Volatility Spillover between Currency and Stock Markets in Financial Crisis Period: Evidence from China

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Abstract

The study aims to investigate the volatility spillover between the currency and stock markets of China for the period from January 01, 2004 to December 31, 2013. The time frame is divided in to pre, amid and post-financial crises periods. "Generalized Autoregressive Conditional Hetroskedasticity (GARCH)" model is used to analyze the shock spread between these markets. The findings suggest significant bidirectional volatility spillover between the currency and stock markets in amidst and post-financial crisis periods. However, the spillover is more pronounced from currency to stock market in the post-financial crisis case. Moreover, unidirectional volatility flow form stock to currency market was observed in the pre-crisis era. The study helps the regulators to make policies that protect the financial markets from shocks. Similarly, the investors can get advantage, i.e. avoid risk and increase returns by diversifying their investment in non-correlated markets.

***Keywords*:** Volatility spillover, Currency market, Stock market, GARCH, China

Introduction

Globalization and revolution in the telecommunication has virtually disappeared borders and distances in today world. World economies and markets are now more integrated and interlinked than ever. This integration posits both costs and benefits for national economies. For instance, on one hand it increases the efficient utilization of scarce resources and accelerates the country's growth process, on the other hand, it worsen the financial crisis of an economy by providing safe path to investors for market exit at the time of economic sufferings. This means that when there is an opportunity in the domestic stock market, foreign investor will exploit it, but at the time of economic unease they will transfer their

resources to the safe heavens. This clientele behavior of foreign investors' may result in volatile capital flow of a country. Thus, the problem faced by the regulators at the time of opening the economy for foreign investors is the regulation of flow of foreign capital. Furthermore, the financial value of an asset is determined by the present value of its future cash flows. Therefore, the relative exchange rate of the domestic currency plays a vital role in the capital flow and market volatility. If domestic currency is appreciating, it will increase the present value of future cash flows of the domestic assets and thus will attract the foreign investors and vice versa. Therefore, volatility in domestic capital flow may be due to the opportunity or challenge posit by the domestic currency and/or stock currency markets.

Extent literature document the potential costs of integrated stock and currency markets (Bae & Zhang, 2015; Maitra & Dawar, 2019; Ngo Thai, 2019). For instance, less diversification options are available to investors and high volatility spillover from one market to the other. This attracted the attention of many economists, policy makers and financial scholars to investigate the association between the stock and currency markets. However, their findings are inconclusive. For instance, Bartov and Badnar (1994) and Jorion (1990) investigated the relationship of US firms' stock returns and US Dollar movements. They failed to document significant association between the US stock and currency markets. Chkili (2012) studied eight emerging economies, i.e. Malaysia, Singapore, Hong Kong, Brazil, Argentina, Maxico, South Korea and Indonesia, and found significant bi-directional volatility spillover in their stock and currency markets. Similarly, (Maitra & Dawar, 2019) reported unidirectional shock transmission between equity and currency markets in Russia and Emerging Eastern European economies. Furthermore, many studies show different linkages in currency and stock markets in normal and crisis periods. For instance, Panda and Deo (2014) investigated the Indian stock and currency markets and reported that significant bi-directional volatility spillover thereof in the post-crisis period than the pre-financial crisis era. Mozumder, N., De Vita, G., Kyaw, K. and Larkin, C. (2015) studied three developed and three emerging economies for volatility spillover in their stock and currency markets in all three periods, i.e. pre, during and post-crisis. Their empirical results reveal significant asymmetric shock flow in stock prices and exchange rates amid-financial crisis period in both developed and emerging economies.

This study aims to provide additional evidences on linkages between the currency and stock markets from China. As an emerging economic giant, China's markets have for greater impact on the global financial system than any other emerging economy. Likewise, emerging economies are also more vulnerable to shock spillover transmitted by global financial system (Prasad E, Rogoff K, Wei S-J, Kose MA). Furthermore, China's financial liberalization drive transforming its economy from

centrally planned to market base economy. Therefore, China set a perfect ground for volatility spillover investigation in its stock and currency markets. Second, the study contribute to the extant literature by providing empirical evidences for the association between the stock prices and exchange rates from all three periods, i.e. pre, amid and post-financial crisis period. This has important implications for both policy makers and investors. Policy makers can anticipate the future stock and currency prices fluctuation in these periods and thus formulate the necessary policies for it. Investors can minimize their risk and increase their returns by analyzing the trend of their security prices in these periods. Third, contrary to other studies which only examined the linkage between the stock and currency markets, we analyzed volatility spillover in these markets.

The remainder of this study is as follow:

Section-2 highlights existing literature, section-3 explains the methodology of the study, and section-4 includes results and discussion while last section, i.e. section-5 presents the conclusion and implications of the study.

Literature

The two widely used explanations for volatility spillover between currency and stock markets are "flow oriented" and "stock oriented" models. Flow Oriented model (Dornbusch & Fischer, 1980; Gavin, 1989) emphasis on the exchange rate effects on firms' output and the country's balance of trade. The decrease in the value of domestic currency improves the local firms' competitiveness in international market and thus encourage them to produce more. Consequently, the firms' income and the country's export increases and imports plunges. This attracts the investors to invest in the country's securities and thus the prices of local stocks rises. While the stock oriented model (Branson & Henderson, 1985; Frankel, 1987) shed light on the choice whether to hold assets in domestic or foreign currency. Stock's return play decisive role in this situation. Higher domestic stock returns increase the country's citizenry wealth and strengthen the domestic currency.

A large number of studies have been conducted to investigate the volatility spillover in currency and stock markets. However, (Franck & Young, 1972) were the first researchers to examine the stock price reaction to exchange rate re-alignment of multinational firms. The extant literature is classified into **six** categories; First, studies with no volatility spillover presence in currency and stock markets; Second, studies with the unidirectional volatility flow in these markets; Third, the literature with findings of bi-directional volatility movement in these markets; Fourth, the work pertinent to the financial crises of 1997 and 2008; Fifth, those studies which have mixed evidences of volatility

transmission in currency and stock markets and finally the group of studies which investigated the volatility spillover shocks amongst different stock markets.

The studies on no volatility spillover between stock and currency markets include; (Kearney & Daly, 1998; Mlambo, Maredza, & Sibanda, 2013; Morales, 2008). A study of Kearney and Daly (1998) investigated the volatility spillover between Australian stock and exchange rate markets and revealed that there is lack of significant volatility spillover from currency to stock market. Likewise, Morales (2008) carried out a similar study for six Latin American Countries i.e. Mexico, Brazil, Argentina, Spain, Venezuela and Colombia with European economies and found no statistically significant correlation thereof. Mambo et al (2013) studied volatility spillover in the South Africa settings for the period of 2000 to 2010. In their study they employed Generalized Autoregressive Conditional Heteroscadasticity Model to investigate the exchange rate volatility and stock prices association. Their findings document a very weak volatility spillover bond in the exchange rate and equity markets. The weak relationship in this market reveal that Johannesburg Stock Exchange (JSE) is a safe destiny for foreign investors.

Literature on unidirectional relationship consist; for instance, (Adjasi, Harvey, & Agyapong, 2008; Chkili & Nguyen, 2014; Doong & Lee; Ebrahim, 2000; Fedorova & Saleem, 2009; Kanas, 2000; Kang & Yoon, 2013; Mozumder, 2013; Ngo Thai, 2019; Okpara & Odionye, 2012; Yang & Chang, 2008). Ebrahim (2000) studied the exchange rate and equity markets for volatility spillover. His results reveal the unidirectional spillover in these markets. Similarly, Kanas (2000) analysed six developed economies i.e. Japan, US, Canada, France, Germany, and UK, and found a unidirectional volatility effect running from equity returns to exchange rate returns for all the mentioned countries except Germany. Similar results, i.e. unidirectional linkage between stock and foreign exchange markets, were also reported by Adjasi et al. (2008) in Ghana settings. Yang and Chang (2008) examined five equity markets, namely, Singapore, Japan, South Korea, Taiwan and USA. Their analyses were carried out on Double Threshold GARCH (DTGARCH) model and suggest unidirectional volatility flow in exchange rate and equity markets of these economies. Fedorova and Saleem (2010) investigated the volatility spillover between the Russian and East Europe Emerging economies' Stock and Currency Markets. They employed Bivariate GARCH BEKK model to investigate it. Their findings show a unidirectional volatility spillover from exchange rate market to stock markets. Doong and Lee (2011) conducted a similar study in South-East Asia economies. They analysed weekly data from 2000 to 2008 for Indonesia, Malaysia, Korea, Taiwan, Philippine, and Thailand for volatility spillover in the equity and currency markets of these economies. Using STCC-EGARCH (1.1) model, they reported

price spillover from stock to exchange rate market. Furthermore, Okpara and Odionye (2012) reported one sided shock transmission in Nigeria settings. Moreover, Mozumder (2013) empirically investigated volatility spillover in Brazil, Ireland, Netherlands, South Africa, Spain and Turkey stock and currency markets. He used EGARCH model and found volatility move from equity to currency markets in these countries. However, the shock spillover pattern is reverse in emerging economies. For instance, Kang and Yoon (2013) documented unidirectional flow of volatility spillover from currency to stock market within Korea. Likewise, Chkili and Nguyen (2014) annualized the BRICS economies and found unidirectional flow in their exchange rate returns and stock market returns.

Likewise, many studies reported bidirectional volatility spillover in currency and stock markets (Aloui, 2007; Andreou, Matsi, & Savvides, 2013; Chkili, 2012; Francis, Hasan, & Hunter, 2006; Kumar, 2013; Qayyum & Kemal, 1961; Sharma & Mishra, 2015; Vardar & Aydogan, 2019; Xiong & Han, 2015). By using Bivariate EGARCH model, Qayyum and Kamal (2006) empirically investigated the volatility spillover in Pakistan's currency and stock markets and found bi-directional relationship between them. Similarly, Francis et al (2006) examined the dynamic relationship of international currency and equity markets. They employed Trivariate GARCH (1.1) model and find significant bi-directional relationship between equity and currency markets. Their results further reveal that the association between USA and foreign stock markets are relatively stronger in volatility than the mean. Moreover, the volatility spillover from currency to stock market is stronger than the equity to currency markets. A similar study was also carried out by Aloui (2007). The result observed the bi-directional flow of volatility between the currency and equity markets of the US and five major European economies. Similar results were also documented in emerging economies. For instance, Chkili (2012) studied eight emerging economies i.e. Malaysia, Singapore, Honk Kong, Brazil, Argentina Mexico, South Korea and Indonesia and found bi-directional flow of shocks between stock and currency markets. In another study, Andreou et al (2013) investigated 12 emerging economies six from Latin America i.e. Argentina, Brazil, Colombia, Chile, Venezuela and Mexico and six from Asia i.e. India, Korea, Malaysia, Pakistan, Philippine, and Thailand. They employed quarto-variate VAR-GARCH and BEKK models to examine the volatility shocks in the equity and currency markets of these developing economies. Their findings suggest bi-directional volatility spillover effect in the equity and currency markets of the studied economies. Furthermore, Kumar (2015) examined currency and equity markets of IBSA (India, Brazil and South Africa). His analysis which was carried on multivariate GARCH and BEKK model confirmed the existence of bi-directional volatility spillover in their currency and equity markets. His findings also suggest that the role of stock market is more significant than the currency

markets in both the first and second movement and spillover. Existing literature also document similar findings for other developing countries, for instance, Xiong and Han (2015) study of China's stock and currency markets, and Sherma and Mishra (2015) investigation of volatility spillover between Indian stock and currency markets.

Volatility Spillover in Financial Crisis

The Asian financial crises of 1997 attracted the scholar's attention to investigate the volatility flow pattern between stock and currency markets in different time periods. The extant literature document this phenomena in financial crisis period of 1997 and 2008 include; for example, rns for shock spillover in three financial crises periods by employing Generalized Autoregressive Conditional Heteroscadasticity model. They revealed that there exists volatility spillover between these two returns during the three crises periods. Further they concluded that there is no a(Choi, Fang, & Fu, 2010; Jebran, Chen, Ullah, & Mirza, 2017; Panda & Deo, 2014; Saha & Chakrabarti, 2011) empirically investigated shock spillover of equity market with currency market of New Zealand in pre-post "Asian Financial Crisis Period" of 1997. They used Exponential GARCH model for analysis purposes and found unidirectional dynamic spillover during pre and post crises period. Saha and Chakrabrati (2011) examined the Indian stock returns with exchange rate retu symmetric affect between currency and stock markets during the three sub-periods. Likewise, Panda and Deo (2014) investigated the shock momentum between India equity and currency market for Pre and Post crisis period. Their analysis, based on GARCH and EGARCH models, reveals significant bi-directional volatility spillover between currency and stock markets in post crises period than pre crises period. Granger et al. (2000) studied the East-Asian countries i.e. Japan, South Korea, Indonesia, Hong Kong, Malaysia, the Philippines, Thailand, Singapore and Taiwan. They used daily data from 1986-1997 and employed Granger causality and Gregory-Hansen co-integration test to find the association between stock prices and exchange rates. Their results reveal that exchange rate changes affects the stocks prices in Thailand and Japan setting. However, contrary relationship was observed in Taiwan case, i.e. stock prices changes leads to exchange rates changes. Moreover, significant bi-directional relationship was seen between the exchange rate and equity prices in South Korea, Indonesia, Malaysia, and the Philippines, a finding in line with Bahmani-Oskooee and Sohrabian (1992) for the USA. Lastly, Singapore failed to record any form of directional relationship. A slimier study Nieh and Lee (2001) investigated stock and currency markets of G-7 countries i.e. USA, Canada, Italy, France, Germany, UK and Japan for the period 1993-1996. They found the dynamic relationship between stock prices and exchange rates.

Furthermore, their results of VECM estimation show that the two variables lack the predictive capabilities for more than two successive days and thus a temporary significant association which remains for a day for certain G-7 countries.

Apart from the above discussion there are also studies that report mixed results, see for example, (Beer & Hebein, 2011; Granger, Huangb, & Yang, 2000; Jebran & Iqbal, 2016). Beer and Hebein (2008) analysed both the emerging and developed economies. Their sample of developed countries consist of US, UK, Canada and Japan while the list of emerging economies include Singapore, South Korea, India, Philippine and Hong Kong. By using EGARCH model they found positive spillover from currency to equity market for Canada, South Korea Japan and India. It means, in these economies when the currency rate plunges the stock prices will decline and vice versa. For other countries the volatility spillover pattern is not persistent. Similar mix results were also reported by Granger et al. (2000) for East Asian countries i.e. Indonesia, Japan, Malaysia, South Korea, Taiwan, Hong Kong, Thailand, and Philippines. They observed bi-directional relationship between the currency rate and stock prices of Indonesia, Malaysia, Philippines and South Korea. In case of Japan and Thailand, their findings were unidirectional. Moreover, no significant association was seen in Singapore currency and equity markets. Furthermore, Jebran and Iqbal (2016) investigated six Asian economies and reported bi-directional asymmetry volatility spillover between stock and currency market of China, Hong Kong, Pakistan and Sri Lanka. Further their study reveals that there exists unidirectional relationship between the Indian markets. They also found no significant shock spillover of Japan's currency and stock markets.

However, a group of scholars of the view that volatility spillover should not be investigated in isolation but the correlation among different markets should also be taken into account. On the basis of correlation among different markets the investors will be able to take important decision about their portfolio diversification. The investors should know about the high correlation among the market indices and the low correlation among the market indices. The high correlated market indices are riskier than the low correlated market indices. Markowitz (1959) investigated the relationship between stock indices and argued that the investors should focus on those markets which are least correlated markets in order to reduce risk. Globalization is the factor which removed the barrier and increased the linkages among the equity markets (Forbes & Rigbon, 2002), same is in updating the technology. Crisis is not only the cause which will affect the local market but these shocks will also transfer to the other markets. There are different factors which interlink the markets, for example, capital flow from

one market to other market, common ties among the economies and same policies related to same issues.

Emerging Markets

Most recently, an attempt was made by many scholars to investigate the volatility spillover in the exchange rate and equity prices by using updated data from many advanced and developing economies. For instance, Alagidebe et al. (2011) used monthly data of five advanced countries, namely Canada, Switzerland, UK, Australia and Japan, for the period 1992-2005 and found no significant long-run association thereof. However, by employing Granger causality test they found causal linkage from currency to stock market in Canada, UK and Switzerland and reverse in Japan, i.e. from stock to currency market. In the same line, Harjito and McGowan (2011) investigated the exchange rate and stock process of four East Asian economies i.e. Singapore, Thailand, Indonesia and Philippines. By analysing weekly data from 1993 to 2002 their findings reveal presence of co-integration between exchange and equity rates and among all the stock markets of these economies. Buberkoku (2013) studied both advanced and developing economies' stock and currency markets for volatility spillover. He used a large dataset comprising monthly data from 1998-2008 of Australia, Canada, England, Germany, Japan, Singapore, South Korea, Switzerland and Turkey. He analyzed the data through Engle-Granger and Johansen cointegration test and Granger causality and observed no statistically significant long-run relationship between currency and stock rates in the studied economies except Singapore. However, in short-run stock prices shocks were observed in the currency markets of Canada, Switzerland and Turkey. Whereas, causality flow is from exchange rate to stock prices for South Korea and Singapore. Furthermore, no causal linkage was seen in either direction in case of England, Germany Australia, and Japan.

For data sensitivity issue, Tsagkanos and Siriopoulos (2013) examined both the daily and monthly data for the period 2008-2012 for US and European Union to check the relationship between the two variables in crises period. They used Johansen co-integration test, non-parametric co-integrating regression and Granger causality test and found short-run shock shocks flow from stock to currency market in USA, while long-run in EU case. Concentrating on financial crunch of 2007-2010, Caporale et al. (2014) analyze the relation between stock prices and exchange rates of developed economies i.e. USA, Canada, UK, Euro area, Japan, Switzerland. They examined weekly data, divided into crisis and non-crisis period by Bivariate UEDCC (Unrestricted Extended Dynamic Conditional Correlation) GARCH model. Their findings suggest unidirectional Granger causality which run from stock prices to currency value in USA and UK; while contrary to this Canada and Euro regions area except

Switzerland bidirectional causality was observed. Kollias et al. (2012) employed rolling regression to investigate the link between the stated variables. The advantage of this technique is that it takes into account the new information as the period proceeds by observation. Their empirical results report no long-run relationship between equity and exchange rates while the causality depends on the market conditions. For instance, the causality direction is from currency market to stock market in non-crisis period and vice versa.

Existing literature also highlight the transmission of volatility spillover from advanced to emerging markets. For instance, Chou et al. (1999) examined the volatility shock spread from the US market to the emerging market of Taiwan. Miyakoshi (2003) find the close association between the Japan and its regional Asian regional stock and currency markets with other global markets. They found that volatility transmit from the US to the Japan's markets and return spillover from Japan to US markets. China showed remarkable high GDP growth in last couple of decades. Therefore, Johansson and Ljungwall (2009) examined the Chines Stock and currency markets with the Hong Kong and Taiwan markets. They employed Multivariate Autoregressive Conditional Heteroscadasticity Model to examine the volatility flow pattern among these markets. Other studies also document no significant association between China and developed markets (Li 2007; Li et al (2009).

The Co-integration Framework

Some of the researchers used the Johanson and Joselius approach along with granger causality test to find the long-run relationship and causality between these two series. Earlier scholars emphasized on the exchange rate and stock returns and did not pay attention to the time level effect of the two variables. This is because of econometric assumptions requiring non-stationarity of data in many finance and macroeconomic analysis. However, contemporary researcher suggests data stationarity to avoid spurious results. Phylaktis and Ravazzolo (2005) were the first one to overcome this problem. They suggested cointegration technique to curb the non-stationarity issue and allow the investigation of stock prices and exchange rate relationship in both levels and differences. They investigated the Pacific Basin countries stock and currency markets for both short and long-term relationship. Earlier, Bahmani-Oskooee and Sohrabian (1992) used cointegration and Granger causality tests to observe causality pattern in stock prices and currency rates of advanced markets. Their findings revealed short-run bidirectional relationship between the studied variables. Similar studies were carried out in other parts of the world. However, results are inconclusive. For instance, the study of Yu (1997) shows some causal connections among East Asian markets (i.e. Tokyo Hong Kong, and Singapore). Conversely, Ajayi and Mougoue´ (1996) found significant relationship, both short-run and long-run, between stock

and currency rate of eight industrial economies. In another study, Ramasamy and Yeung (2005) studied the stock and currency rates of nine East Asian countries and testified that the casualty flow vary according to the period. For instance, in crisis period stock prices changes leads to exchange rate variations in these countries. In an extensive study Cumperayot et al. (2006) investigated the stock and currency markets of 26 countries for volatility spillover. They employed simultaneous equation probit model for their analysis purposes. These authors observed that stock market crash was followed by the sharp currency fall on the same day in crisis affected emerging economies.

Bahmani-Oskooee and Sohrabian (1992) found that the S & P 500 and the effective currency rate of the dollar are not stationary. Further they applied the Cointegration technique and recorded no long-run relationship between these two series. However, their finding highlights the cause-and-effect relationship in the short-run. Smyth and Nandha (2003) examined four South Asian economies i.e. Pakistan, India, Sri Lanka and Bangladish for linkage in their stock and currency markets. By using daily data for 11 years for the period 1995-2001 they found no significant long-run association in all the four countries. By using Granger Causality test they reported that currency rate affect equity prices in Sri Lanka and India but for the other two countries i.e. Pakistan and Bangladesh no such movement was observed. Yau and Nieh (2006) investigated the fifteen years monthly data i.e. 1991-2005, of Taiwan and Japan from for the association between the stock -prices and the currency exchange rates i.e. NTD/Yen. They used the Granger causality test and reported a bidirectional causality in the stock prices of both economies. However, no causal relationship was seen on the currency side. Furthermore, by using Johansen co-integration test they concluded that no long-run relationship exist in the studied variables. But, Yau and Nieh (2009) revisited their employing co-integration approach with threshold effect between equity and exchange rates in Taiwan and Japan and US exchange rate effect on Taiwan's financial market. But, Yau and Nieh (2009) revisited the issue by testing for cointegration with threshold effect between the stock prices and the exchange rates in Japan and Taiwan and the effect of US exchange rate on the financial market of Taiwan monthly data from 1991-2008. Results reveals different linkage this time. For instance, long-run relationship between NTD/JPY and stock prices of the two countries was seen. Moreover, the short-run causal linkage disappeared in the revised version. These findings are in line with the notion that a long-run positive association transmits from currency of either USA or Japan to the Taiwan stock market.

Ismail and Isa (2009) applied cointegration for finding the long-run association in the two markets of Malaysia by using data from 1990-2005, and found no significant evidence of long-run thereof. Pan et al. (2007) employed Cointegration and Granger Causality test to study the stock-currency bond in

seven Asian countries (i.e. Korea, Malaysia, Taiwan, Japan, Hong Kong and Thailand). The daily data was used from 1988-1998. Their findings do not provide sufficient evidence for the presence of long-run linkage between the stock prices and currency rates. They found significant causal relationship in Japan, Hong Kong, Thailand and Malaysia from currency market to stock market prior to crisis period, i.e. the 1997, in Asian Financial Markets, but amidst crisis no cause and effect relationship in Malaysian stock and currency markets.

The GARCH and EGARCH Models

Extant literature document the dynamic relationship between the exchange rate and stock prices. Many of these studies used Generalized ARCH (GARCH) model to investigate this linkage. For instance, so (2001) examined the US dollar and interest rate relationship via Multivariate Exponential Generalized Autoregressive Conditionally Heteroskedastic (EGARCH). His findings suggest the volatility spillover between dollar and interest rate. Further, the relationship between the two markets is temporary. By using the same econometric model Laopodis (1988) investigated volatility spillover among three European and three non-European monetary system. The results record existence of significant volatility spillover among these markets except the Yen. In another study, Chung (2003) studies the spot and future markets of Taiwan to diagnose the volatility flow pattern. His finding show concurrent correlations and price information spillover between the two markets. Koutmos and Booth (1995) investigated the New York, Tokyo and London stock exchange markets for volatility spillover and find asymmetric shock transmission among these markets. Considering the economies of world most advanced economies, Kanas (2000) carried out his volatility spillover enquiry in the six well-established stock and exchange markets of US, Japan, Canada, UK, France and Germany. The results support asymmetric volatility spillover from stock to exchange market for five economies, Germany is an exception. Conducting another study, Kanas and Kouretas (2002) studied the mean and variance causality via EGARCH-M and CIV methodology for four Latin American markets. Their findings reveal substantial evidence for presence of both mean and variance causality. Furthermore, the casualty in means was greatly influenced causality in variance. This model, i.e. multivariate GARCH, was also used by Caporate et al. (2002) for volatility spillover in four Asian economies. In his detail study, Assoe (2001) analyzed both developed and emerging markets. He took five advanced and eleven emerging markets for volatility spillover in their stock and exchange markets with the US markets. Moreover, Yang and Doong (2004) explored the G-7 markets for mean and volatility flow pattern. The empirical results of the study consistent with the asymmetric flow of volatility shocks from stock to

exchange market. However, Chiang and Yang (2003) found that a higher exchange rate fluctuation contributes marginally to a lower US local equity market correlation in most cases.

The policy measures instituted as a result of the crisis are likely to have affected the structure and correlation of the markets and the underlying return generating processes. Therefore, the validity of pre-crisis studies on important financial variables and relationships is suspicious. Previous evidence suggests that significant events associated with a country (Karolyi and Stulz, 1996) have an informational spillover effect on other countries. This "shift interdependence effect" of dramatic news regarding a country has also been well-documented in Arshanapalli and Doukasm (1993), Bennett and Kelleher (1988), Jeon and Van Furstenberg (1990) and Lee and Kim (1993), who found that stock market linkages change as a result of catastrophic events like the 1987 stock market crash.

Multivariate Model

Globalization and telecommunication revolution has virtually disappeared borders and distances in today world. International trade, foreign investment and foreign exchange transactions has increased many folds. Investors can now easily find, assess and buy the security or currency which best met his investment need. However, asset and currency rate of a country is also influenced by its macroeconomic indicators and fiscal and monetary policies i.e. GDP growth rate, Balance of Trade (BOT), Balance of Payment (BOP), Inflation, interest rate etc. Investors pay special attention to these factors in their investment decisions. For instance, Chen et al. (1986) used an APM model to investigate the relationship between the macroeconomic variables (i.e. Inflation, industrial production, risk premia etc.) and stock return in USA settings. They found substantial evidence that the studies macroeconomic variables have significant effect on the stock returns. Similar results were also reported by Fama and French (1993).

The proximity of the Asian-Pacific countries may lead to conclusion of a close association their markets and vulnerability to shocks spillover from adjacent economies. However, many pre-crisis studies reveal weak cross-market linkages thereof (Chowdhury, 1994; Eun and Shim, 1989; Lee, Petit, and Swankoski, 1990; Liu and Pan, 1997). The financial crisis of 1997 is provocative in this regards as it suggests a shift in the regional market linkages linkage. Furthermore, it has changed the investors' perception, domestic liquidity volatility pattern and structure of the political economy. Forbes and Rigobon (2001) suggest that a necessary condition to conclude contagion is a shift in the interdependence arrangement of regional economies. The mere presence of interdependence before and during the crisis is not in itself a sufficient and necessary condition to show contagion. The purpose

of this paper is to show that change took place in the interdependence of the economies. Two important explanations for contagion are: first, it will deteriorate the international diversification effectiveness; second, while it is difficult to judge the contagion channel, one would hope that there exists a bail-out plan to stop a process unwarranted by a country's economic fundamentals to spin out of control and take down other economies with it.

Tian and Ma (2010) examined the relationship between stock prices and macroeconomic variables (i.e. money supply, exchange rates, consumer price index and industrial production) in China setting. They used monthly data set from 1995- 2009 employed the ARDL model of cointegration for analysis purpose. Their findings show no sufficient evidence for cointegration presence before financial liberalization, i.e.2005, however, it exist in the post liberation era. Exchange rate and money supply positively affect the stock prices in Shanghai stock market. Similarly, the consumer price index of past month trigger changes in stock prices. Chortareas et al. (2011) conducted their study in oil rich Middle East region. They considered oil prices as a moderator between the stock prices and exchange markets of these economies. Their analysis was based on Johansen cointegration model. Results reveal no long-run cointegration between the currency exchange rates and stock prices when oil prices are not considered. Moreover, when the oil prices are taken into account, again no long-run co-integration was observered for full studied period, i.e. 1994-2006. However, when investigated for pre and post oil price shock period results show that after the crunch, exchange rates, stock prices and oil prices are cointegrated in Saudi Arabia, Egypt, and Oman. But for Kuwait, long-run linkage was recorded between equity and oil prices. Currency rates are positively associated with stock prices in Oman and Egypt, while in Saudi Arabia this link is inverse. Liu and Tu (2011) used daily data from 2001-2007 and take exchange rate and foreign investment as determinants of equity prices and examined the volatility spillover in Taiwan. The results show that the exchange rate and the stock prices are affected by the over buying and overselling of foreign capital. Furthermore, the three conditional means show asymmetric mean-reverting behavior. This means that negative returns revert relatively faster than the positive ones. Finally, the volatility movement of all the three markets reveal the GARCH effects.

Eun and Shim (1989) use daily (closing) index returns on nine stock (Australia, Japan, Hong Kong, United Kingdom, Switzerland, France, Germany, Canada, United States) markets to study market interdependence. Their period of study was December 1979 to December 1985. The authors used impulse response functions and variance decomposition in Vector Auto Regression (VAR) to measure the strength and inventions from one market to the others. They find surprisingly low linkage between these markets, but the US market asserts itself as the most dominant and influential market. The

estimated lag response to a shock in the US market is estimated as a day and this supports the notion of informational efficient global stock markets.

Cheung and Liu (1994) tested for the presence of a long-run connection among five Asian stock markets (i.e. Malaysia, Hong Kong, Singapore, Korea and Taiwan) during the period 1980-1990. Using a multivariate cointegration model, their findings lack evidence on the presence of cointegration. However, using the same indices in US Dollars, they unveiled evidence of cointegration and concluded that movements in the US dollar during the period of study invalidate the multivariate cointegration analysis findings.

Howe, Martin, and Wood, Jr. (1997) use classical and modified re-scaled range analysis to research long-term memory in Pacific Rim Equity Markets. Their period of study is January 1981 to May 1994. They find the presence of a long-range non-linear deterministic structure in Japan, Singapore, Korea, and Taiwan, which ranges from three to four years in duration. However, after correcting for short-range dependence using Lo's modified rescale analysis, all evidence of memory disappears.

Pan and Liu (1997) and Pan, Liu, and Roth (1997) use Johansen's Cointegration test and Modified Cointegration with GARCH to study common stochastic trends and volatility in five Asian Pacific equity markets. Their period of study is April 1988 to December 1994. They found that the five Asian markets and the USA market are highly integrated through the second moments of stock returns, but not the first moment.

Persva and Lean (2011) in their model included other variables like inflation rates, oil prices and interest rates as the important determinants of stock prices for the main oil producing countries like Oman, Iran, Egypt, Saudi Arabia, Kuwait and Jordan. The results of the study showed that all variables were cointegrated. In the case of Iran, Egypt and Oman before stock crises a bi-directional causality existed in both short and long-run between exchange rate and stock prices. In the case of Kuwait, short-run causality transmit from exchange rate to stock prices was observed. Basher et al. (2012) also included oil prices in their model. They used VAR model for the emerging markets to find the relationship among stock prices. They included an extra variable of Global economic activity in their model which affects the oil prices. After analysis of monthly data from 1998 to 2008 they found that when oil prices raises, stock prices and exchange rates decreases. Eita (2012) used quarterly data and Johnsen method for the study to find the determinants of stock prices for Namibia. The results showed that the variables like exchange rates, inflation rates money supply and interest rates affect stock prices. There found positive connection between stock prices with money supply and economic activity.

However, negative relationship was seen of stock prices with inflation and interest rate. In the same way Inegbedin (2012) using Cochran-Orcutt Autoregressive model for the Nigeria and using data from 2001 to 2009. The result showed an indirect relationship between exchange rates and stock prices. The relationship between stock prices and inflation rates, stock prices and interest rates were insignificant when observed individually but the joint effect of these variables on the stock prices was significant.

Geographical linkage is amongst the important factors that causes spillover effects. In the recent decades scholars paid more attention to the geographically connected emerging economies, especially the one located in the Asian region. Bekaert (1998) proved that there is strong positive relationship between liberalization policies, territorial connection and world market returns which indicates strong spillover effects between countries. Ng (2000) examined regional factors for spillover effect and reported significant correlation in the pacific Basin markets. Similarly, study of miykoshi (2003) investigated markets of Asian region and proved that the regional factors have stronger affect than the world markets. However, the results of some papers showed contrary findings. For instance, Chan et al. (2003) showed a strong effect from the US to the Asian markets. Likewise, Bayoumi and Swiston (2007) proved Global financial conditions the major factor of spillovers. Fujiwara Takashi (2012) showed that US paly vital role in the fluctuation of Asian financial markets, while the increase in the role of China is negligible in the Asian financial markets. Lin (2012) added foreign reserves and interest rates as an additional variable in the connection of stock and stock prices. He used monthly data from 1986 to 2010 and employed the ARDL model to examine the portfolio adjustment in the emerging markets of Asia like Thailand, Taiwan, Korea, Philippines, Indonesia and India. The results revealed that the relationship between stock prices and exchange rate became stronger in the crises period as compare to pre crises period. Spillover effect was observed from stock prices to exchange rates. Aslam and Ramzan (2013) used the variables like per capita income, CPI, real effective exchange rates Index, and discount rate as the main determinants of stock prices in Pakistan. The NLS and ARMA models were used. There is observed a negative effect of inflation and discount rate on the Karachi stock price index, however the effect of per capita income and real effective exchange rates on the Karachi stock price index was positive. This study helps that how macroeconomic variables can be used for the better performance of stock market. Groenewold and Paterson (2013) introduced an extra variable of commodity prices for the relationship between exchange rate and stock markets. Their findings suggest that when the commodity prices were not considered, exchange rates and stock prices were not cointegrated. But when commodity prices are included, significant cointegration was observed among all the three variables. Furthermore, no causality linkage in any direction was seen

between exchange rates and stock prices in the short-run. However, a bi-directional causality effects observed in the case of commodity prices and stock prices. Contagion phenomenon is another significant factor like the spillover effects. The financial contagion may be defined as the rise in the strength of linkage of financial markets in the crises period (Forbes and Rigobon, 2002; Dungey et al., 2010). The results of different studies showed different results, some studies showed that in the time of financial or Global crises there is increase in the spillover effects (Baig andGoldfajn 1999; Caporale et al., 2006; Saleem, 2008), however some studies found negligible effects of contagion (Bekaert and Ng,2005). Bekaert et al. (2012) rejected the increase in the spillover effects during the financial and global crises. This study aims to fill the gap by investigating the volatility spillover between the currency and stock markets of China.

Methodology

Several studies have documented the volatility spillover effect among the different equity and currency markets. Different researcher used different methods to find the shocks among the markets. Among these researchers, most of the researchers employed the GARCH model to find the shock spillover between the stock prices and exchange rates, for example, (Pan and Liu, 1997; Caporate et al., 2002; Liu and Tu, 2011)

This study aims to investigate the volatility spillover between the stock and currency markets of China in pre, amidst and post-financial crisis period. Daily China total market prices data were taken from the Data Source "yahoofinance.com". The Data for exchange rates RMB/USD were collected from oanda.com. The span of sample period consists of 10 years from 2004 to 2013. Financial Crisis period lays amid the centre of the study period. The total observations of the study are; 2,606, and the full time period is grouped into three sub periods like;

- Period_1 (Pre-Financial crisis): January 1, 2004 to December 31. 2007
- Period_2 (Amid- Financial crisis): January 1, 2008 to December 31, 2009
- Period_3 (Post- Financial crisis): January 1, 2010 to December 31, 2013

The following formulas are used to calculate the stock market and exchange returns:

- Ln (Pt/Pt-1)*100……..(For stock Returns)
- Ln (Et/Et-1)*100 ……..…(For exchange rate returns)

Where Pt; means the current day closing price, and Pt-1; is the previous day closing price, Et and Et-1; for exchange rate of the current day and previous day respectively.

Descriptive statistics is used to understand the nature of the time series data. Augmented Dickey Fuller (ADF) test (Dickey & Fuller, 1979) is used to find the stationarity in the stock and exchange returns. The following question was used for this purpose:

$$\Delta Yt = \alpha + \theta T + (1 - \beta) Y_{t-1} + \sum_{j=1}^{\rho} \gamma_1 \Delta Y_{t-j} + \varepsilon t$$

Where Δ is the first difference operator; Y_t represent variable, which is analysed for unit root; α, is constant; T, for time trend and finally ρ is the lag number.

For ADF test the null hypothesis isH_0: $(1 - \beta) = 0, \beta = 1$, entailing the non-stationary of Y_t The null hypothesis of ADF test is that a time series data comprises a unit root. By rejecting the null hypothesis will means that Y_t has no unit root.

To find the volatility spillover between the stock prices and the exchange rates of China for the financial crisis periods, Generalized Autoregressive Conditional Heteroskedascity (1.1) (GARCH) model was used. Jebran and Iqbal (2016) used Generalized Autoregressive

Conditional Heteroscedasticity model to examine volatility transmission between the stock and currency markets of Pakistan. The models used for this study are presented in equation (1), (2), (3), and (4). Equation (1) and (3) investigated volatility flow from currency to stock market while the equation (2) and (4) examined the inverse pattern i.e. volatility spillover from Stock foreign exchange market.

$$y_{t\,(SSE)} = C + y_{t-1(SEE)} + \delta_{t-1(RMB)} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$y_{t\,(RMB)} = C + y_{t-1(RMB)} + \delta_{t-1(SSE)} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$h_{t(SSE)} = \alpha_0 + \gamma_1 \varepsilon_{t-1}^2 + \gamma_2 h_{t-1} + \delta_{Residual\ of\ RMB} \quad \ldots\ldots\ldots\ldots \quad (3)$$

$$h_{t(RMB)} = \alpha_0 + \gamma_1 \varepsilon_{t-1}^2 + \gamma_2 h_{t-1} + \delta_{Residual\ of\ SSE} \quad \ldots\ldots\ldots\ldots \quad (4)$$

Equations (1) and (2) are the mean equations whereas (3) and (4) are the variance equations for stock and foreign exchange markets respectively.

Whereas;$\alpha_0 \geq 0, \gamma_{1,}\gamma_2 \geq 0$ shows ARCH term, h_t denote the variance of both the equity returns and the exchange rate returns in equation (3) and (4), respectively, $\alpha_{0,}\gamma_{1,}\gamma_{2,}$and δ are the coefficients. The information about volatility spillover from the previous period is calculated as the lag of squared residual from the mean equation (ε_{t-1}^2), previous periods forecast variance (h_{t-1}) and the squared residual of currency rate and stock prices respectively in the above two equations.

Result and Discussion

Table 1 depict the descriptive statistics of the study in three periods: pre-financial crisis, amid-financial crisis and post-financial crisis. The average stock returns of Shanghai Stock Exchange (SSE) in pre-financial crisis period were positive while amid-financial crisis are negative. For instance, the pre-financial crisis period the mean value is 0.1206 whereas amid-financial era it is -0.0909.The post-financial crises period average is -04015. The standard deviation of all the three periods is volatile. However, amid-financial crisis period volatility is relatively more than the pre and post-financial crisis periods. Moreover, negative Skewness was observed in all the three periods. The kurtosis value shows that the data is leptokurtic. Finally, the Jarque-Bera test in all the periods (Pre, amid and Post-financial crisis) indicates that the data is not normal.

Table 1. Descriptive Statistics of Stock Index (SSE)

Period	Pre-Financial Crisis	Amid-Financial Crisis	Post-Financial Crisis
Mean	0.1206	-0.0909	-0.0415
Median	0.0705	0.0187	0.0000
Max.	7.8903	9.0343	4.2332
Min.	-9.2562	-7.4910	-5.4449
Std.Dev	1.5589	2.3472	1.1638
Skewness	-0.4437	-0.0348	-0.3026
Kurtosis	6.6290	4.4886	5.2403
Jarque-Bera	605.9822	48.2988	233.7950
Obs	1042	522	1042

Table 2: Descriptive Statistics of Exchange Rate (RMB)

Period	Pre-Financial Crisis	Amid-Financial Crisis	Post-Financial Crisis
Mean	-0.0120	-0.0130	-0.0106
Median	0.0000	-0.0044	-0.0015
Max.	0.3636	0.8328	1.0438
Min.	-2.0211	-0.4453	-1.1689
Std.Dev	0.0924	0.1046	0.1591

Skewness	-10.2926	0.8544	-0.4327
Kurtosis	219.1229	12.2690	10.8936
Jarque-Bera	2046352	1932.1330	2737.7870
Obs	1042	522	1042

The descriptive statistics of the exchange rates (RMB) is shown in Table 2 for all three periods: pre, amid and post-financial crisis. The results reveal negative average exchange returns in all series. The standard deviation in all the three sub periods is highly volatile. The series are negatively skewed in pre and post-financial crisis periods, while positively skewed amid-crisis. This indicates the asymmetric pattern of the periods. The kurtosis values for all the three sub periods are positive, indicating leptokurtic character in data. Finally, the Jarque-Bera row values are highly significant which suggest abnormality in the series.

Table 3; reports data stationarity test results. The unit root technique is employed to find the stationarity in equity and currency rate returns for all the three sub periods. The Augmented Dickey Fuller test (Dickey & Fuller, 1979) was used for said purpose. The returns of stock index (SSE) and currency rate returns (RMB) were used for the unit root analysis. The findings revealed that the data is stationary at level in all the three periods.

Table 3: Stationarity Test

Period	Augmented Dickey Fuller Test (At Level)		
	Pre-Financial Crisis	Amid-Financial Crisis	Post-Financial Crisis
SSE	-31.96*	-22.89*	-32.41*
RMB	-33.98*	-23.78*	-10.66*

Notes: *significance at 1%.

Table 4; highlight the findings of mean equations i.e. equition (1) and (2). The mean equations exhibit the volatility transmission between the equity returns and the exchange returns for all the three sub-periods. In the pre-financial crisis era, the lag return affect is insignificant in exchange rate market. This means that currency market returns (RMB) do not depend on their previous return, i.e. own lag. In this period, i.e. pre-financial crisis, stock market returns are also insignificant for its first lag. This suggests that the fluctuation in the previous stock market returns has no effect on the current day equity returns. However, in post-financial crisis period the analysis of exchange returns (RMB) reveal statistically significant results at first level lag. This implies that currency market depends on their own first lag. The result tells that changes in previous currency returns brought changes in the current currency returns. Due to changes in the previous currency returns the current day returns decreased by

-0.24%. Similarly, there is unidirectional return turbulence from stock to currency market in post-financial crisis period. The fluctuation in stock returns decreased the currency market returns by -0.013%.

Table 4: Mean Equation Results

	Pre-Financial crisis		Amid-Financial crisis		Post-Financial crisis	
	RMB	**SSE**	**RMB**	**SSE**	**RMB**	**SSE**
C	-0.0185**	0.0825	-0.0206***	0.2294***	-0.0187***	-0.0337
	(0.02)	(0.05)	(0.00)	(0.00)	(0.00)	(0.35)
RMB (-1)	-0.0262	-0.5898	-0.0471	0.2208	-0.2402***	-0.1531
	(0.66)	(0.93)	(0.27)	(0.67)	(0.00)	(0.82)
SSE(-1)	-0.0054	0.0025	0.0009	0.0182	-0.0130***	0.0050
	(0.19)	(0.32)	(0.66)	(0.79)	(0.00)	(0.34)

* **, **, * indicates p <1%, 5%, and 10%

The analysis of volatility spillover effect is shown in Table 5. The volatility spillover is estimated from RMB to SSE and also from SSE to RMB. The magnitude of the volatility spillover is found to be highest (-0.88) from currency to stock market in the post-financial crisis period.

The findings lacks substantial evidence for existence of volatility spillover from currency to stock market in China setting. This helps investors in portfolio diversification. The absence of shocks transmission from foreign exchange market to stock market in the pre-financial crisis period provides more opportunities to investors. For instance, it reduces the investment risk and raise the portfolio returns.

The results show significant bidirectional volatility flow between the currency market and stocks market in other two periods, i.e. amid and post financial crisis. However, the post-financial crisis period is more vulnerable to volatility spillover than amid-financial crisis period. Moreover, shock transmission is greater from currency to stock market while low from stock to currency market in the post-financial crisis period. It means that the spillover impact of currency market is more than the stocks market of China. The bidirectional spillover of volatility suggests that the turbulence in one market leads to turbulence in other market in China. Thus, we can conclude that the China stock and currency markets are interconnected. Further it reveals more investment risk and less diversification choices for investors in China setting.

The unidirectional volatility is found only in the pre-financial crisis period from stock to currency market. Unidirectional volatility spillover provide the understanding about those shocks that are raised

in one market and are spread to the other one whereas the shocks acceptance market doesn't react to the jolt sender.

Table 5: Variance Equation Results

	Pre-Financial Crisis		Amid-Financial Crisis		Post-Financial Crisis	
DV →	**RMB**	**SSE**	**RMB**	**SSE**	**RMB**	**SSE**
α_0	0.0074***	0.0314***	0.0179***	0.2319***	0.0018***	2.2201***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\beta_1\varepsilon_{t-1}^2$	-0.0055***	0.0557***	0.0185	0.0603***	0.2897***	-0.0196**
	(0.00)	(0.00)	(0.31)	(0.00)	(0.00)	(0.05)
$\alpha_1 h_{t-1}$	0.5633***	0.9330***	-0.6821***	0.8905***	0.6834***	-0.6114***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
λ	0.001***	-0.0450	0.0065***	-0.2176***	-0.0009***	-0.8845***
	(0.00)	(0.90)	(0.00)	(0.00)	(0.00)	(0.00)

* **, **, * indicates p <1%, 5%, and 10%

Conclusion

The study aims to investigate the volatility spillover between the currency and stock markets of China for the period from January 01, 2004 to December 31, 2013. The full period was then divided into three sub periods, i.e. pre, amid and post-financial crisis period. Daily data were used to find the spillover between these two markets. The statistical techniques, unit root and GARCH models were employed to examine the data stationarity and volatility spillover between the currency and stock markets respectively. The empirical results show significant volatility spillover between currency and stock market of China. For all the three sub periods, i.e. pre, amid and post-financial crisis, the flow of volatility is different. For instance, the results suggest significant bidirectional volatility spread between the currency and stocks amid and in post-financial crisis periods. However, the shock transmission is more pronounced in the case of post-financial crisis period. Furthermore, the volatility spillover is more pronounced from currency market to stock market than the stock to currency setting. The unidirectional volatility is found only in the pre-financial crisis period and its flow is from equity market to foreign exchange market. Finally, the results lack substantial evidence for existence of significant volatility spillover from currency market to stock market in in pre-financial crisis period.

The study has important implications for investors and policy makers. Investors, both the institutional and individual, can get advantage by diversifying their investment in those markets which are non-correlated. Consequently their risk decline and returns increase. Furthermore, they can safeguard their investment from the market crash by making portfolio in non-integrated markets. Policy makers can use this information for the economic stability while making such policies which can protect the markets from financial shock during crisis. They can also anticipate any future financial crisis in one market on the basis of crash of the other market. Thus, the investors and policy makers should pay special attentions to the China stock and currency market linkage at the time of their strategic decision making and policy formulation.

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