CHAPTER 3: LITERATURE REVIEW:
THE PRESENT STATE OF ART

3.1 INTRODUCTION

As emerging markets are striving to become independent and developed, the key challenge that they are facing is dependence on mature countries by different ways and means. Whether the economies are dependent or not would be measured by the level of macro-economic integration, integration of stock markets, synchronization of business cycles etc. The study on dependence between countries becomes further more important when one country is going through financial or economic crisis. In the last three decades, the global markets have witnessed a series of financial crisis. The international equity crash of October 1987, also called the ‘Black Monday’ spread to Europe hitting the US markets. The 1994 economic crisis in Mexico, or the ‘tequila crisis’, led to sharp decline in Latin American markets like Argentina, Brazil and Chile. In July 1997, many Asian stock markets collapsed due to fall of Thai Baht which led to worldwide economic meltdown. The crisis started in Thailand and spread to North and South American, European and South African financial markets. The ‘Russian flu’ hit Russia in August 1998 devaluing the ruble, thus affecting many regions beyond expectations, specially the Baltic. The recent US Sub-prime mortgage crisis christened as ‘once in a century storm’ spread quickly to other countries which triggered the recession of 2008 (Dingemans, 2012).

Of late, researchers have started taking keen interest in the area of international stock markets being inter-linked and interdependent with each other. As economies have become open and dependent on each other, any negative shock to one economy might lead to economic unrest in the other. The economies have opened up for setting up of basic industries, up gradation of services, investment in various financial instruments, capital inflows etc (Aloui et al., 2011; Celik, 2012). As global investors are always on a look out for new and better investment avenues to allocate their portfolios for reducing risk and increasing returns, many Asian markets proved to be a good investment destination, as they exhibited exceptionally high economic growth rate during the past two decades. The sustainability of the growth rate of Asian stock markets is due to foreign institutional inflows, structural and institutional reforms and
financial liberalization (Aye et al., 2014; Bhar and Nikolava, 2009a; Manamperi, 2014). India proved to be a good investment destination post the reforms from 1991 onwards (as discussed in Chapter 2). Further, the investment managers were keen on understanding the reaction of India and other Asian markets when a negative shock hit an international stock market. Examination of dynamic risk-return properties, potential volatility spillover effects, inter-relationship between countries during and post crisis period, time to mitigate the negative impact (if any) etc. were an important task to guide the investors. Short and long–run stock market dynamics can have critical implications for diversification of portfolio, hedging and risk allocation. Thus, there is a growing need to understand the behavior of markets to mitigate the risks of asset allocation and possible contagion between markets.

3.2 INTERDEPENDENCE VERSUS CONTAGION: THEORETICAL FRAMEWORK

A clear distinction between interdependence and contagion is important to understand the propagation mechanism of shock from one country to another. Taking examples from the past events, the propagation of shock during 1998 from Russia to Brazil would be termed as contagion (Forbes and Rigobon, 2002). The two economies do not share common fundamentals and there are no direct trade linkages between them. Both of them are located in different geographic regions bearing different economic structures. Further, during the tranquil period, any shock to the Russian economy does not have any significant impact on the markets of Brazil. On the other hand, one can consider the example of the U.S and Canada, which have similar market structures, apart from sharing the same geographical region, they have strong trade linkages. The two economies are inter-linked during tranquil times and hence, a large negative shock to the US economy can easily get transmitted to Canada. In this case, the transmission of a large shock from the US to the Canadian economy should not be termed as contagion as the two economies are interdependent on each other during tranquil periods as well. The cross market linkages between the two economies exist during the tranquil period and hence, the transmission of shock is a continuation of the cross market linkage between the US and Canada (Forbes and Rigobon, 1998).

Transmission of shocks from crisis originating country to other countries may be due to common fundamentals shared by them. This spillover effect of negative shocks
might also happen during stable periods, suggesting that the countries were interdependent on each other (Calvo and Reinhart, 1996; Pritsker, 2000; Chiang et al., 2007). Another set of researchers argued that the co-movements between the countries might be due to factors other than fundamentals. The transmission of shocks might be due to irrational factors like herding behavior (Tan et al., 2008; Zhou and Lai, 2009; Chiang and Zheng, 2010), financial panic, loss of confidence of investors etc. (Jeanne and Masson, 2000; Claessens et al., 2001).

Kaminsky et al. (2003) called the phenomenon of decline in stock prices, fall in the economic output, devaluation of currencies, and scarcity of capital flows in the international as well as domestic markets as “fast and furious” contagion after the financial turmoil across East Asia in 1997. On the other hand, Bekaert et al., (2005) has defined contagion as, “correlation over and above what one would expect from economic fundamentals”. This means that the macro economic variables are expected to carry contagion effect to other parts of the world. The increase in correlation which cannot be defined due to change in the fundamentals is termed as contagion by the authors. Based on this definition, Baele and Inghelbrecht (2010) developed a two-factor model incorporating both regional and global market shocks. They examined the procedure for a set of 14 European countries over last 3 decades, i.e. 1970–2000 and did not find any evidence of contagion. According to Edwards (2008), contagion is the transfer of information from one country to another over and above ex-ante expectations. This means that the investors and other stakeholders have some expectations of propagation of shocks from one country to another; any information transfer or reaction over and above expected is termed as contagion.
Table 3.1: Causes of Contagion

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Issues/ causes of contagion</th>
<th>Authors</th>
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<tbody>
<tr>
<td>1</td>
<td>Transmission of shocks due to common fundamentals</td>
<td>Calvo and Reinhart, 1996; Pristker, 2000; Chiang et. al., 2007</td>
</tr>
<tr>
<td>2</td>
<td>Due to factors other than fundamentals:</td>
<td></td>
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<td></td>
<td>a) herding behavior</td>
<td>Dungey et al., 2003; Tan et al., 2008; Zhou and Lai, 2009; Chiang and Zheng, 2010</td>
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<td></td>
<td>b) financial panic, loss of confidence of investors etc.</td>
<td>Jeanne and Masson, 2000; Claessens et al., 2001</td>
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<tr>
<td>3</td>
<td>Propagation of shocks in excess of that which can be explained by fundamentals</td>
<td>Eichengreen and Rose, 1996</td>
</tr>
<tr>
<td>4</td>
<td>Contagion is defined as a significant increase in the cross market correlation during the period of crisis</td>
<td>Forbes and Rigobon, 2002</td>
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<td>5</td>
<td>Phenomenon of decline in stock prices as &quot;fast and furious&quot;</td>
<td>Kaminsky et al., 2003</td>
</tr>
<tr>
<td>6</td>
<td>Volatility spillover</td>
<td>Naoui et al., 2010</td>
</tr>
<tr>
<td>7</td>
<td>Correlation is over and above what one would expect from economic fundamental</td>
<td>Bekaert et al., 2005</td>
</tr>
<tr>
<td>8</td>
<td>Contagion is the transfer of information from one country to another over and above ex-ante expectations</td>
<td>Edwards, 2008</td>
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While the above causes of contagion, listed in Table 3.1, have been widely accepted in literature and applied in cross–country studies as evidences, the most extensively used definition is following Forbes and Rigobon, (2002), “contagion is defined as a significant increase in the cross market correlation during the period of crisis.” To infer whether there exists contagion between any two countries, one needs to compare the correlation between the countries, pre (before/ tranquil) and during (turmoil) the crisis. According to this approach, if a country is hit by a crisis leading to significant increase in correlation from tranquil period to period of turmoil; then there exists contagion between the countries. However, if two countries are highly correlated and remain so post the crisis as well; then the countries are said to be interdependent on
each other. This is because crisis in one country did not lead to significant increase in correlation between the countries. Interdependence between countries is when after the crisis, the level of correlation between the countries remains the same as before the crisis. This further means that the countries have strong linkages or share similar fundamentals and macro-economic conditions and policies with each other.

In order to differentiate the above definition from rest of the pre-conceptions on contagion, it was proposed to utilize the phrase “shift-contagion”. This phrase was suggested by Forbes and Rigobon (1998) suggesting that contagion arises only when there is a significant shift in the cross-market linkages. The definition also doesn’t discuss anything about how this shift would occur as cross-market linkages can be measured by various statistics, such as shift in the correlation in asset returns or transmission of shocks or volatility, etc. Considering the example of Russian crisis, the impact of the fall in the Russian ruble on the Polish zloty will be considered as shift contagion only if there was a significant increase in the correlation between the two currencies post the Russian crisis. This definition of contagion is very useful and appeals intuitively as it provides a method to test contagion; i.e. by testing correlation between any two countries before and after a shock to one of the countries.

The definition of contagion given by Forbes and Rigobon (2002) is widely accepted by researchers as this definition further focuses on investment strategy of international portfolio managers. Generally, shocks are country specific and therefore, the stock market of each country should display low correlations. Portfolio risk should apparently reduce due to international portfolio diversification, further increasing the returns. If, after a negative shock to an economy, the shock gets transmitted to other economies, it would reduce the portfolio returns; thus defeating the very purpose of international diversification. Thus, this definition clearly focuses on the magnitude of impact of country specific crisis from crisis originating country to other countries. A less stringent definition would not be able to address this issue.

3.3 THEORETICAL LITERATURE OF CONTAGION

Shocks are internationally propagated through various channels like trade links, financial links, investors’ behavior, information asymmetries, multiple equilibrium and competitive devaluation (Dornbusch et al., 2000). The theories related to
contagion have been categorized as crisis contingent theories and non-crisis contingent theories (Forbes and Rigobon, 2001). The theories that explain the reasons of change in transmission mechanisms during a crisis are crisis contingent theories. They further explain the reasons behind the increase in cross market linkages after a shock. Non-crisis contingent theories are based on the assumption that the transmission mechanisms do not change during the pre-crisis (tranquil times) and during-crisis (turmoil) periods. Thus, the cross market linkages do not increase after a shock. Crisis contingent theories are supported by the evidence of contagion (shift contagion), where the non-crisis contingent theories are supported by the evidence of no contagion.

**Figure 3.1: Theoretical Models of Contagion**

Source: Author

### 3.3.1 Crisis Contingent Theories

The crisis contingent theories can further be classified into three mechanisms: multiple equilibria, endogenous liquidity and political economy (Figure 3.1). Crisis in one country leading to ripple effects or changes in the market sentiment in another country for reasons unexplained by macroeconomic fundamentals is known as **multiple equilibria** (Masson, 1998). Crisis in a country affects the investors’ sentiments towards market conditions. These sentiments get transmitted to investors’ of other countries, thus shifting the economy from a good equilibrium to a bad equilibrium, thereby causing a crash in the second economy. This illustration of Masson (1998) has been challenged by Mullainathan (2002) who argued the logic that investors imperfectly remember past events. Memories of the past get triggered when the country gets exposed to the crisis. The investors recomputed their priors and
assign higher probability to a bad state (variables such as interest rates, debt default etc.). This would further trigger the market to fall due to correlated past memories, and not correlated fundamentals. Both these models argue that the country specific shocks get spread to other parts of the world due to investors’ behavior and expectations, and not due to any real linkages between the two countries. These sets of theories not only elaborate the bunching of crises but also explain the reasons as to why speculations hammer the fundamentally strong economies. Hence, post crisis, the changes in the price of one country with respect to the other country further aggravates during the shift between equilibrium. Thus, the investors’ expectation changes during crisis period and they transmit the crisis in other economies as their behavior changes post the crisis. Hence, these propagation mechanisms do not exist during the tranquil period as against the period of turmoil.

The second mechanism in the category of crisis-contingent theories is the **endogenous liquidity shocks**. It was suggested that a crisis in one country can lead to downfall of the liquidity in the market and thus, the liquidity of the market participants (Forbes and Rigobon, 2000). In order to fulfill their obligations of margin calls, or to meet regulatory requirements and to continue to operate in the market in the current scenario, the investors will have to restructure their portfolios and sell investments in the foreign countries. Therefore, in order to overcome the liquidity pressure (i.e. liquidity shock) that the investors are facing in the crisis affected areas, the investors are forced to sell their investments / holdings in other countries which are still unaffected by the crisis. Heavy selling of securities in other countries affects the financial markets and the prices of the securities in these countries fall drastically, thus propagating the shocks to other parts of the world which were not affected by the initial crisis (Valdes, 1996).

Another model of endogenous liquidity, developed by Calvo (1999) is rooted for asymmetric information availability among investors. In this case, the informed investors get clues on the financial status of the economy and are hit by the liquidity shocks; they end by selling large part of their investments to overcome the liquidity pressures. Unknowing the reasons behind the selling off of investments by the informed investors, the uninformed investors follow suit and sell their holdings in other countries. These uninformed investors are unable to differentiate between a
liquidity and bad signal, so they charge a premium when the informed investors are not net sellers. In both the models discussed above, i.e. multiple equilibria and endogenous–liquidity based models; there is an increase in the correlation in asset prices due to liquidity shocks. The propagation mechanism takes place only after a country is hit by a shock, i.e. only after an initial shock and not during tranquil period.

The last propagation mechanism in the category of crisis-contingent theories is political contagion. Using the situation of European devaluations during 1992-93, Drazen (2000) has developed a model based on some assumptions. The assumption is that to maintain one’s own country’s fixed exchange rate viz-a-viz a benchmark currency. Hence, when the central bank of a country decides to do away with its peg, it paves the way for the central banks of other countries, thus reducing the political costs to other countries of abandoning their respective pegs. This increases the possibility of switching exchange rate regimes between the countries. We observe that the propagation of shock occurs through a mechanism that did not exist before the initial crisis.

The category of crisis-contingent theories suggests various mechanisms of international propagation of shocks. The different channels of transmission of shocks under this category include: investor psychology based multiple equilibria, portfolio reconstitution based endogenous-liquidity based shocks and exchange rate regimes based on political economy and stability. One critical analysis of the above mentioned mechanisms is that the transmission mechanism of the shocks before the crisis is different from after (post) crisis situation. The crisis causes a structural shift, so that shocks are transmitted through those channels/ mechanisms that do not exist during tranquil times. All the above mentioned theories support the concept given by Forbes and Rigobon (2002) on shift-contagion.

3.3.2 Non-Crisis Contingent Theories

The non-crisis contingent theories explain the fact that even when shocks propagate internationally, it does not lead to shift-contagion. These set of theories support the view that the transmission mechanisms, post crisis are not significantly different from the initial shocks operating in any country. The channels of propagation of shocks under these theories assume that these channels are “real linkages” among the
countries as many are based on economic fundamentals. Thus, any evidence of large cross market correlations among these countries support the fact that the countries have some common linkages among them that existed before the crisis. These theories can further be broadly categorized into four channels: trade linkages, policy coordination, country reevaluation and random aggregate shocks.

The first propagation mechanism, **trade linkages**, could work through various combined effects (Kaminsky *et al.*, 2003). As suggested by Gerlach and Smets (1995), if a country devalues its currency, it would directly increase the competitiveness of its goods in the international market. This will lead to increase in exports to a second country and hamper domestic sales within the second country. This devaluation could also have the indirect effect of decreasing export sales from the countries which battle in the same third markets. Either of the above mentioned effects could directly affect a country’s exports and output. The above situation may lead to increase in expectations of exchange rate devaluation, if the competitive loss is severe enough.

The second propagation mechanism under the category of non-crisis contingent theories is **policy coordination**. This mechanism believes that if there is a crisis in one country, then other countries might change their policies accordingly. For example, a currency crisis in one country may trigger policy changes in other countries to beat the possible propagation of the initial shock in the first country (Dungey and Tambakis, 2005).

The third propagation mechanism under the category of non-crisis contingent theories is **country reevaluation** is based on the learning of the investors. Investors of a country closely study the reasons and impact of a crisis in one country and apply the same knowledge in their country. Thus, the observations made for other countries during turmoil period acts as a guide to the investors to be applied in countries with similar macro-economic structures and policies. For example, if a country with weak financial system is susceptible to crisis, then the investors will evaluate the financial system of the countries in which they have invested. They would further adjust their probabilities of a crisis for the countries (Forbes and Rigobon, 2000).
The last propagation mechanism under the category of non-crisis contingent theories is **random aggregate**. This channel of propagation suggests that global shocks could fundamentally affect many countries at the same time. For example, if there is an increase in the rate of interest internationally, then it would lead to fall in the international supply of capital which would slow down many economies (Dornbusch *et al.*, 2000).

There are **two main implications** of the above mentioned theories: **first**, there tends to be lot of integration between stock market indices. Thus, the tests that have to be designed to measure the propagation of shocks have to consider the problem of endogenous variables. **Second**, these theories suggest that the mechanism of propagation of shocks during the quiet period and the period of crisis may be similar. For example, shocks may be transmitted through trade linkages also. It is assumed that the trade linkages will not change during the period of crisis (which might last about a month) so much so that it will affect the mechanism of transmission of shock. This theory further argues that whether shocks are negative or positive, for every shock only symmetric effects are felt by the stock markets (Rigobon, 1999). Thus, the issue of symmetric and asymmetric shocks needs attention and hence, has been dealt within this thesis in **Chapter 5** on Asymmetric Dynamic Conditional Correlation GARCH (ADCC-GARCH).

### 3.4 **EMPIRICAL LITERATURE OF CONTAGION**

Significant empirical research has been done to test for the existence of financial contagion during period of crisis applying different methodologies. Each methodology suggests its own set of variables and parameters for testing transmission of shocks across various countries. These studies have their origins from work done by Sharpe (1964), Grubel and Fadner (1971), King and Wadhwani (1990), Engle *et al.*, (1990) and Bekaert and Hodrick (1992) etc.

Researchers have used various methods to measure contagion effects between markets. Each of the methods has some drawbacks which have further urged other researchers to find better methods to model contagion. Before modeling for contagion, it is imperative to test for interdependence between asset markets during
tranquil period. This has been referred to in literature as latent factor model which is based on financial factor models (Sharpe, 1964; Solnik, 1974).

Many empirical models of contagion are in conformity with the definition given by Forbes and Rigobon (2002), where an increase in correlation between countries during crisis period is termed as contagion. Literature provides various econometric techniques to model contagion between financial markets and these include: Changes in correlation coefficients between markets (King and Wadhwani, 1990; Lee and Kim, 1993; Calvo and Reinhart, 1996); other approaches using correlation analysis (Karolyi and Stulz, 1996; Longin and Solnik, 1995); ARCH and GARCH models (Hamao et al., 1990; Susmel and Engel, 1994; Billio and Caporin, 2010); VAR or VECM model (Apergis and Miller, 2009; Miller and Ratti, 2009; Filis, 2010); regime-switching model (Gallo and Otranto, 2008); and extreme value theory based models to estimate tail dependence (Bae et al., 2003; Chan-Lau et al., 2004; Longin and Solnik, 2001; Poon et al., 2004); dynamic conditional correlation (Rajwani and Kumar, forthcoming; Rajwani and Kumar, 2015; Chittedi, 2015; Ahmed et al., 2013, Hwang et al. 2013; Celik, 2012; Chiang et al., 2007); copula approach (Samitas and Tsakalos, 2013; Wen et al., 2012; Wang et al., 2011, Roboredo, 2011), etc. Some of these techniques are discussed below:

a) Correlation Method

The first method to measure contagion was correlation method suggested by Forbes and Rigobon (1999). As discussed earlier, the term ‘shift-contagion’ was coined by Forbes and Rigobon (2001, 2002) to denote transmission of shocks from one country to another. Forbes and Rigobon suggested change in the correlation between any two markets under study; i.e. pre-crisis correlation should be compared with post crisis correlation to examine whether there have been significant changes in the correlation between the tranquil period and the crisis period. If the correlation between the tranquil period and period of turmoil has changed significantly, then it will be termed as contagion. This method is the simplest and the first to determine the level of propagation of shocks from one country to another. The preliminary work in this area was done by King and Wadhwani (1990) on testing the existence of contagion. Significant increase in correlation was found between international equity markets
after the October 1987 crash (King and Wadhwani, 1990; Calvo and Reinhart, 1996; Ramchand and Susmel, 1998).

A major drawback of the methodology was pointed out by Forbes and Rigobon (1999) suggesting that the financial markets face lot of financial interactions simultaneously and the above mentioned approach was unable to account for the same. Little evidence of shift contagion was found during the Mexican, Asian and Russian crisis in equity markets of emerging economies (Forbes and Rigobon, 1999; Rigobon 2002). Correlation method when applied on bond markets of various countries showed low probabilities of contagion. The method was applied to examine the likelihood of occurrence of crisis in one country given that another country is facing crisis during a given period of time (Lomakin and Paiz, 1999). No shift contagion was concluded when applied to bond markets of Argentina and Mexico during 1994 to 1999 (Rigobon, 2003). Few researchers suggested that the correlation co-efficient method was inadequate for testing contagion between financial markets as this method does not consider conditional heteroskedasticity (Boyer et al., 1999; Forbes and Rigobon, 2002; Longin and Solnik, 2001). To overcome this problem, Rigobon (2002) proposed a methodology that gives valid results by considering the presence of heteroskedasticity in the data and simultaneity bias. This method is based on the assumption of presence of heteroskedasticity in asset returns (Ahlgren and Antell, 2010). Presence of heteroskedasticity has been assumed to be based on the assumption that there are continuous changes in the variance of the crisis-generating country shock (Gravelle et al., 2006). For example, during periods of crisis, generally the variance between any two assets/ stock market returns would also increase. This would further increase the correlation between the two assets ignoring the fact that it might be due to change in the structural transmission of shocks between the set of stock markets/ assets under study (Gravelle et al., 2006; Ahlgren and Antell, 2010).

The correlation test proposed by Forbes and Rigobon (2002) underwent further change in a regression framework, as suggested by Dungey et al. (2005). Extending the testing of contagion in a multivariate framework, Dungey et al. (2005) proposed to use the correlation test “within a regression framework as a Chow test for structural break of a regression co-efficient” (Ahlgren and Antell, 2010). It was further pointed out that the assumption on which correction of heteroskedasticity was
based, was unrealistic. The assumption of variance being idiosyncratic was not real as the results would always find no contagion between the markets under study. Bae et al. (2003) in their paper suggested that contagion is an event which generally depicts non-linear relationship between market returns. A linear measure to examine contagion would be inappropriate to use. Considering the drawbacks of correlation method mentioned above, many researchers proposed Vector Auto-regression method (VAR) to measure contagion between markets.

b) Vector Auto-Regression (VAR) Method

In this approach, to endogenously relate various groups of financial market data, a simple VAR model of returns across equity markets is used. Sometimes, ad hoc exogenous variables are also associated to particular events in some studies related to VAR (Baig and Goldfajn, 1998; Ellis and Lewis, 2000). Apart from standard problems related to VAR approach, the VAR model is unable to capture the known GARCH style properties of the data under study (Dungey 2001). An extension to the approaches suggested by Baig and Goldfajn (1998); Ellis and Lewis (2000) was suggested by Kaminsky and Schmueler (1999), which identifies ‘good’ and ‘bad’ events that happen in an economy. The methodology has been used by various researchers in examining financial contagion between markets (Karolyi and Stulz, 2003) due to simplicity of the administration of the method (Wen et al., 2012; Majid and Kassim, 2009). No distinction needs to be made between endogenous and exogenous variables as the distinction between the two is quite subjective in nature and therefore makes sense to treat both of them equally (Majid and Kassim 2009; Sims, 1980). Moreover, through this technique, misspecification problems can be avoided as there are no strict rules on assignment of structural relationships of the variables used in the study. The model allows us to examine and assess the strength and direction of the variables and interaction between them. For example, the model can be used to ascertain the effect of gold price in one market on another market. This can be done through Variance Decomposition and Impulse Response Functions (IRFs) which can be derived from VAR model. The VAR model when used to monitor asset returns helps the researcher in controlling for serial correlation.

Previous studies used to employ variables at log level in VAR method (Sims, 1980). Since the log level variables are mostly non-stationary in nature, the results derived
there from may be misleading and spurious. To overcome this issue, it is proposed to make the variable stationary before running the VAR model. This can be done by finding the VAR differences of the variables which would further introduce misspecification problem in the model. A level VAR or Vector Error Correction Model (VECM) should be used in case such a problem of misspecification arises (Engle and Granger, 1987; Majid and Kassim, 2009).

The VAR method suffers few limitations. The model neglects the fact that often asset returns might not be normally distributed. While measuring contagion between different financial markets, there is possibility that the markets share a non-linear dependence on each other. The model does not allow a researcher to obtain time-varying correlations due to the problem of heteroskedasticity. In such a case, a VAR or VECM model will not be able to capture contagion effect between two different financial markets. The VAR model is further incapable of capturing the “changes in the tails of asset return curves” (Wen et al., 2012). For constructing a test on contagion indices, Pesaran and Pick (2007) consider the endogeneity of the crisis. This has been done by using instrumental variable estimation. Some evidence of contagion has been found while testing for contagion during the 1997-98 Asian crisis (Dungey et al., 2005). By applying the test of Favero and Giavazzi (2002) for examining contagion between markets; one would generally find positive results when applied (Anlgren and Antell, 2010). Further, one would get similar results by applying tests suggested by Pesaran and Pick (2007) and test suggested by Dungey et al., (2007). The researchers who have applied VAR/VECM model are Apergis and Miller (2009); Miller and Ratti (2009); Filis (2010); Park and Ratti (2008). The VAR methodology proved to be a better method for measuring contagion than the correlation method.

c) Dynamic Conditional Correlation Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH) Model and Asymmetric DCC-GARCH Model

There are many limitations of the above two methodologies used by various researchers on financial contagion. First is the problem of heteroskedasticity when measuring correlations as during the crisis period there are issues of volatility increase. Second, the results of nearly all the tests are affected by the choice of period
of study and break dates (Billio and Pelizzon, 2003). Third, following the definition given by Forbes and Rigobon, 2002; a significant increase in the sample correlation between markets is contagion. Hence, to term that there exists “contagion” between markets, there has to be dynamic increment in correlations. Fourth, in the estimation of cross-country correlations, there are further problems of omitted variable and lagged dependent variable (Chiang et al., 2007). To overcome the above mentioned limitations, DCC-GARCH and ADCC-GARCH models have been used to examine financial contagion.

To capture the co-movements of any two stock market return series, financial econometricians heavily rely upon multivariate GARCH models. For example, to analyze conditional VAR of a portfolio, there is a need to study the conditional variances and co-variances of the assets in that class of portfolio. Constant conditional correlation model introduced by Bollerslev (1990) and the DCC model proposed by Tse and Tsui (2002) and Engle (2002) are amongst the plethora of multivariate GARCH models. The literature is also enriched by recent reviews on multivariate GARCH models by Bauwens, Laurent and Rombouts (2006), Silvennoinen and Terasvirta (2009), Francq and Zakoian (2010a), etc.

Cappiello et al. (2006) brings out an important limitation of the DCC GARCH approach; is that the conditional correlation does not take into account the dynamics of asymmetric effects. This further implies that the DCC model does take into consideration the impact of past shocks on the future conditional volatility and correlation; it is still unable to distinguish between the effect of positive and negative shocks. Cappiello et al. (2006) suggested the ADCC model to capture the potential asymmetries in the conditional correlations between series.

The ADCC model is an extension of DCC model that allows for the “leverage effect”, i.e. to study the behavior of current volatility due to asymmetric impact of the positive and negative returns. Of late, few papers have looked into the asymmetries in a multivariate framework (Mc Aleer, Hoti and Chan, 2009; Mc Aleer, Chan, Hoti and Liebermann, 2009; Francq and Zakoian, 2010b).

The ADCC process extends its scope from DCC GARCH in the following ways: First, it considers the news impact of the specific series and allows for conditional
asymmetries in correlation dynamics. Secondly, this is a better measure to examine correlation numbers among different asset classes and further analyses the asymmetric responses (if any) in conditional variances and whether there are any correlation to negative returns (Cappiello et al., 2006).

Applying these models, studies on the integration of Asian stock markets have given mixed results. No contagion between US and various Asian markets has been reported by Chan et al. (1992) and Ibrahim (2005). However, evidences of co-integration among Asian emerging markets and developed markets were found (Arshanapalli et al., 1995; Masih and Masih, 1999; Majid et al., 2008; and Karim and Majid, 2009). In a more recent study on the impact of the US Sub-prime crisis on the integration and co-movements of emerging stock markets, namely Malaysia and Indonesia; it was found that the stock markets tend to show greater degree of integration during the crisis period than during tranquil period (Majid and Kassim, 2009). Studies conducted previously on US market suggest that the US market is one of the most influential stock market in the world. It was found that the US market is a “global factor” which affects most of the Asian markets (Cheung and Mak, 1992). It was further found that the ASEAN markets show greater degree of influence towards US stock market than the Japanese stock market (Arshanapalli et al., 1995, Ibrahim, 2005 and Majid et al., 2008). High degree of integration has been found between the US stock market and few emerging markets (Majid and Kassim, 2009). The studies indicating significant conditional correlation between emerging markets and the US stock market also exist in literature (Naoui et al., 2010; Celik, 2012; Naoui et al., 2010a; Gallegati, 2012). On the other hand, no impact of the US crisis on the long run co-movement among stock index futures markets from Japan, Singapore, China, and Thailand was found (Karim et al., 2011). Hence, the mixed results further urged to examine and validate contagion between the US market and various Asian markets.

The DCC-GARCH and ADCC-GARCH methods help us in analyzing the contagion from one country to another. Both the methods help us in examining contagion when there exists linear relationship between the marginals or series under the study. There is further a possibility that the relationship between the series is of non-linear in nature and hence, DCC and ADCC GARCH will not be able to reap correct results even though both are dynamic in nature unlike the correlation method suggested by
Forbes and Rigobon (2002). These further increased the need of measuring contagion using some other methodologies, which would consider the non-linearity of series; and dissipate more information on the joint behavior of the series under study. The methodology discussed below throws light on the above mentioned aspect.

d) Copula

The copula model is based on the theorem suggested by Sklar (1959) which is now used to evaluate models of time-varying multivariate conditional densities. Copulas allow us to decompose the multivariate distribution and to model the marginal behavior of a series. Thus, multivariate distributions are decomposed into marginal distributions and a copula which explains the relationship between all the marginal distributions. Hence, a m-dimensional joint distribution function needs to be broken down into its m-marginal distributions and a copula.

The copula methodology considers all the possible forms of distribution; i.e. parametric and non-parametric estimates. Non-parametric estimates suffer from lack of precision. When there are large numbers of dimensions (say, four) of the distribution under study or when state vector is applied to multivariate distributions; it suffers from lack of precision. In such a situation, to further get results, a trade-off is followed by mis-specifying a parametric specification. Thus, goodness-of-fit tests should be run to test the proposed specifications of the model.

Another advantage of the copula function is that it proves to be very useful in measuring the tail dependence to further study the dependence between the two return series in their joint tails. The propensity of markets to go up or down together is tail dependence. In other words, it measures the probability that the two series are in the lower or upper joint tails. For understanding the different dependent structures, various types of copula models are available: for no tail dependence: the Gaussian copula; for symmetric tail dependence: the Student-t copula; for lower tail dependence and zero upper tail dependence: the Clayton copula; for upper tail dependence and zero lower tail dependence: the Gumbel copula; and for asymmetric tail dependence and nest symmetry as a special case: the Symmetrized Joe-Clayton (SJC) copula. Thus, a copula function helps in understanding different dependent structures between any two distributions.
3.5 OBJECTIVE OF THE STUDY

The present study compliments the existing literature in two ways:

a) To Test For Interdependence

The first objective of the present study is to study the co-integration between Indian stock market with other major Asian stock markets and the US stock market. The financial reforms in the stock markets, setting up of SEBI and clearing corporations, capital adequacy norms, risk containment measures and many other measures initiated by the government since 1991 were fruitful to make the markets more transparent. It further helped in increasing the inflow of capital from international institutional as well as individual investors thus, making India a lucrative market for investment (for details, please refer to Chapter 2). Studies on integration have potential benefits of asset allocation and financial stability of a country (Ibrahim, 2005). Capital mobility and removal of barriers between countries has increased the movement of capital and thus, the need for international portfolio diversification and risk reduction. This has increased the need to study correlation patterns among countries, especially during turbulent times. It is generally understood that the correlation among markets may differ drastically during quiet period versus crisis period. This will further help investors in hedging their positions in the market to avoid losses. Hence, a need is felt to study whether stock markets of various countries are interdependent on each other.

The objective of the present study is to complement the existing literature by examining the integration hypothesis and analyze the linkages between the Indian stock market with the other stock markets namely Indonesia, China, Hong Kong, Japan, Taiwan, South Korea, Malaysia and the US in the presence of endogenous structural break. In this context, the econometric technique by Lee and Strazicich (2003) that uses a Lagrange Multiplier (LM) test statistics and allows for at most two breaks both under the null and the alternative hypothesis have been used. To the best of our knowledge, similar study for the Indian stock market context has not been explored earlier. Most of the earlier studies on stock market integration focused on standard unit root and co-integration tests. However, as observed by Herzer and Lehmann (2006), such standard tests are biased towards accepting the null hypothesis of a unit root in the presence of structural breaks. Standard co-integration tests also
tend to falsely accept the null of no co-integration when there is a structural break under the alternative hypothesis (Herzer and Felicitas, 2006). This study therefore, applies the Gregory and Hansen (1996) co-integration technique that allows for one endogenously determined structural break in the co-integration relationship.

b) To Test For Contagion

Once the level of interdependence between stock markets (under study) is determined, the next step is to find the level of contagion between the US stock market and the Asian stock markets under study in the context of US Sub-prime crisis of 2008. As discussed, considering the definition given by Forbes and Rigobon (2002), contagion can be determined between markets when a negative shock hits a country. Contagion helps in analyzing how much a country gets affected due to negative shock to a country which might share common fundamentals or might have no linkages between them. Thus, the second objective of the present study is to examine contagion from the US stock market to Asian stock markets (under study), considering US as the crisis-originating country. To examine financial contagion from the US stock markets to the Asian stock markets under study, DCC-GARCH and ADCC-GARCH frameworks have been applied. As discussed in the earlier section, the DCC-GARCH and the ADCC-GARCH models are multivariate GARCH models that allow the researcher to measure time varying conditional correlations and also to address the problem of heteroskedasticity. These models further allow to perceive active investor behavior in relation to the dynamic/significant changes in news and innovation.

The second objective is further extended to examine the contagion from the US stock market to the Indian and other Asian markets under study, using Copula technique. This technique helps in understanding the joint behavior of a set of random variables. Copulas allow us to decompose the multivariate distribution and to model the marginal behavior of a series. As discussed in the previous section, the main advantage of copula over correlation and other methods is that it allows for the non-linear dependence between marginals. Copulas further demonstrate tail behavior of the marginals under study as increased tail dependence indicates the actual depth and width of contagion between markets. To the best of our knowledge, no work has been done in finding contagion from the US stock market to the Indian and other Asian market comparing with DCC/ ADCC-GARCH and copula techniques.
3.6 CONCLUDING OBSERVATIONS

During periods of high volatility, markets tend to be correlated which in turn has important implications on policy formulation for international portfolio diversification, capital adequacy and risk management strategy for investors (Billio and Pelizzon, 2003). The need to understand the spread of shocks to other countries is important due to the following reasons: First, international investors thrive on international diversification of portfolio to increase returns and to reduce possibility of risk. This can only be possible if the stock markets of the countries display relatively low correlations. It has been examined that generally the shocks are country specific and then they spread to other countries. If there exists contagion between countries, after a shock, internationally diversified portfolios will reap poor returns, thus, defeating the very purpose of international portfolio diversification. Thus, one should not ignore contagion while designing an investment strategy.

Secondly, it is generally assumed that after a large negative shock to a country, investors will have asymmetric reactions to the shock. Hence, it is important to study investor behavior so as to understand their reactions during positive and negative shocks.

Thirdly, it is important to understand whether two countries are interdependent on each other or have some sort of contagion relationship because if the countries are interdependent on each other, a negative shock to one country will definitely impact the other country’s financial flows. The level of impact will be dependent on the level of interdependence between the countries. In such a case, bail-out funds might come to the rescue of the non-crisis originating country. Through bail-out funds, the country will be able to buy time to make necessary adjustments into their system; but the country will not be able to fool-proof protect themselves from the impact of the shock in the crisis-originating country.

Last but not the least; a country might experience negative shocks on its financial flows due to negative shocks in the crisis-originating countries. These two countries might share common macro-economic fundamentals and policies. Thus, the effect might be of temporary nature as the crisis is not supported by the fundamentals of the
non-crisis originating country. Thus, the contagion effect on the country might be mitigated through injection of funds to stabilize the economy.