase the volatility of emerging LAS markets as compared to positive news. Furthermore, the majority asymmetric coefficients of the oil market are also significant and positive, showing that negative unexpected shocks of majority LAS markets will increase the volatility more in oil markets as compared to the positive shocks. Constant conditional correlation is positively significant for all pairs of oil and stock market.

Table 4.14: Estimates of VAR(1)-AGARCH(1,1) Model for Oil and Latin American Stock Markets during Chinese Stock Market Crash.

	BRAZ	**OIL**	**CHIL**	**OIL**	**MEXI**	**OIL**	**PERU**	**OIL**
Panel A. Mean Equation								
Constant	0.001	0	3.34E-04	1E-04	-2E-05	3E-04	3E-04	-1E-04
	[0.257]	[0.893]	[0.140]	[0.839]	[0.925]	[0.684]	[0.251]	[0.856]
r^s_{t-1}	0.04	0.114**	0.201***	0.02	0.116***	0.113	0.235***	0.15
	[0.279]	[0.043]	[0.000]	[0.831]	[0.002]	[0.229]	[0.000]	[0.185]
r^o_{t-1}	0.023	0.067*	0.016	0.077**	-7E-03	0.063*	2E-03	0.061
	[0.311]	[0.062]	[0.110]	[0.025]	[0.571]	[0.086]	[0.859]	[0.106]
Panel B. Variance Equation								
Constant	0.000***	0	1e-05***	8e-06***	1e-05**	-9E-06	3e-06**	1E-07
	[0.004]	[0.573]	[0.003]	[0.001]	[0.017]	[0.364]	[0.011]	[0.957]
$(e^s_{t-1})^2$	0.039	0.013	0.426***	-2E-03	0.125**	-2E-03	0.012	-5E-04
	[0.229]	[0.296]	[0.000]	[0.216]	[0.016]	[0.278]	[0.553]	[0.845]
$(e^o_{t-1})^2$	0.023	0.036*	-0.019	0.016	0.026	-0.012	-0.049	6E-03
	[0.444]	[0.097]	[0.465]	[0.151]	[0.868]	[0.215]	[0.243]	[0.567]
h^s_{t-1}	0.307***	0.123***	0.476***	3E-04	0.516***	0.018**	0.794***	0.011
	[0.007]	[0.002]	[0.000]	[0.938]	[0.000]	[0.026]	[0.000]	[0.106]

h^o_{t-1}	0.023	0.918***	-9E-03	0.935***	0.279	0.961***	0.118	0.955***
	[0.760]	[0.000]	[0.808]	[0.000]	[0.537]	[0.000]	[0.174]	[0.000]
Asymmetry	0.328***	0.045**	-0.234**	0.076***	0.079**	0.069***	0.169***	0.061***
	[0.001]	[0.080]	[0.041]	[0.002]	[0.030]	[0.000]	[0.000]	[0.007]
Panel C. Correlations								
$\rho^{s,o}$	0.248***		0.227***		0.196***		0.259***	
	[0.000]		[0.000]		[0.000]		[0.000]	
Panel D. Diagnostic Tests								
LogL	4507.9		4709.062		4645.89		4575.811	
Aic	-10.242		-11.48		-11.421		-11.099	
Sic	12		-11.186		-11.128		-10.805	
JB	653.53***	1197.6***	703.83***	384.54***	408.97***	406.19***	375.02***	356.87***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	8.228	11.729	11.584	10.551	13.436	7.388	11.579	7.123
	[0.767]	[0.468]	[0.480]	[0.568]	[0.338]	[0.831]	[0.480]	[0.849]
Q^2[12]	5.306	13.302	12.541	11.426	9.618	9.245	9.573	6.251
	[0.947]	[0.348]	[0.403]	[0.493]	[0.649]	[0.682]	[0.653]	[0.903]

Notes: ^{s}, ^{o} and [ ] denote the LA stock, oil market and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

4.4.4 Spillovers Patterns during US Financial Crisis and Chinese Stock Market Crash

The return spillover is evident from oil to Brazil and Peru stock markets, whereas volatility is not transmitted from oil to LAS markets during full sample period. During US financial crisis, the return and volatility transmission from oil to most of the LAS markets is highly insignificant.

The return and volatility is also insignificant from oil to LAS markets during Chinese crash. It implies that most of the LAS markets are not sensitive to the risk of oil prices. The LAS markets also provides the diversification opportunities to the portfolio investors of the oil-stock pairs.

4.5 Spillover between Gold and Asian Stock Markets

This section provides the results of spillovers between gold and Asian stock markets during all sample periods.

4.5.1 Linkages between Gold and Asian Stock Markets during the Full Sample Period [Jan 2001-Jul 2018]

Table 4.15 represents the results of spillover between Gold and Asian emerging stock markets during full sample period. The current stock returns of all Asian markets are significantly affected by the lag returns. This shows that change in past stock prices helps to predict current stock prices in short-run for emerging Asian stock markets. Furthermore, lagged gold returns significantly affect the current gold returns.

The return spillover from gold to China, Indonesia, Malaysia, Thailand, and Taiwan equity markets is highly significant. These findings are similar to the results of (Miyazaki and Hamori, 2013), they report the significant return spillover from gold to equity markets. This reveals that the mean effect of gold market is significantly transmitted to the majority Asian equity markets. Moreover, the mean transmission from all Asian stock markets to Gold market is highly insignificant except India, Korea, and Malaysia.

The results reveal that the lag shock effect is significantly positive for all Asian stock markets in short run. Furthermore, the sensitivity of past own volatility is also statistically significant for Asian emerging equity markets, therefore ARCH (1) model is more suitable for estimations. The coefficient of past own shock is smaller as compared to the coefficient of the past own volatility in all Asian emerging stock markets, proposing that past volatility is more valuable factor to forecast future volatility as compared to past own shocks. In addition, the sensitivity of past own shocks and volatility are significantly affected the volatility of Gold markets.

The gold asset market shocks significantly and inversely impacts the conditional-volatility of Malaysia and Philippine stock markets. Therefore, gold market shocks lead towards the decline in volatility of Malaysia and Philippine equity markets. The gold market volatility is influenced by the shocks in equity markets of India, Indonesia, Korea, Philippines, and Taiwan. The past-volatility of Gold market do not significantly influence the conditional volatility of the majority Asian emerging stock markets (except Malaysia). Thus, only Malaysian market volatility is influenced by the gold market volatility. Furthermore, past volatility of the majority Asian stock markets (Except Korea, Philippine, and Taiwan) does not transmit to the Gold markets. In contrast, (Arouri et al., 2015) find a significant volatility transmission between gold and equity market.

The asymmetric coefficients of all Asian stock markets are positive and significant, which infers that the negative news (or unexpected shock) of gold market has more ability to increase the volatility of all Asian Stock markets as compared to positive news. In addition, the asymmetric coefficient of gold market is negatively significant, showing that negative unexpected shock of emerging Asian Stock markets will decrease the volatility more in gold markets as compared to the positive shock. Constant conditional correlation (CCC) is positively significant for majority pairs of gold and stock markets.

TABLE 4.15: Estimates of VAR(1)-AGARCH(1,1) Model for Gold and Asian Stock Markets during Full Sample Period.

	CHN	**GOLD**	**IND**	**GOLD**	**KOR**	**GOLD**	**INDO**	**GOLD**	**MYS**	**GOLD**
Panel A. Mean Equation										
Constant	3e-04**	3e-04***	4e-04***	3e-04***	2e-04**	3e-04***	5e-04***	3e-04***	1e-04**	3e-04***
	[0.020]	[0.004]	[0.001]	[0.005]	[0.035]	[0.004]	[0.000]	[0.005]	[0.049]	[0.006]
r^s_{t-1}	0.056***	7E-03	0.138***	0.016*	0.082***	0.020**	0.151***	0.013	0.193***	0.037**
	[0.000	[0.461]	[0.000]	[0.099]	[0.000]	[0.019]	[0.000]	[0.221]	[0.000]	[0.016]
r^g_{t-1}	-0.027***	0.051***	0.016	0.050***	-2E-03	0.053***	0.043***	0.049***	0.022**	0.052***
	[0.098]	[0.001]	[0.268]	[0.003]	[0.857]	[0.002]	[0.005]	[0.001]	[0.005]	[0.002]
Panel B. Variance Equation										
Constant	1e-06***	1e-06***	2e-06***	2e-06***	1e-06***	2e-06***	4e-06***	1e-06***	7e-07***	1e-06***
	[0.003]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$(e^s_{t-1})^2$	0.066***	-2E-03	0.052***	0.023***	0.026***	8e-03*	0.070***	0.015**	0.082***	3E-04
	[0.000]	[0.600]	[0.000]	[0.001]	[0.000]	[0.099]	[0.000]	[0.026]	[0.000]	[0.784]
$(e^g_{t-1})^2$	1E-03	0.077***	-2E-03	0.078***	2E-03	0.077***	5.e-03*	0.076***	-0.011***	0.082***
	[0.184]	[0.000]	[0.270]	[0.000]	[0.261]	[0.000]	[0.076]	[0.000]	[0.001]	[0.000]
h^s_{t-1}	0.920***	6E-03	0.869***	-4E-03	0.931***	-0.013**	0.830***	0.012	0.873***	1E-03
	[0.000]	[0.317]	[0.000]	[0.678]	[0.000]	[0.025]	[0.000]	[0.383]	[0.000]	[0.445]
h^g_{t-1}	1E-03	0.915***	2E-03	0.917***	-3E-03	0.919***	-5E-03	0.920***	0.015***	0.911***
	[0.180]	[0.000]	[0.215]	[0.000]	[0.116]	[0.000]	[0.187]	[0.000]	[0.001]	[0.000]
Asymmetry	0.022***	-0.021**	0.113***	-0.022**	0.075*	-0.023***	0.112***	-0.022**	0.075***	-0.021**
	[0.003]	[0.021]	[0.000]	[0.012]	[0.000]	[0.005]	[0.000]	[0.023]	[0.000]	[0.040]
Panel C. Correlations										
$\rho^{s,g}$	0.064***		0.044***		0.052***		0.080***		0.043***	
	[0.000]		[0.001]		[0.000]		[0.000]		[0.002]	
Panel D. Diagnostic Tests										
LogL	29264.4		29827.4		29804.8		29972.4		32600.4	

Aic	-9.852		-9.801		-10.199		-10.179		-11.356	
Sic	-9.458		-9.407		-10.15		-9.987		-10.962	
JB	1518.3***	5714.0***	705.15***	5606.6***	621.96***	5261.4***	1254.5***	5716.1***	1518.2***	4836.2***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	53.297***	7.353	18.165	6.823	9.706	6.922	10.29	6.457	15.808	7.237
	[0.000]	[0.833]	[0.111]	[0.869]	[0.642]	[0.863]	[0.590]	[0.891]	[0.200]	[0.842]
Q^2[12]	10.748	10.671	11.793	9.954	5.603	10.277	18.588	9.578	20.236*	10.337
	[0.551]	[0.557]	[0.462]	[0.620]	[0.935]	[0.592]	[0.273]	[0.653]	[0.063]	[0.586]

	PAK	**GOLD**	**PHL**	**GOLD**	**THA**	**GOLD**	**TAIW**	**GOLD**
Panel A. Mean Equation								
Constant	1e-03***	1E-04	3e-04**	3e-04***	5e-04***	3e-04**	2e-04*	3e-04***
	[0.000]	[0.667]	[0.034]	[0.002]	[0.000]	[0.014]	[0.066]	[0.002]
r^s_{t-1}	0.182***	0.011	0.148***	0.012	0.118***	0.019	0.101***	2E-04
	[0.000]	[0.612]	[0.000]	[0.273]	[0.000]	[0.132]	[0.000]	[0.980]
r^g_{t-1}	0.012	0.035	0.015	0.050***	0.054***	0.052***	0.041***	0.053***
	[0.537]	[0.186]	[0.364]	[0.001]	[0.001]	[0.001]	[0.002]	[0.001]
Panel B. Variance Equation								
Constant	2E-06	4e-06***	1e-05***	1e-06***	-1E-07	6e-07*	1e-06***	2e-06***
	[0.225]	[0.008]	[0.000]	[0.000]	[0.871]	[0.054]	[0.000]	[0.000]
$(e^s_{t-1})^2$	0.044***	4E-03	0.053***	0.020**	0.072***	3E-03	0.032***	8e-03***
	[0.005]	[0.650]	[0.000]	[0.019]	[0.000]	[0.727]	[0.000]	[0.001]
$(e^g_{t-1})^2$	0.014	0.02	(-1e-03**	0.081***	7E-03	0.044***	-2E-03	0.080***
	[0.204]	[0.153]	[0.017]	[0.000]	[0.123]	[0.001]	[0.244]	[0.000]
h^s_{t-1}	0.795***	0.027	0.798***	-0.019*	0.835***	0.057***	0.920***	(-6e-03*
	[0.000]	[0.132]	[0.000]	[0.085]	[0.000]	[0.000]	[0.000]	[0.066]

h^{g}_{t-1}	6E-03	0.903***	4E-03	0.915***	-6E-03	0.959***	6E-04	0.915***
	[0.603]	[0.000]	[0.153]	[0.000]	[0.328]	[0.000]	[0.750]	[0.000]
Asymmetry	0.253***	0.058**	0.107***	-0.025***	0.123***	-0.019**	0.079***	-0.022**
	[0.000]	[0.018]	[0.000]	[0.008]	[0.000]	[0.018]	[0.000]	[0.011]
Panel C. Correlations								
$\rho^{s,g}$	-0.01		0.049***		0.039***		0.038***	
	[0.644]		[0.001]		[0.002]		[0.006]	
Panel D. Diagnostic Tests								
LogL	10718.6		29847.9		30087.8		30093.5	
Aic	-12.232		-10.542		-10.39		-10.396	
Sic	-12.062		-10.148		-9.965		-10.001	
JB	1694.9***	3658.2***	1167.1***	5399.9***	1039.8***	7411.5***	460.71***	5459.3***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	53.183***	7.398	14.006	6.835	34.730***	6.269	25.856**	6.776
	[0.000]	[0.830]	[0.300]	[0.868]	[0.001]	[0.902]	[0.011]	[0.872]
$Q^2[12]$	9.709	3.707	5.554	10.509	1.155	16.903	11.582	10.4
	[0.641]	[0.988]	[0.937]	[0.571]	[0.923]	[0.153]	[0.480]	[0.581]

Notes: ^{s}, ^{g} and [ ] denote the Asian stock, gold market and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

4.5.2 Linkages between Gold and Asian Stock Markets during the US Financial Crisis Period [Aug 2007-July 2010]

Table 4.16 presents the findings of spillovers between gold and Asian emerging stock market during the US financial crisis. The lag returns significantly influence the current returns of all Asian emerging markets. Moreover, current gold returns are significantly influenced by their lag returns during US financial crisis. These findings reveal that past stock prices and gold prices help us to predict prices in the short run.

The return spillover from gold to majority Asian markets (except Indonesia and Malaysia) is highly insignificant. Besides, the mean transmission effect from majority Asian markets (except India) to gold markets is highly insignificant during US financial crisis.

The past own shocks of India, Malaysia, Philippine, and Thailand are found to be significant. Furthermore, the gold market volatility is significantly affected by their lag shocks during US financial crisis. The sensitivity of past own volatility is significant for all Asian stock markets. Moreover, the coefficient of past own volatility is also significant and positive for gold market during US financial crisis. The coefficient of past own volatility is higher than the coefficient of the past own shock in all Asian stock markets, suggesting that lag volatility is a more important factor to forecast volatility as compared to past own shocks.

The shocks in gold markets significantly influence the volatility of Indonesia, Malaysia, and Taiwan stock markets. Furthermore, the gold market volatility is influenced by shocks in China, Korea, Philippine, Taiwan, and Thailand equity markets in US financial crisis. The past volatility of Indonesia, Malaysia and Taiwan stock markets are significantly affected by the volatility in gold markets. The gold market volatility is significantly influenced by the volatility of Indonesia, Korea, Philippine, and Thailand equity markets in US financial crisis. The asymmetric coefficients of Asian stock markets are significant and positive, showing that negative news (or unexpected shock) of gold market has more ability to increase the volatility of all Asian equity markets as compared to the positive news. The constant conditional correlation is positively significant for majority pairs of gold and stock markets except for Pakistan and Philippine.

4.5.3 Linkages between Gold and Asian Stock Markets during the Chinese Stock Market Crash [Jun 2015-May 2018]

Table 4.17 represents the results of spillovers between gold and Asian stock markets during Chinese crash. The lag stock returns influence the current stock returns of majority Asian stock markets (except Korea) during Chinese crash. Thus, returns become predictable for the short run in the majority Asian stock market during Chinese crash. Moreover, past returns of gold market insignificantly influence the current returns during Chinese crash. Thus, Gold returns become unpredictable for the short run in Gold market during Chinese crash.

The return transmission is found to be significant from Gold to China, India, Pakistan, and Thailand stock markets during Chinese crash. However, India, Indonesia, and Malaysia stock markets transmit mean effect to gold market. The coefficient of past own shock is significant in the majority Asian stock markets. Moreover, the sensitivity of past own volatility is significant in all Asian equity markets. The coefficient of lag volatility is higher as compared to the coefficient of past own shocks, thus past own volatility plays an important role in predicting future volatility in Asian Stock markets. The gold market shocks influence the conditional volatility of the China, Indonesia, Korea, Malaysia, and Taiwan stock markets during Chinese crash. The past shocks of majority Asian equity markets (except Malaysia) do not significantly affect the conditional volatility of gold market during Chinese crash.

Table 4.16: Estimates of VAR(1)-AGARCH(1,1) Model for Gold and Asian Stock Markets during US Financial Crisis.

	CHN	**GOLD**	**IND**	**GOLD**	**KOR**	**GOLD**	**INDO**	**GOLD**	**MYS**	**GOLD**
Panel A. Mean Equation										
Constant	1E-04	1e-03**	1e-03***	9e-04***	-9E-06	7E-04	3E-04	1e-03***	2e-04**	6e-04***
	[0.878]	[0.011]	[0.002]	[0.004]	[0.986]	[0.118]	[0.532]	[0.004]	[0.042]	[0.007]
r^s_{t-1}	0.068*	0.029	0.154***	0.038**	0.067*	-0.03	0.144***	4E-03	0.205***	0.039
	[0.070]	[0.221]	[0.000]	[0.043]	[0.074]	[0.416]	[0.000]	[0.850]	[0.000]	[0.299]
r^g_{t-1}	-7E-03	0.083**	5E-03	0.077**	-0.052	0.078**	0.106**	0.068*	0.043***	0.077***
	[0.906]	[0.025]	[0.853]	[0.011]	[0.210]	[0.048]	[0.014]	[0.039]	[0.001]	[0.002]
Panel B. Variance Equation										
Constant	1e-05***	-1E-06	6e-06***	2E-06	6e-06**	1e-05*	2e-05***	4E-07	1e-06**	3E-07
	[0.001]	[0.354]	[0.002]	[0.151]	[0.012]	[0.083]	[0.004]	[0.810]	[0.013]	[0.355]
$(e^s_{t-1})^2$	4E-05	0.066*	0.094***	0.029	-0.022	0.055***	-0.017	0.051	0.102***	-2E-04
	[0.998]	[0.100]	[0.000]	[0.152]	[0.102]	[0.000]	[0.509]	[0.221]	[0.000]	[0.895]
$(e^g_{t-1})^2$	-9E-04	0.059***	4E-03	0.071***	0.029	-0.037	-0.011*	0.052***	-0.016*	0.068***
	[0.867]	[0.004]	[0.423]	[0.000]	[0.182]	[0.148]	[0.055]	[0.006]	[0.081]	[0.000]
h^s_{t-1}	0.854***	-0.018	0.836***	-0.024	0.956***	-0.088**	0.493***	0.232***	0.834***	3E-03
	[0.000]	[0.716]	[0.000]	[0.397]	[0.000]	[0.028]	[0.000]	[0.003]	[0.000]	[0.283]
h^g_{t-1}	0.015	0.926***	-7E-04	0.925***	0.069	0.767***	0.031**	0.925***	0.023*	0.947***
	[0.111]	[0.000]	[0.908]	[0.000]	[0.161]	[0.000]	[0.031]	[0.000]	[0.074]	[0.000]
Asymmetry	0.147***	-0.013	0.120***	-0.017	0.122***	0.172***	0.464***	-0.017	0.088***	-0.037***
	[0.000]	[0.575]	[0.001]	[0.434]	[0.000]	[0.000]	[0.000]	[0.421]	[0.002]	[0.001]
Panel C. Correlations										
$\rho^{s,g}$	0.112***		0.152***		0.093***		0.099***		0.122***	
	[0.001]		[0.000]		[0.008]		[0.002]		[0.000]	
Panel D. Diagnostic Tests										
LogL	4192.65		7362.49		4398.5		4374.09		12036.4	

Aic	-10.153		-10.769		-10.629		-10.606		-12.553	
Sic	-10.027		-10.573		-10.336		-10.313		-12.403	
JB	379.81***	642.07***	445.27***	42.865***	353.56***	682.97***	427.25***	637.25***	415.89***	101.25***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	12.903	5.456	17.395	12.223	12.143	7.154	11.272	6.13	13.302	10.274
	[0.376]	[0.941]	[0.135]	[0.428]	[0.434]	[0.847]	[0.506]	[0.909]	[0.347]	[0.592]
Q^2[12]	10.369	15.108	8.179	5.259	8.306	16.515	6.718	15.086	8.344	5.68
	[0.584]	[0.236]	[0.771]	[0.949]	[0.761]	[0.169]	[0.876]	[0.237]	[0.758]	[0.931]

	PAK	**GOLD**	**PHL**	**GOLD**	**THA**	**GOLD**	**TAIW**	**GOLD**
Panel A. Mean Equation								
Constant	2e-03***	8e-04*	4E-04	1e-03***	8e-04*	1e-03***	0	0.001**
	[0.000]	[0.082]	[0.464]	[0.001]	[0.087]	[0.008]	[0.697]	[0.023]
r^s_{t-1}	0.085**	0.018	0.132***	-4E-03	0.116***	0.011	0.120***	-0.037
	[0.043]	[0.636]	[0.001]	[0.876]	[0.001]	[0.714]	[0.002]	[0.180]
r^g_{t-1}	-0.051	0.091**	0.03	0.076*	0.046	0.091**	0.041	0.041
	[0.218]	[0.028]	[0.411]	[0.062]	[0.195]	[0.015]	[0.339]	[0.243]
Panel B. Variance Equation								
Constant	1e-05*	-1E-07	5e-05***	3e-06**	5E-06	6E-07	0	0
	[0.098]	[0.880]	[0.000]	[0.029]	[0.159]	[0.694]	[0.342]	[0.989]
$(e^s_{t-1})^2$	0.05	0.05	0.075***	0.062*	0.046*	-0.032***	0.003	0.048***
	[0.278]	[0.184]	[0.001]	[0.070]	[0.083]	[0.000]	[0.742]	[0.000]
$(e^g_{t-1})^2$	-0.013	0.068***	-2E-03	0.078***	3E-03	0.077***	-0.033***	-0.034***
	[0.306]	[0.001]	[0.216]	[0.000]	[0.804]	[0.001]	[0.006]	[0.001]
h^s_{t-1}	0.552***	0.123	0.665***	-0.079**	0.849***	0.055***	1.000***	-0.102
	[0.000]	[0.173]	[0.000]	[0.048]	[0.000]	[0.005]	[0.000]	[0.594]

h^g_{t-1}	0.023	0.953***	-5E-03	0.926***	-3E-04	0.938***	1.026***	-0.375
	[0.264]	[0.000]	[0.286]	[0.000]	[0.982]	[0.000]	[0.000]	[0.231]
Asymmetry	0.352***	-0.058**	0.166**	-0.017	0.128***	-0.033	0.060***	0.150**
	[0.000]	[0.018]	[0.011]	[0.488]	[0.001]	[0.163]	[0.001]	[0.021]
Panel C. Correlations								
$\rho^{s,g}$	0.049		0.041		0.093***		0.114***	
	[0.222]		[0.266]		[0.006]		[0.001]	
Panel D. Diagnostic Tests								
LogL	3121.17		4376.88		4420.44		4378.2	
Aic	-11.079		-10.799		-10.87		-10.832	
Sic	-10.679		-10.505		-10.577		-10.538	
JB	2047.0***	3314.7***	2689.6***	672.17***	342.49***	672.49***	357.41***	638.43***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	40.220***	5.915	10.557	6.558	12.868	6.222	13.507	7.51
	[0.000]	[0.920]	[0.567]	[0.885]	[0.379]	[0.905]	[0.333]	[0.822]
$Q^2[12]$	3.182	7.554	25.364**	15.234	7.74	16.923	6.396	17.196
	[0.994]	[0.819]	[0.013]	[0.229]	[0.805]	0.153]	[0.895]	[0.142]

Notes: ^{s}, ^{g} and [ ] denote the Asian stock, gold market and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

Table 4.17: Estimates of VAR(1)-AGARCH(1,1) Model for Gold and Asian Stock Markets during Chinese Stock Market Crash.

	CHN	**GOLD**	**IND**	**GOLD**	**KOR**	**GOLD**	**INDO**	**GOLD**	**MYS**	**GOLD**
Panel A. Mean Equation										
Constant	3E-04	-2E-04	3e-04*	-1E-04	3E-04	-3E-05	2E-05	-5E-05	-5E-05	-1E-04
	[0.247]	[0.410]	[0.095]	[0.549]	[0.205]	[0.903]	[0.945]	[0.848]	[0.700]	[0.571]
r^s_{t-1}	0.065***	-8.0E-05	0.159***	0.056*	0.027	-0.028	0.152***	0.053**	0.153***	0.079*
	[0.006]	[0.995]	[0.000]	[0.054]	[0.226]	[0.248]	[0.000]	[0.027]	[0.000]	[0.063]
r^g_{t-1}	-0.038*	0.041	0.043*	0.035	-6E-03	0.023	0.039	0.033	0.019	0.031**
	[0.087]	[0.122]	[0.081]	[0.271]	[0.742]	[0.382]	[0.110]	[0.301]	[0.187]	[0.327]
Panel B. Variance Equation										
Constant	4E-07	1e-06***	1e-06**	-2E-07	1e-06***	1e-06***	4e-06***	3E-07	7e-07***	4E-08
	[0.206]	[0.007]	[0.020]	[0.414]	[0.001]	[0.002]	[0.006]	[0.182]	[0.000]	[0.677]
$(e^s_{t-1})^2$	0.057***	-5E-03	-0.023**	0.013	0.011	-2E-03	0.102***	-1E-02	0.072***	-6e-03***
	[0.000]	[0.274]	[0.045]	[0.210]	[0.224]	[0.538]	[0.001]	[0.152]	[0.001]	[0.002]
$(e^g_{t-1})^2$	(-7e-03***	0.034***	2E-03	-2E-04	0.045***	7E-03	0.017**	9e-03*	0.049***	-5E-03
	[0.000]	[0.001]	[0.674]	[0.969]	[0.000]	[0.309]	[0.041]	[0.089]	[0.008]	[0.184]
h^s_{t-1}	0.940***	6.82E-03	0.858***	0.039*	0.928***	1.39E-03	0.776***	0.046*	0.848***	9e-03**
	[0.000]	[0.347]	[0.000]	[0.075]	[0.000]	[0.842]	[0.000]	[0.062]	[0.000]	[0.035]
h^g_{t-1}	0.011***	0.938***	0.014	0.978***	-0.041**	0.963***	-0.013	0.977***	-0.040*	0.991***
	[0.000]	[0.000]	[0.101]	[0.000]	[0.011]	[0.000]	[0.293]	[0.000]	[0.076]	[0.000]
Asymmetry	3E-03	0.025**	0.166***	0.015***	0.080***	0.019**	0.096***	1E-02	0.108***	0.021***
	[0.747]	[0.029]	[0.000]	[0.007]	[0.000]	[0.039]	[0.009]	[0.194]	[0.001]	[0.000]
Panel C. Correlations										
$\rho^{s,g}$	0.043**		-0.074***		0.031		-3.07E-03		-0.014	
	[0.045]		[0.001]		[0.123]		[0.905]		[0.562]	
Panel D. Diagnostic Tests										
LogL	11641.5		8888.81		6750.01		8795.29		0	

Aic	-11.997		-12.983		-12.77		-12.823		-13.958	
Sic	-11.847		-12.786		-12.636		-12.626		-13.761	
JB	546.75***	3967.1***	176.03***	1234.9***	185.70***	3518.0***	159.16***	2998.7***	435.77***	3584.9***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	19.851*	6.973	12.774	7.324	12.871	5.206	12.665	7.292	11.341	4.897
	[0.070]	[0.859]	[0.386]	[0.835]	[0.378]	[0.951]	[0.394]	[0.838]	[0.500]	[0.961]
Q^2[12]	17.069	3.532	6.119	6.228	13.008	3.765	8.116	3.748	18.025	5.456
	[0.147]	[0.990]	[0.910]	[0.904]	[0.368]	[0.987]	[0.776]	[0.988]	[0.115]	[0.941]

	PAK	**GOLD**	**PHL**	**GOLD**	**THA**	**GOLD**	**TAIW**	**GOLD**
Panel A. Mean Equation								
Constant	3E-04	5E-05	1E-04	-7E-05	7E-05	-4E-05	-6E-06	-9E-05
	[0.246]	[0.861]	[0.642]	[0.759]	[0.695]	[0.880]	[0.978]	[0.693]
r^s_{t-1}	0.304***	0.033	0.056*	0.028	0.108***	0.039	0.116***	7E-03
	[0.000]	[0.266]	[0.065]	[0.275]	[0.000]	[0.180]	[0.000]	[0.821]
r^g_{t-1}	0.054**	0.037	0.017	0.057	0.080***	0.022	0.021	0.029
	[0.033]	[0.364]	[0.591]	[0.101]	[0.001]	[0.436]	[0.335]	[0.357]
Panel B. Variance Equation								
Constant	5e-06***	1E-07	4e-06*	-1E-07	-1E-06	1e-06**	3e-06***	-3E-10
	[0.003]	[0.509]	[0.082]	[0.730]	[0.269]	[0.015]	[0.002]	[0.999]
$(e^s_{t-1})^2$	-0.019	2E-04	0.02	9E-03	-0.017	0.013	-0.031*	8E-03
	[0.402]	[0.978]	[0.571]	[0.671]	[0.322]	[0.108]	[0.058]	[0.215]
$(e^g_{t-1})^2$	1E-03	0.018**	7E-03	3E-03	7E-03	0.010*	0.018***	-5E-03
	[0.846]	[0.017]	[0.251]	[0.728]	[0.470]	[0.071]	[0.002]	[0.514]
h^s_{t-1}	0.842***	-0.019	0.870***	-0.013	0.803***	0.085**	0.846***	6E-03
	[0.000]	[0.184]	[0.000]	[0.639]	[0.000]	[0.045]	[0.000]	[0.690]

h^g_{t-1}	-2E-03	0.981***	-2E-03	0.983***	0.028	0.949***	-0.013	0.992***
	[0.760]	[0.000]	[0.824]	[0.000]	[0.131]	[0.000]	[0.108]	[0.000]
Asymmetry	0.258***	-3E-03	0.128***	0.019**	0.227***	-6E-03	0.206***	0.017***
	[0.000]	[0.734]	[0.001]	[0.035]	[0.000]	[0.506]	[0.000]	[0.007]
Panel C. Correlations								
$\rho^{s,g}$	-0.044		8.02E-04		-0.017		-0.041*	
	[0.193]		[0.978]		[0.536]		[0.087]	
Panel D. Diagnostic Tests								
LogL	5466.43		4189.2		9046.62		9032.53	
Aic	-13.072		-13.183		-12.962		-13.27	
Sic	-12.778		-12.948		-12.765		-13.073	
JB	416.74***	3908.5***	687.98***	3970.0***	516.44***	3233.7***	540.53***	3830.7***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	19.617*	4.757	19.194*	4.255	16.224	5.009	13.522	5.497
	[0.075]	[0.966]	[0.084]	[0.978]	[0.181]	[0.958]	[0.332]	[0.939]
$Q^2[12]$	17.627	4.944	14.026	5.175	12.277	3.323	12.157	7.173
	[0.128]	[0.960]	[0.299]	[0.952]	[0.424]	[0.993]	[0.433]	[0.846]

Notes: ^{s}, ^{g} and [ ] denote the Asian stock, gold market and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

The volatility transmission is found from gold to China, Korea and Malaysia stock markets. However, volatility is transmitted from India, Indonesia, Malaysia, and Thailand stock markets to gold Market during Chinese crash. The asymmetric coefficient of majority Asian markets is significant and positive except China stock market. Furthermore, the asymmetric coefficient of gold market is also significant and positive in majority cases. Constant conditional correlation is negatively significant when Gold asset is paired with India and Taiwan stock market.

4.5.4 Spillover Patterns during US Financial Crisis and Chinese Stock Market Crash

The return spillover is significant from gold to most of the Asian stock markets during full sample period. However, the volatility is not transmitted from gold to Asian stock markets during full sample period. Moreover, the return and volatility spillover from gold to most of the Asian stock markets is insignificant during US financial crisis. The return spillover is significant from gold to four Asian markets (China, India, Pakistan and Thailand) during Chinese crash. In addition, volatility is not transmitted from gold to majority Asian stock markets (except China, Korea and Malaysia) during US financial crisis. Volatility patterens are varying during full sample crisis periods. Therefore, Investors to adjust their portfolio allocation between oil-stock portfolio during crisis period.

4.6 Spillover between Gold and Latin American Stock Markets

This section provides the results of spillovers between gold and Latin American stock markets during all sample periods.

4.6.1 Linkages between Gold and Latin American Stock Markets during the Full Sample Period[Jan 2001-Jul 2018]

Table 4.18 represents the findings of spillovers between Gold and Latin American stock(LAS) markets during full sample period. The current stock returns of all LAS markets are influenced affected by the lag returns. This shows that change in past stock prices helps to predict current stock prices in the short run for LAS markets. Furthermore, lagged gold returns significantly affect the current gold returns. These findings are similar to the results of (Raza et al., 2016), they report a significant return spillover from gold to equity markets. The return spillover is insignificant from gold to LAS markets. Moreover, the mean spillover from LAS markets to Gold market is highly significant.

The results reveal that the sensitivity of past own shocks is significantly positive for LAS markets in short run. Furthermore, the sensitivity of past own volatility is also significant for LAS markets. The coefficient of past own shock is smaller as compared to the coefficient of the past own volatility in all LAS markets. It suggests that lag volatility is a more valuable factor to forecast volatility as compared to past own shocks. Besides, sensitivity of past own shocks and volatility is significantly influenced the gold market volatility.

The gold market Shocks influence the conditional volatility of Chile and Mexico equity markets. The gold market volatility is not influenced by the shocks in LAS markets. The Gold market volatility affects the conditional volatility of Chile and Mexico equity markets. Furthermore, past volatility of the LAS markets does not transmit to the Gold markets.

Table 4.18: Estimates of VAR(1)-AGARCH(1,1) Model for Gold and Latin American Markets during Full Sample Period.

	BRAZ	**GOLD**	**CHIL**	**GOLD**	**MEXI**	**GOLD**	**PERU**	**GOLD**
Panel A. Mean Equation								
Constant	4E-04*	3E-04***	3E-04***	3E-04**	2E-04**	3E-04**	4E-04***	3E-04**
	[0.058]	[0.005]	[0.003]	[0.011]	[0.040]	[0.013]	[0.000]	[0.021]
r^s_{t-1}	0.058***	0.043***	0.212***	0.034**	0.109***	0.060***	0.247***	0.107***
	[0.000]	[0.000]	[0.000]	[0.025]	[0.000]	[0.000]	[0.000]	[0.000]
r^g_{t-1}	3E-04	0.050***	0.01	0.053***	0.012	0.050***	1E-02	0.033**
	[0.990]	[0.002]	[0.336]	[0.000]	[0.346]	[0.002]	[0.438]	[0.028]
Panel B. Variance Equation								
Constant	7E-06***	2E-06***	2E-06***	2E-06***	1E-06***	1E-06***	4E-06***	2E-06***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$(e^s_{t-1})^2$	0.032***	-9E-03	0.053***	-9E-04	0.022***	1.4E-03	0.121***	3E-03
	[0.000]	[0.303]	[0.000]	[0.710]	[0.001]	[0.772]	[0.000]	[0.581]
$(e^g_{t-1})^2$	2E-03	0.081***	-4E-03**	0.082***	0.017***	0.060***	6E-03	0.081***
	[0.388]	[0.000]	[0.020]	[0.000]	[0.000]	[0.000]	[0.198]	[0.000]
h^s_{t-1}	0.892***	0.017	0.853***	3E-03	0.913***	4E-03	0.784***	0.023
	[0.000]	[0.189]	[0.000]	[0.436]	[0.000]	[0.593]	[0.000]	[0.158]
h^g_{t-1}	-2E-03	0.917***	6E-03*	0.916***	-0.016***	0.931***	-3E-03	0.913***

	[0.445]	[0.000]	[0.075]	[0.000]	[0.000]	[0.000]	[0.577]	[0.000]
Asymmetry	0.094***	-0.028**	0.122***	-0.026***	0.104***	-0.013	0.101***	-0.029***
	[0.000]	[0.012]	[0.000]	[0.004]	[0.000]	[0.162]	[0.000]	[0.004]
Panel C. Correlations								
$\rho^{s,g}$	0.052***		0.018		0.022		0.158***	
	[0.000]		[0.211]		[0.101]		[0.000]	
Panel D. Diagnostic Tests								
LogL	2835.2		3153.6		3037.9		2761	
Aic	-9.643		-10.895		-10.271		-9.243	
Sic	-9.249		-10.501		12		-9.564	
JB	336.13***	5821.4***	7165.2***	5634.5***	362.88***	4781.2***	890.05***	4544.3***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	10.607	6.833	16.627	6.861	6.728	6.938	22.635***	8.962
	[0.563]	[0.868]	[0.164]	[0.867]	[0.875]	[0.862]	[0.000]	[0.706]
Q^2[12]	16.083	9.3	4.087	10.362	9.753	9.921	7.751	12.338
	[0.187]	[0.677]	[0.982]	[0.584]	[0.638]	[0.623]	[0.804]	[0.419]

Notes: ^{s}, ^{g} and [ ] denote the LA stock, gold market and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

The asymmetric coefficients of all LAS markets are significant and positive, showing that negative news (or unexpected shock) of gold market has more ability to magnify the volatility of all LAS markets as compared to positive news. In addition, the asymmetric coefficient of gold market is negatively significant, showing that negative unexpected shock of emerging LAS markets will decrease the volatility more in gold markets than the positive shock. Constant conditional correlation is positively significant for the pairs of Brazil-Gold and Peru-Gold pairs.

4.6.2 Linkages between Gold and Latin American Stock Markets during the US Financial Crisis Period [Aug 2007-July 2010]

Table 4.19 reveals the findings of spillovers between gold and Latin American stock(LAS) market during the US financial crisis. The lag returns affect the current returns of majority LAS markets (except Mexico). Moreover, the current gold markets returns are significantly influenced by their lag returns during US financial crisis.

These findings reveal that past stock prices and gold prices help us to predict prices in the short run. The return spillover from gold to LAS markets is highly insignificant. In addition, the mean transmission effect from majority LAS markets (except Brazil) to gold markets is highly insignificant during US financial crisis. The lag shocks significantly affect the conditional volatility of Brazil and Peru. Furthermore, the gold market volatility is affected by their own past shocks during US financial crisis.

The sensitivity of past own volatility is significant for LAS markets. Moreover, the coefficient of past own volatility is also significant for the gold market. The coefficient of past own volatility is higher than the coefficient of the past own shock in all LAS markets, suggesting that lag volatility is more valuable factor to forecast volatility as compared to past own shocks.

Table 4.19: Estimates of VAR(1)-AGARCH(1,1) Model for Gold and Latin American Stock Markets during US Financial Crisis.

	BRAZ	**GOLD**	**CHIL**	**GOLD**	**MEXI**	**GOLD**	**PERU**	**GOLD**
Panel A. Mean Equation								
Constant	3E-04	7E-04	5E-04	1E-03**	-9E-05	8E-04*	-5E-04	1E-03***
	[0.623]	[0.149]	[0.131]	[0.030]	[0.845]	[0.072]	[0.286]	[0.010]
r^s_{t-1}	0.077**	0.070***	0.209***	0.058	0.055	0.041	0.245***	0.091
	[0.033]	[0.006]	[0.000]	[0.104]	[0.136]	[0.256]	[0.000]	[0.200]
r^g_{t-1}	0.063	0.060*	6.98E-03	0.086**	0.026	0.085**	-6E-03	0.055**
	[0.245]	[0.064]	[0.811]	[0.018]	[0.469]	[0.032]	[0.877]	[0.049]
Panel B. Variance Equation								
Constant	6E-06	6E-06	3E-06	1E-06	3E-06***	4E-06*	7E-06**	1E-06
	[0.117]	[0.232]	[0.144]	[0.364]	[0.006]	[0.072]	[0.044]	[0.218]
$(e^s_{t-1})^2$	-6E-03	0.078***	0.039	0.013	0.011	0.035**	0.109***	0.024
	[0.690]	[0.008]	[0.165]	[0.302]	[0.403]	[0.025]	[0.000]	[0.370]
$(e^g_{t-1})^2$	9E-03	-0.048***	-0.023	0.063***	0.013	-0.018	-7E-03	0.093***
	[0.335]	[0.001]	[0.207]	[0.004]	[0.366]	[0.597]	[0.396]	[0.000]
h^s_{t-1}	0.903***	-0.047	0.778***	0.016	0.951***	-0.060**	0.773***	9E-03
	[0.000]	[0.605]	[0.000]	[0.246]	[0.000]	[0.013]	[0.000]	[0.711]
h^g_{t-1}	0.068	0.787***	0.036	0.929***	0.043	0.863***	5.10E-03	0.929***

	[0.161]	[0.000]	[0.181]	[0.000]	[0.172]	[0.000]	[0.514]	[0.000]
Asymmetry	0.158***	0.100***	0.242***	-9E-03	0.092***	0.120***	0.185***	-0.040*
	[0.000]	[0.002]	[0.000]	[0.737]	[0.000]	[0.010]	[0.000]	[0.097]
Panel C. Correlations								
$\rho^{s,g}$	0.092***		0.032		0.095***		0.170***	
	[0.005]		[0.261]		[0.007]		[0.000]	
Panel D. Diagnostic Tests								
LogL	4208		4680.7		4432.6		3927	
Aic	-10.118		-11.236		-10.736		-10.424	
Sic	-10.012		10.942		-10.443		-10.131	
JB	321.98***	658.01***	301.04***	665.36***	355.71***	663.08***	315.42***	661.09***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	11.268	7.185	10.688	6.178	12.756	6.856	10.022	7.754
	[0.506]	[0.845]	[0.556]	[0.907]	[0.387]	[0.867]	[0.614]	[0.804]
Q^2[12]	9.851	16.455	7.652	15.777	12.964	15.638	8.036	15.875
	[0.629]	[0.171]	[0.812]	[0.202]	[0.372]	[0.208]	[0.782]	[0.197]

Notes: ^{s}, ^{g} and [ ] denote the LA stock, gold market and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

The shocks in gold markets do not significantly affect the conditional volatility of LAS markets. Moreover, the gold market volatility is influenced by shocks in Brazil and Mexico stock markets during US financial crisis.

The LAS markets volatlity is not significantly influenced by the volatility in gold markets. The conditional volatility of gold markets is significantly influence by the past volatility of Mexico equity market during US financial crisis. The asymmetric coefficients of LAS markets are significant and positive, indicating that negative news (or unexpected shock) of gold market has more ability to magnify the LAS volatility markets as compared to positive news. Constant conditional correlation is positively significant for majority pairs of gold and stock markets except for Chile.

4.6.3 Linkages between Gold and Latin American Stock Markets from the Chinese Stock Market Crash [Jun 2015-May 2018]

Table 4.20 represents the findings of spillovers between gold and Latin American stock(LAS) markets during Chinese crash. The one period lagged stock returns significantly affect the current stock returns of majority LAS markets (except Brazil) during Chinese crash. Thus, returns become predictable for the short run in the majority LAS markets during Chinese crash. Moreover, past returns of gold market do not significantly affect the current returns during Chinese crash. Therefore, Gold returns become unpredictable for the short run in Gold market during Chinese crash.

The mean transmission from Gold to Mexico stock market is significant during Chinese crash. However, Chile and Peru stock markets transmit a mean effect to gold market. The coefficient of past own shock is significant in majority of LAS markets (except Brazil). Moreover, the sensitivity of past own volatility is significant in all LAS markets. The coefficient of past own volatility is higher than the coefficient of past own shocks, therefore past own volatility plays an important role in predicting future volatility in LAS markets.

TABLE 4.20: Estimates of VAR(1)-AGARCH(1,1) Model for Gold and Latin American Stock Markets during Chinese Crash.

	BRAZ	**GOLD**	**CHIL**	**GOLD**	**MEXI**	**GOLD**	**PERU**	**GOLD**
Panel A. Mean Equation								
Constant	4.2E-04	5.6E-05	8.7E-05	-2.3E-04	0.000	0.000	1.8E-04	-2.4E-04
	[0.328]	[0.83]	[0.679]	[0.431]	[0.895]	[0.798]	[0.383]	[0.256]
r^s_{t-1}	0.041	0.011	0.212***	0.073*	0.118***	0.053	0.231***	0.128***
	[0.329]	[0.624]	[0.000]	[0.063]	[0.003]	[0.168]	[0.000]	[0.000]
r^g_{t-1}	0.018	0.041	8.0E-04	8.9E-03	0.056*	0.032	-7.4E-04	-1.6E-04
	[0.775]	[0.295]	[0.972]	[0.782]	[0.062]	[0.386]	[0.978]	[0.996]
Panel B. Variance Equation								
Constant	2.3E-05*	3.0E-07	1E-06***	9.9E-07	0.000***	0.000	3E-06**	2.5E-07
	[0.075]	[0.486]	[0.004]	[0.128]	[0.002]	[0.104]	[0.013]	[0.523]
$(e^s_{t-1})^2$	0.058	0.266**	0.034*	-5.0E-03	0.129***	0.000	0.050*	3.4E-03
	[0.161]	[0.028]	[0.099]	[0.292]	[0.003]	[0.993]	[0.056]	[0.751]
$(e^g_{t-1})^2$	4.5E-03	0.019*	0.053**	9.9E-03	0.070***	0.006	0.021**	0.011
	[0.233]	[0.073]	[0.039]	[0.314]	[0.009]	[0.511]	[0.032]	[0.158]
h^s_{t-1}	0.474***	0.591*	0.925****	3.4E-03	0.509***	0.066	0.812***	0.051**
	[0.000]	[0.093]	[0.000]	[0.869]	[0.000]	[0.362]	[0.000]	[0.041]
h^g_{t-1}	-8.4E-03	0.986***	-0.033	0.964***	-0.153**	1.005***	-0.012	0.970***

	[0.410]	[0.000]	[0.418]	[0.000]	[0.026]	[0.000]	[0.518]	[0.000]
Asymmetry	0.169*	6.2E-03	0.048*	8.6E-03	0.103**	0.001	0.089**	0.012
	[0.051]	[0.542]	[0.076]	[0.580]	[0.033]	[0.923]	[0.012]	[0.211]
Panel C. Correlations								
$\rho^{s,g}$	0.069**		-0.041		-0.058*		0.151***	
	[0.032]		[0.155]		[0.071]		[0.000]	
Panel D. Diagnostic Tests								
LogL	5033.8		3246.7		5541.2		8840.9	
Aic	-12.223		-13.212		-13.434		-12.853	
Sic	-11.93		-12.978		-13.14		-12.656	
JB	463.87***	3500.3***	447.94***	3456.3***	106.89***	2886.4***	345.3***	2486.8***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Q[12]	4.687	5.343	12.849	4.976	9.723	4.002	14.795	5.728
	[0.968]	[0.946]	[0.380]	[0.959]	[0.640]	[0.983]	[0.253]	[0.929]
$Q^2[12]$	14.318	5.929	17.078	4.82	14.085	4.803	9.741	3.596
	[0.281]	[0.920]	[0.147]	[0.964]	[0.295]	[0.964]	[0.639]	[0.990]

Notes: ^{s}, ^{g} and [ ] denote the LA stock, gold market and P-Value respectively. ***/1 percent, **/2 percent, and */10 percent significance-level.

The past shocks of gold market significantly affect the conditional volatility of Chile, Mexico and Peru stock markets during Chinese crash. The past shocks of Brazil stock market significantly affect the conditional volatility of gold market during Chinese crash.

There is a significant evidence of volatility transmission from gold to Mexico stock market. However, there is a significant evidence of volatility spillover from Brazil and Peru stock markets to gold market during Chinese crash. The asymmetric coefficient of Latin American markets is significant and positive. Furthermore, the asymmetric coefficient of gold market is also insignificant and positive in all cases. Constant conditional correlation is positively significant when Gold asset is paired with Brazil and Peru stock market, whereas negatively significant between gold and Mexico stock markets during Chinese crash.

4.6.4 Spillover Patterns during US Financial Crisis and Chinese Stock Market Crash

This study finds an insignificant return spillover from gold to Latin American stock markets. However, Volatility is transmitted from the gold to Chile and Mexico equity markets during the full sample period. During the US financial crisis, the return and volatility spillover from gold to LAS markets is highly insignificant.

The return and volatility spillover is also insignificant from gold to LAS markets (except Mexico) during Chinese crash. Thus, the portfolio of gold and majority LAS markets provides an opportunity for diversification to portfolio investors especially during crisis periods.

4.7 Optimal Weights and Hedge Ratios-Portfolio Implications

This section provides the optimal weights and hedge ratios for three type of pairs (stock-stock, oil-stock, and gold-stock) during full sample period, US financial crisis and Chinese crash. Tables 4.25 indicate the optimal weights and hedge ratios for the pairs of Asia-USA stock portfolio during the full sample and US financial crisis. The range of optimal portfolio weights is 0.37 for IND/USA to 0.68 for MYS/USA during the period of full sample, showing that for a $1 portfolio of India-USA, 37 cents should be allocated in Indian stocks and the remaining 63 cents in the USA stock market.

In addition, in $1 Malaysia-USA portfolio,68 cents should be invested in Malaysian stock market and remaining 32 cents in USA stock market during full sample period. During US Financial crisis, average optimal portfolio weight ranges from 0.38 for IND/USA to 0.80 for MYS/USA. The optimal weights of Asia-USA portfolios are higher during US financial crisis as compared to the weights in full sample period. It suggests that investors should increase their asset allocation for Asian stocks in Asia-USA portfolio during US financial crisis and should decrease the allocation for US stocks during US financial crisis.

Regarding the hedge ratio, the range of average hedge ratio is 0.04 for PAK/USA to 0.27 for IND/USA during the period of full sample, showing that a long position of $1 in Pakistani stocks can be hedged for short position of 4 cents in USA stocks. In addition, a long position in $1 in India can be hedged for short position of 27 cents in USA stocks. During US financial crisis, the average hedge ratios range is 0.08 for PAK/USA to 0.36 for IND/USA during US financial crisis. The optimal hedge ratios for Asia-USA pairs are higher in US financial crisis as compared to the full sample period.

Tables 4.26 indicate the optimal weights and hedge ratios for the pairs of Asia-China stock portfolio during the full sample and Chinese crash. The range of optimal weights is 0.56 for IND/CHN to 0.81 for MYS/CHN during the period of full sample, indicating that for a $1 portfolio of India-China, 56 cents should be invested in Indian stocks and the remaining 44 cents in the Chinese stock market. In addition, in $1 Malaysia-China portfolio, 81cents should be invested in Malaysian stock market and remaining 18 cents in Chinese stock market during full sample period.

TABLE 4.21: Dynamic Conditional Correlations between USA, China, Oil, Gold and Asian Stock Markets.

Sample Period		CHN	IND	INDO	KOR	MYS	PAK	PHL	TAIW	THA
Full Sample	USA	-	0.213	0.13	0.193	0.096	0.014	0.052	0.156	0.162
Full Sample	CHN	-	0.154	0.164	0.208	0.167	0.049	0.14	0.207	0.149
Full Sample	OIL	0.064	0.113	0.113	0.103	0.093	0.017	0.096	0.089	0.105
Full Sample	GOLD	0.054	0.045	0.07	0.056	0.034	0.007	0.04	0.032	0.034
US Crisis	USA	-	0.344	0.227	0.285	0.21	0.046	0.121	0.202	0.308
US Crisis	OIL	0.128	0.249	0.206	0.208	0.21	-0.01	0.149	0.23	0.234
US Crisis	GOLD	0.082	0.079	0.047	0.085	0.036	-0.03	0.008	0.07	0.078
Chinese Crash	CHN	-	0.224	0.18	0.313	0.14	0.131	0.202	0.268	0.256
Chinese Crash	OIL	0.19	0.159	0.143	0.145	0.127	0.088	0.097	0.12	0.163
Chinese Crash	GOLD	-0.02	-0.17	0.007	-0.1	0.034	-0.09	-0.005	-0.076	-0.095

TABLE 4.22: Dynamic Conditional Correlation between USA, China, Oil, Gold and Latin American Stock Markets.

Sample Period		BRAZ	CHIL	MEXI	PERU
Full Sample	USA	0.541	0.468	0.617	0.367
Full Sample	CHN	0.124	0.094	0.091	0.095
Full Sample	OIL	0.161	0.105	0.127	0.201
Full Sample	GOLD	0.033	0.002	0.009	0.123
US Crisis	USA	0.726	0.576	0.763	0.528
US Crisis	OIL	0.26	0.184	0.269	0.362
US Crisis	GOLD	0.015	0.011	0.053	0.132
Chinese Crash	CHN	0.104	0.138	0.112	0.148
Chinese Crash	OIL	0.249	0.216	0.224	0.29
Chinese Crash	GOLD	0.041	0.004	-0.068	0.088

Table 4.23: Summary of Return and Volatility Spillovers from US, China, Oil and Gold to Asian Stock Markets.

Spillovers	Sample Period	↱	CHN	IND	INDO	KOR	MYS	PAK	PHL	TAIW	THA
Return	Full Sample	USA	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Volatility	Full Sample	USA	-	Yes	No	No	No	Yes	Yes	No	Yes
Return	Full Sample	CHN	-	Yes	No	No	No	No	Yes	No	No
Volatility	Full Sample	CHN	-	Yes	No	No	No	No	No	Yes	No
Return	Full Sample	OIL	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Volatility	Full Sample	OIL	No	Yes	Yes	Yes	Yes	No	No	No	No
Return	Full Sample	GOLD	Yes	No	Yes	No	Yes	No	No	Yes	Yes
Volatility	Full Sample	GOLD	No	No	No	No	Yes	No	No	No	No
Return	US Crisis	USA	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Volatility	US Crisis	USA	-	No	Yes	No	No	No	No	No	No
Return	US Crisis	OIL	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Volatility	US Crisis	OIL	No	No	No	Yes	No	No	No	Yes	Yes
Return	US Crisis	GOLD	No	No	Yes	No	Yes	No	No	No	No
Volatility	US Crisis	GOLD	No	No	Yes	No	Yes	No	No	Yes	No
Return	Chinese Crash	CHN	-	No	No	No	No	No	No	No	No
Volatility	Chinese Crash	CHN	-	Yes	Yes	No	No	No	No	Yes	Yes
Return	Chinese Crash	OIL	Yes	No	No	Yes	Yes	No	Yes	Yes	No
Volatility	Chinese Crash	OIL	No	Yes	No	Yes	No	No	No	No	No
Return	Chinese Crash	GOLD	Yes	Yes	No	No	No	Yes	No	No	Yes
Volatility	Chinese Crash	GOLD	Yes	No	No	Yes	Yes	No	No	No	No

Table 4.24: Summary of Return and Volatility Spillovers from US, China, Oil and Gold to Latin American Stock Markets.

Spillovers	Sample Period	$\Rsh$	BRAZ	CHIL	MEXI	PERU
Return	Full Sample	USA	No	Yes	Yes	Yes
Volatility	Full Sample	USA	Yes	No	No	No
Return	Full Sample	CHN	No	No	No	No
Volatility	Full Sample	CHN	No	No	No	No
Return	Full Sample	OIL	Yes	No	No	Yes
Volatility	Full Sample	OIL	No	No	No	No
Return	Full Sample	GOLD	No	No	No	No
Volatility	Full Sample	GOLD	No	Yes	Yes	No
Return	US Crisis	USA	No	No	No	Yes
Volatility	US Crisis	USA	No	No	No	No
Return	US Crisis	OIL	No	No	No	No
Volatility	US Crisis	OIL	No	No	Yes	No
Return	US Crisis	GOLD	No	No	No	No
Volatility	US Crisis	GOLD	No	No	No	No
Return	Chinese Crash	CHN	No	No	No	No
Volatility	Chinese Crash	CHN	No	No	No	No
Return	Chinese Crash	OIL	No	No	No	No
Volatility	Chinese Crash	OIL	No	No	No	No
Return	Chinese Crash	GOLD	No	No	Yes	No
Volatility	Chinese Crash	GOLD	No	No	Yes	No

Moreover, the range of optimal weights is 0.52 for PHL/CHN to 0.82 for MYS/CHN during Chinese crash. The optimal weights of Asia-China portfolios are higher in Chinese crash as compared to the optimal weights in full sample period. It infers that investors should decrease their asset allocation in Chinese stock during Chinese crash as compared to the full sample period. Regarding the hedge ratio, the range of average hedge ratio is 0.04 for PAK/CHN to 0.21 for KOR/CHN during the period of full sample, showing that a long position of $1 in Pakistani stocks can be hedged for short position of 4 cents in Chinese stocks. In addition, a long position in $1 in Korea can be hedged for short position of 21 cents in Chinese stocks. Moreover, the optimal hedge ratio range is 0.09 for MYS/CHN to 0.26 for TAIW/CHN during Chinese crash. The optimal hedge ratios of Asia-China pairs are higher in Chinese crash as compared to the hedge ratio in full sample period.

Table 4.25: Optimal Weights and Hedge Ratios for the portfolio of Asian and USA Stocks.

	IND/USA	INDO/USA	KOR/USA	MYS/USA	PAK/USA	PHL/USA	TAIW/USA	THA/USA
Full Sample Period								
w_t^{SU}	0.37	0.41	0.4	0.68	0.41	0.42	0.43	0.41
β_t^{SU}	0.27	0.13	0.24	0.06	0.04	0.06	0.17	0.17
US Financial Crisis								
w_t^{SU}	0.38	0.51	0.54	0.8	0.52	0.57	0.52	0.52
β_t^{SU}	0.36	0.18	0.21	0.11	0.08	0.09	0.15	0.22

Notes: w_t^{SU}, β_t^{SU} refer to the optimal weights and hedge ratios respectively.

Table 4.26: Optimal Weights and Hedge Ratios for the portfolio of Asian and Chinese Stocks.

	IND/CHN	INDO/CHN	KOR/CHN	MYS/CHN	PAK/CHN	PHL/CHN	TAIW/CHN	THA/CHN
Full Sample Period								
w_t^{SC}	0.56	0.57	0.56	0.81	0.57	0.56	0.59	0.59
β_t^{SC}	0.15	0.15	0.21	0.09	0.04	0.12	0.2	0.13
Chinese Crash								
w_t^{SC}	0.65	0.61	0.66	0.82	0.58	0.52	0.66	0.73
β_t^{SC}	0.17	0.13	0.23	0.09	0.11	0.18	0.26	0.14

Notes: w_t^{SC}, β_t^{SC} refer to the optimal weights and hedge ratios respectively.

Table 4.27 reports the optimal weights and Hedge ratios for the pairs of Latin America-USA stock markets during full sample and US financial crisis. The findings reveal that the range of optimal weights is 0.11 for BRAZ/USA to 0.57 for CHIL/USA in full sample period, revealing that for a $1 portfolio of Brazil-USA, 11 cents should be invested Brazilian stock market and the remaining 89 cents in the USA stock market. The average optimal weights range is 0.18 for BRAZ/USA to 0.77 for CHIL/USA during US financial crisis. The optimal weights of Latin American-USA portfolio are higher during US financial crisis as compared to the full sample period. It suggests that portfolio investors should increase investment in Latin American stock markets and decrease asset allocation in US stock market in Latin America-USA portfolio during US financial crisis.

The optimal hedge ratio range is 0.37 for CHIL/USA to 0.90 for BRAZ/USA during full sample period, showing that $1 long position in Chile stocks can be hedged for 37 cents with a short position in US stocks. During US financial crisis, the range of optimal hedge ratio is 0.41 for CHIL/USA to 0.84 for BRAZ/USA. The optimal hedge ratios are higher for Latin America/USA (except BRAZ/USA) during US financial crisis as compared to the full sample.

Table 4.28 reports the optimal weights and Hedge ratios for the pairs of Latin America-China stock markets during full sample and Chinese crash. The findings reveal that the range of optimal weights is 0.41 for BRAZ/CHN to 0.71 for CHIL/CHN in full sample period, revealing that for a $1 portfolio of Brazil-CHN, 41 cents should be invested Brazilian stock market and the remaining 59 cents in the Chinese stock market. The range of average optimal weights is 0.37 for BRAZ/CHN to 0.66 for CHIL/CHN during Chinese crash. Furthermore, the optimal weights of Latin American-CHN portfolio are lower during Chinese crash as compared to the full sample period. It suggests that portfolio investors should decrease investment in Latin American stock market to minimize the risk of Latin America-China portfolio during Chinese crash.

The optimal hedge ratio range is 0.05 for CHIL/CHN to 0.12 for BRAZ/CHN during full sample period, showing that $1 long position in Chile stocks can be hedged for 5 cents with a short position in US stocks. Moreover, the optimal hedge ratio range is 0.09 for CHIL/CHN to 0.13 for BRAZ/CHN during Chinese crash. The optimal hedge ratios are higher during Chinese crash as compared to the full sample period.

Table 4.29 shows the optimal weights and hedge ratios for an oil-Asia stock portfolio during the full sample, US crisis and Chinese crash. The average optimal weight range is 0.68 for CHN/OIL to 0.90 for MYS/OIL during the full sample period, indicating that for a China-oil portfolio of $1, 68 cents should be invested in Chinese stocks and the remaining 32 cents in the oil market. During the US financial crisis, the average optimal portfolio weight ranges from 0.62 for CHN/OIL to 0.92 for MYS/OIL. The majority optimal weights are higher during US financial crisis as compared to the full sample period. It suggests that investors should increase their asset allocation for Asian stock, while decrease for Oil assets during US financial crisis.

Table 4.27: Optimal Weights and Hedge Ratios for the Portfolio of Latin American and USA Stock.

	BRAZ/USA	CHIL/USA	MEXI/USA	PERU/USA
Full Sample Period				
w_t^{SU}	0.11	0.57	0.38	0.42
β_t^{SU}	0.90	0.37	0.69	0.43
US Financial Crisis				
w_t^{OU}	0.18	0.77	0.52	0.4
β_t^{SU}	0.84	0.41	0.71	0.58

Notes: w_t^{SU}, β_t^{SU} refer to the optimal weights and hedge ratios respectively.

During the Chinese crash, the average optimal portfolio weights vary from 0.81 for CHN/OIL to 0.93 for MYS/OIL. Moreover, the optimal weights are higher during Chinese crash as compared to the full sample period. It suggests that portfolio investors should increase their asset allocation for Asian stocks during Chinese crash.

The average hedge ratio range is 0.01 for PAK/OIL to 0.07 for IND/OIL during the full sample period, indicating that a $1 long position in Pakistani stocks can be

Table 4.28: Optimal Weights and Hedge Ratios for the Portfolio of Latin American and Chinese Stocks.

	BRAZ/CHN	CHIL/CHN	MEXI/CHN	PERU/CHN
Full Sample Period				
w_t^{SC}	0.41	0.71	0.62	0.62
β_t^{SC}	0.12	0.05	0.07	0.06
Chinese Crash				
w_t^{SC}	0.37	0.66	0.64	0.6
β_t^{SC}	0.13	0.09	0.1	0.1

Notes: w_t^{SC}, β_t^{SC} refer to the optimal weights and hedge ratios respectively.

hedged for 1 cent with a short position in oil assets. During US financial crisis, the average hedge ratio range is -0.01 for PHL/OIL to 0.20 for IND/OIL. Furthermore, the hedge ratios are higher in US financial crisis as compared to the full sample period. However, the average hedge ratio range is -0.01 for MYS/OIL to 0.05 for KOR/OIL during Chinese crash. Further, hedge ratios are lower during Chinese crash as compared to the full sample period.

Table 4.30 reports the optimal weights and hedge ratios for oil-LA stock portfolios during full sample, US crisis and Chinese crisis periods. The average optimal weight range is 0.61 for BRAZ/OIL to 0.84 for CHIL/OIL during full sample period, indicating that for portfolio of $1, 61 cents should be invested in Brazil stocks and remaining 39 cents in oil market. In addition, in $1 Chile stock-oil portfolio, 84 cents should be invested in Chile stocks and reaming 16 cents in oil market during full sample period. However, average optimal portfolio weight ranges from 0.63 for BRAZ/OIL to 0.85 for CHIL/OIL during US financial crisis. The optimal stock weights are found to be higher for BRAZ/OIL and CHIL/OIL during US financial crisis as compared to the stock weights during full sample period. Whereas, the optimal weights are lower for MEXI/OIL and PERU/OIL during US financial crisis as compared to the stock weights during full sample period. It implies that in order to minimize risk of portfolio without lowering expected returns, investors should increase their investment in Brazil and Chile stocks, whereas investors should decrease their investment in oil for portfolios of

BRAZ/OIL and CHIL/OIL during US financial crisis as compared to full sample period. Moreover, investors should decrease their investments in Mexico and Peru stock markets, whereas investors should increase their investment in oil in portfolios of MEXI/OIL and PERU/OIL during US financial crisis as compared to the full sample period. Moreover, the average optimal portfolios vary from 0.76 for BRAZ/OIL to 0.94 for remaining three pairs during Chinese crash. The average optimal weights of all Latin American stocks in stock-oil portfolio are found to be higher during Chinese crash as compared to the optimal stock weights during full sample. It suggests that investors should increase their investment in Latin American stock market and decrease their investment in oil for the portfolio of LA stocks-oil during Chinese crash as compared to the full sample period.

The average hedge ratio range is 0.04 for CHIL/OIL to 0.12 for BRAZ/OIL during full sample period, indicating that a $1 long position in Chile stocks can be hedged for 4 cents with short position in oil assets. In addition, a $1 long position in Brazil can be hedged for 12 cents short position in oil during full sample period. Furthermore, average hedge ratio range is 0.07 for CHIL/OIL to 0.24 for PERU/OIL during US financial crisis. The average hedge ratio is found to be higher during US financial crisis as compared to the average hedge ratios during full sample period. However, the average hedge ratio range is 0.07 for MEXI/OIL to 0.16 for BRAZ/OIL during Chinese crash. The average hedge ratios are higher during Chinese crash as compared to the hedge ratios during full sample period.

Table 4.31 reports the optimal weights and hedge ratios for gold-Asia stock portfolios during full sample, US crisis and Chinese crisis periods. The average optimal weight range is 0.375 for CHN/Gold to 0.682 for MYS/Gold during full sample period, indicating that for portfolio of $1, 37.5cents should be invested in Chinese stocks and remaining 62.5 cents in gold market. In addition, in $1 Malaysian stock-gold portfolio, 68.2 cents should be invested in Malaysian stocks and reaming 37.8 cents in gold market during full sample period. However, average optimal portfolio weight ranges from 0.309 for CHN/Gold to 0.719 for MYS/Gold during US financial crisis.

TABLE 4.29: Optimal Weights and Hedge Ratios for the Portfolio of Asian Stocks and Oil Markets.

	CHN/OIL	IND/OIL	KOR/OIL	INDO/OIL	MYS/OIL	PAK/OIL	PHL/OIL	THA/OIL	TAIW/OIL
Full Sample Period									
w_t^{SO}	0.68	0.74	0.74	0.75	0.9	0.74	0.75	0.76	0.76
β_t^{SO}	0.05	0.07	0.07	0.06	0.03	0.01	0.04	0.06	0.05
US Financial Crisis									
w_t^{SO}	0.62	0.66	0.77	0.76	0.92	0.7	0.7	0.74	0.75
β_t^{SO}	0.14	0.2	0.12	0.11	0.08	0.01	-0.01	0.14	0.14
Chinese Crash									
w_t^{SO}	0.81	0.91	0.91	0.89	0.93	0.85	0.85	0.94	0.89
β_t^{SO}	0.04	0.03	0.05	0.04	-0.01	0.04	0.04	0.03	0.00

Notes: w_t^{SO}, β_t^{SO} refer to the optimal weights and hedge ratios respectively.

TABLE 4.30: Optimal Weights and Hedge Ratios for the Portfolio of Latin American Stock and Oil Markets.

	BRAZ/OIL	CHIL/OIL	MEXI/ OIL	PERU/OIL
Full Sample Period				
w_t^{SO}	0.61	0.84	0.79	0.79
β_t^{SO}	0.12	0.04	0.06	0.11
US Financial Crisis				
w_t^{SO}	0.63	0.85	0.77	0.73
β_t^{SO}	0.22	0.07	0.13	0.24
Chinese Crash				
w_t^{SO}	0.76	0.94	0.94	0.94
β_t^{SO}	0.16	0.08	0.07	0.1

Notes: w_t^{SO}, β_t^{SO} refer to the optimal weights and hedge ratios respectively.

Majority Asian optimal stock weights are found to be lower during US subprime crisis as compare to stocks weights during full sample period. It suggests that investors should allocate lower assets allocation in Asian stock for oil-Asian stock portfolio during US financial crisis. Moreover, the average optimal portfolios vary from 0.423 for PHL/Gold to 0.727 for MYS/Gold during Chinese crash. But, average optimal weights of stocks in stock-gold portfolio are found to be higher during Chinese crash as compare to the optimal stock weights during full sample period. It suggests that portfolio investor should increase their investment in Asian stocks during Chinese crash.

The average hedge ratio range is 0.045 for THA/Gold to 0.096 for INDO/Gold during full sample period, indicating that a $1 long position in Thailand stocks can be hedged for 4.5 cents with short position in Gold. In addition, a $1 long position in Indonesia can be hedged for 9.6 cents with short position in gold during full sample period. Furthermore, average hedge ratio range is -0.024 for PAK/GOLD to 0.198 for IND/Gold during US subprime crisis. The average hedge ratio of Stock/Gold is found to be higher for majority Asian markets during US financial crisis as compare to the average hedge ratios during full sample period. However, the average hedge ratio range is -0.072 for IND/Gold to 0.055 for CHN/Gold during Chinese crash. Majority of the Asian markets has negative hedge ratio during Chinese crash, indicating that one dollar invested in Asian stocks (except China) can be hedged by buying gold. The lowest hedging ratio is IND/Gold is -0.072, indicating that one-dollar investment in Indian stock can by hedged by buying 7.2 cents of gold during Chinese crash. The hedge ratios are lower in Chinese crash as compared to the full sample period. Overall, optimal weights and hedge ratios are different during full sample and crisis periods. These optimal weights and hedge ratios have important insights for portfolio managers to reduce their risk and to maintain returns.

Table 4.32 reports the optimal weights and hedge ratios for gold-LA stock portfolios during full sample, US crisis and Chinese crisis periods. The average optimal weight range is 0.28 for BRAZ/Gold to 0.59 for CHIL/Gold during full sample period, indicating that for portfolio of $1, 28 cents should be invested in Brazil stocks and remaining 72 cents in gold market. In addition, in $1 Chile stock-gold portfolio, 59 cents should be invested in Chile stocks and reaming 41 cents in gold market during full sample period. However, average optimal portfolio weight ranges from 0.30 for BRAZ/Gold to 0.62 for CHIL/Gold during US financial crisis. The optimal stock weights are found to be higher for BRAZ/GOLD and CHIL/GOLD during US financial crisis as compared to the stock weights during full sample period. Whereas, the optimal weights are lower for MEXI/GOLD and PERU/GOLD during US financial crisis as compared to the stock weights during full sample period. It implies that in order to minimize risk of portfolio without lowering expected returns, investors should increase their investment in Brazil and Chile stocks, whereas investors should decrease their investment in gold for portfolios of BRAZ/GOLD and CHIL/GOLD during US financial crisis as compared to full sample period. Moreover, investors should decrease their investments in Mexico and Peru stock markets, whereas investors should increase their investment in gold in portfolios of MEXI/GOLD and PERU/GOLD during US financial crisis as compared to the full sample period. Moreover, the average optimal portfolios vary from 0.25 for BRAZ/Gold to 0.57 for CHIL/Gold during Chinese crash. The average optimal weights of majority Latin American stocks in stock-gold portfolio are found to be lower during Chinese crash as compared to the optimal stock weights during full sample. It suggests that investors should decrease their investment in Latin American stock market and increase their investment in gold for the portfolio Latin American stocks and gold during Chinese crash as compared to the full sample period.

The average hedge ratio range is 0.02 for CHIL/Gold to 0.16 for PERU/Gold during full sample period, indicating that a $1 long position in Chile stocks can be hedged for 2 cents with short position in Gold. In addition, a $1 long position in Peru can be hedged for 16 cents short position in gold during full sample period. Furthermore, average hedge ratio range is 0.02 for CHIL/GOLD to 0.16 for BRAZ/Gold and PERU/GOLD during US financial crisis. The average hedge ratio is found to be higher for BRAZ/GOLD and MEXI/GOLD during US financial crisis as compared to the average hedge ratios during full sample period.

Table 4.31: Optimal Weights and Hedge Ratios for the Portfolio of Emerging Asian Stocks and Gold.

	CHN/GOL	IND/GOL	KOR/GOL	INDO/GOL	MYS/GOL	PAK/GOL	PHL/GOL	THA/GOL	TAIW/GOL
Full Sample Period									
w_t^{SG}	0.375	0.432	0.439	0.44	0.682	0.452	0.428	0.463	0.457
β_t^{SG}	0.091	0.055	0.096	0.07	0.031	0.007	0.06	0.046	0.045
US financial Crisis									
w_t^{SG}	0.309	0.391	0.43	0.446	0.719	0.459	0.494	0.416	0.375
β_t^{SG}	0.168	0.198	0.118	0.104	0.083	-0.024	0.031	0.135	0.068
Chinese Crash									
w_t^{SG}	0.45	0.522	0.494	0.605	0.727	0.498	0.423	0.568	0.584
β_t^{SG}	0.055	-0.072	-0.001	-0.066	-0.008	-0.051	0.013	-0.036	-0.014

Notes: w_t^{SG}, β_t^{SG} refer to the optimal weights and hedge ratios respectively.

Table 4.32: Optimal Weights and Hedge Ratios for the Portfolio of Latin American Stock Markets and Gold.

	BRAZ/GOLD	CHIL/GOLD	MEXI/GOLD	PERU/GOLD
Full Sample Period				
w_t^{SG}	0.28	0.59	0.48	0.48
β_t^{SG}	0.09	0.02	0.03	0.16
US Financial Crisis				
w_t^{SG}	0.3	0.62	0.46	0.4
β_t^{SG}	0.16	0.02	0.11	0.16
Chinese Crash				
w_t^{SG}	0.25	0.57	0.53	0.46
β_t^{SG}	0.07	0.01	-0.06	0.13

Notes: w_t^{SG}, β_t^{SG} refer to the optimal weights and hedge ratios respectively.

However, the average hedge ratio range is -0.06 for MEXI/Gold to 0.13 for PERU/Gold during Chinese crash. The hedge ratio of -0.06 indicates that one dollar invested in Mexico stocks can be hedged by buying 6 cents of gold during Chinese crash. Moreover, the average hedge ratios are lower during Chinese crash as compared to the hedge ratios during full sample period. These optimal weights and hedge ratios have important insights for portfolio managers to reduce their risk and to maintain returns during full sample and crisis periods.

Chapter 5

Conclusion and Recommendation

This study aims to examine the return and volatility spillover between different markets (Stock, Oil, and Gold) during full sample period, US financial crisis and Chinese stock market crash. Moreover, it calculates the optimal weights and hedge ratios for different portfolios during both crisis. It analyses the spillover between three sets of markets; stock-stock, oil-stock, gold-stock. It uses the daily data of accepted benchmark stock indices of the nine emerging Asian markets, four Latin American markets and the US. The emerging Asian stock markets include China, India, Indonesia, Korea, Malaysia, Pakistan, Taiwan, Philippine and Thailand. The Latin American markets include Brazil, Peru, Mexico and Chile. Moreover, it uses the Brent prices as an indicator of international oil prices benchmark, whereas London gold spot prices as indicator of International benchmark gold prices. To cover both US financial crisis and Chinese stock market crash periods, it uses a sample period from January 2000 to June 2018. It uses a VAR-AGARCH model for the estimation of return and volatility spillover, which is proposed by McAleer et al. (2009). Following are the empirical findings of the six dimensions of the study.

First, this study estimates the return and volatility spillover from USA to Asia and China to Asia stock markets during full sample, and both crises. It finds a return transmission from USA to Asian stock markets during US financial crises, whereas no return spillover is found from China to Asian stock markets during Chinese crash. Moreover, volatility effect is not transmitted from US to Asian stock markets during US financial crisis, whereas volatility transmits from China to four Asian stock markets (India, Indonesia, Taiwan and Thailand) during Chinese crash. It implies that US and China stock markets do not transmit risk to majority emerging Asian stock markets during crisis period.

Second, this study estimates the return and volatility spillover from US to Latin America and China to Latin America stock markets during full sample, and both crises. It finds that return and volatility spillovers are not found to be significant from USA to majority Latin American markets during US financial crisis. It implies that international portfolio investors can diversify their portfolio by investing in US and Latin American stock markets. During Chinese crash, return and volatility are also not transmitted from the China to Latin American stock markets. It implies that diversification benefits can increased by investing in a portfolio of Chinese and Latin American stock markets during Chinese crash.

Third, this study estimates the return and volatility spillover from oil to emerging Asian stock markets during full sample, and both crises. The return spillover is significant, whereas volatility transmission is insignificant from oil to majority Asian stock markets during US financial crisis. Moreover, the return spillover is significant, whereas volatility spillover is insignificant from oil to most of the Asian stock markets during Chinese crash. Overall, the risk of few emerging Asian markets sensitive to the international oil prices during both crisis. It implies that the return and risk of few emerging Asian stocks are sensitive to international oil prices during US crisis. Moreover, diversification opportunities are higher between oil and Asian stocks during Chinese crash.

Fourth, this study estimates the return and volatility spillover from oil to Latin American stock markets during full sample, and both crises. The return and volatility transmission is insignificant from the oil to most of the Latin American stock markets during US financial crisis. However, only Brazil stock market is sensitive to the international oil markets during US financial crisis. Moreover, the return and volatility transmission is insignificant from the oil to Latin American stock markets during Chinese crash. It suggests that investors can minimize risks by investing in a portfolio of oil and Latin American stock markets during crisis periods.

Fifth, this study estimates the return and volatility spillover from gold to emerging Asian stock markets during full sample, and both crises. The return spillover from gold to majority Asian markets is insignificant during US financial crisis. Moreover, volatility spillover is evident from gold to three Asian markets (Indonesia, Malaysia and Taiwan)during US financial crisis. Moreover, the return spillover is significant from gold to four Asian stock markets (China, India, Pakistan and Thailand) during Chinese crash. In addition, volatility is only transmitted from gold to few Asian stock markets (China, Korea, and Malaysia) during Chinese crash. Overall, few Asian stock markets receive the risk from gold market during crisis. It suggests that investors can get benefit of diversification by investing in portfolio of gold and majority Asian stock markets during US financial crisis and Chinese crash.

Sixth, this study estimates the return and volatility spillover from gold to Latin American stock markets during full sample, and both crises. This study finds an insignificant return and volatility spillover from US to Latin American stock markets during US financial crisis. Thus, addition of gold in portfolio of Latin American stocks will reduce the risk of portfolio during US financial crisis. Moreover, the return and volatility transmission is also insignificant from gold to Latin American stock markets(except Mexico) during Chinese crash. It suggest that diversification opportunities are higher in portfolio of gold and majority Latin American stock markets during Chinese crisis.

Overall, the volatility spillover results vary during crisis periods, thus portfolio investors needs to adjust their portfolios during crisis period to diversify risk. Therefore, this study estimates the optimal weights and hedge ratios to get maximum benefit of diversification during full sample, US financial crisis, and Chinese crash. The optimal portfolio analysis suggests that investors should increase their asset allocation for Asian stocks in Asia-USA portfolio during US financial crisis. Moreover, investors should decrease their asset allocation in Chinese stocks during Chinese stock markets crash.

For LA-USA portfolio, investors should increase investment in Latin American stock markets during US financial crisis. For LA-China portfolio, investors should decrease their investment in Latin American stocks during Chinese crash. Moreover, investors should increase their asset allocation for most of Asian stocks in Asia-oil portfolio during US financial crisis. For Asia-oil portfolio, investors should also increased the asset allocation for Asian stocks during Chinese crash. Investors should increase their investment in Brazil and Chile stocks for the Brazil-OIL and Chile-OIL portfolios during US financial crisis. For LA-oil portfolio, investors should increase their investment in Latin American stock markets during Chinese crash as compared to the full sample.

These results are helpful in asset allocation decisions of individual and institutional portfolio investors in the world, especially during crisis (originated from US and Chinese markets). However, one of the limitations of study is that the optimal weights and hedge ratios are only helpful for the management of portfolios during future crisis from the US and China, but not from the other part of the world. These findings are also useful for policymakers of emerging Asian and Latin American economies, especially on how policy makers deal with higher interconnectedness between the stocks, oil-stocks and gold-stock markets during crisis period. The findings of volatility spillover between different financial markets would be of greater interest for policymakers to stabilize the economy and financial markets during different crises. Therefore, policymakers need to design such policies that would safeguard the financial sector from international financial shocks from US and China. They can also predict the impact of financial crises in one market on their own markets with the help of spillovers between financial markets.

5.1 Limitation of the Study and Recommendations for Future Research

This study explores the pairs of stock-stock, oil-stock, and gold-stocks during the full sample period, US financial crisis, and Chinese stock market crash. This study can be extended in various ways, Like

1. This study focuses on the spillovers from US stock, Chinese Stock, crude oil, and gold markets to emerging stock markets (Asian and Latin American stock markets) during Chinese crash. Further studies can be conducted on spillovers from the US stock, Chinese Stock, crude oil, and gold markets to the emerging (Europe, Middle East, and Africa) and frontier (Asia, Europe, Middle East, and Africa) stock markets during the Chinese crash.

2. Several other pairs of markets are recommended to explore during the Chinese crash, i.e., stock-bond, stock-real estate, stock-industrial metals, metals-energy, stock-exchange rate, metal-exchange rate, and energy-exchange rate, etc.

3. This study just apply the VAR-AGARH model to examine the spillover between financial markets. However, several other techniques can be applied to examine return and volatility spillover between markets during the Chinese crash, i.e., BEKK-GARCH, DCC-GARCH, Diebold and Yilmaz approach, and Copulas methods, etc.

4. This study does not calculate the hedging effectiveness of the portfolios, thus it is recommended to calculate hedging effectiveness of portfolios during Chinese crash.

5. This study calculates the hedge ratios. In addition, it is also suggested to explore the determinants of hedge portfolio returns during the crisis and non-crisis periods.

6. Two big crashes (Chinese crash of 2015 and the COVID-19 outbreak) were emerged from the China, thus it is also suggested to examine the differences in spillovers during both crisis.

7. This study uses the daily data, it is suggested to explore the spillovers between markets using intraday data during the Chinese crash.

Overall, the Chinese stock market crash provides the huge room for further analysis, because this crash is not fully explored in literature.

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