CHAPTER 5

RESEARCH METHODOLOGY
# CHAPTER 5

## RESEARCH METHODOLOGY

### CHAPTER OUTLINE

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5.1. Introduction

A vast literature has concentrated on measuring the interdependence of financial markets. Measuring market interdependence in form of market correlation, integration, causality and spillover effects are a common feature of this literature. Regarding the spillover effect, some studies consider only the return movement among markets, while some other studies measure the information spillover through both returns and the volatility of returns (Mukherjee & Mishra, 2010). Several studies demonstrated that the volatility of asset return / price reveals more information rather than the return / price itself (Kyle, 1985).

The studies on financial markets interdependence among and within countries as the literature reveals include research under specific title, mostly such as correlation, integration, causality relationship, and spillover of return and volatility. Most studies have concentrated on relationship among international financial markets (cross-border) and some of studies have also focused on the domestic financial markets. Both groups of studies have made use of the combination of more than one type of measurement and analyzing technique such as correlation coefficient analysis, cointegration, and causality test, Vector Auto Regression (VAR) in order to implementation Impulse Response Functions (IRF) as well as Variance Decomposition (VD), Autoregressive Conditional Heteroskedasticity (ARCH) model and its augmentation, i.e. the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model. But data analysis is usually begun with the descriptive statistics.
5.2. Descriptive Statistics

Descriptive statistics most often include: Mean, Median, Maximum, Minimum, Standard Deviation, Skewness, Kurtosis and Jarque-Bera. These statistics are calculated based on price, return and volatility of variables. The results of these statistics usually indicate central parameters, dispersion parameters, Skewness and Kurtosis of data.

5.3. Measuring of Financial Market Interdependence

In the existing literature the most popular methodologies for measuring the financial market interdependence can be generally classified into five groups: 1) The cross-market correlation coefficient, 2) Cointegration test, 3) Granger causality analysis, 4) Vector Auto Regression (VAR) to use the generalized Impulse Response Function (IRF) and the Variance Decomposition (VD), 5) The ARCH and GARCH models, (Elyasiani & Zhao, 2008; Forbes & Rigobon, 2002).

Empirical studies have usually used these methodologies jointly to investigate market interdependence. In this study a combination of these varies methodologies have also been employed and that include the cross-market correlation coefficient, cointegration, Granger analysis, and Variance Decomposition test.

5.3.1. Cross-Market Correlation Coefficient Analysis

The cross-market correlation coefficient is one of the most popular methods for measuring the interdependence between two variables. Correlation coefficient can be either positive or negative. Positive correlation between two markets indicates that markets price
moves in the same direction and hence do not reduce portfolios volatility or risk of investment.

The concept of correlation is one of the frequently used concepts in the field of investigating the relationship among different variables. Following the usage of the concept of correlation by Markowitz (1952) for developing the portfolio theory, the concept found a more extensive application in the field of financial researches. Markowitz proved that variance of return of one portfolio is the weighted mean of correlation coefficients of the return from the assets which make the same portfolio. Therefore, to decrease variance (risk) of portfolio, such assets have to be searched for that have no correlation and they should even have negative correlation coefficient.

5.3.1.1. Background of Cross-Market Correlation Coefficient Analysis

In the literature on financial markets interdependence this method has been vastly employed to assess the co-movement among financial markets, which among them can be attributed to: Liu (2012), Hu, Lin and Kao (2008), Chordia, Sarkar and Subrahmanyam (2005), Sturges (2000), Solnik, Boucrelle and Fur (1996).

5.3.1.2. Methodology of Cross-Market Correlation Coefficient Analysis

The correlation coefficient is a measure which quantifies the relationship between two variables, with no need to introduce variables as independent or dependent. The two most widely used correlation coefficients are: Spearman’s correlation coefficient and Pearson’s correlation coefficient. Contrary to the spearman’s rank-order correlation coefficient, the Pearson’s correlation coefficient is a parametric method (Chok, 2010). The
Pearson correlation coefficient from among the correlation coefficients is more appropriate under certain circumstances. This coefficient is a scale to measure the degree of the linear relationship between two variables and its value lies between -1 and +1 means (-1 ≤ r ≤ +1) and it is defined as the ratio of the covariance of the two variables to the product of their respective standard deviations as follow:

$$r = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2} \sqrt{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}}$$

The important merit of this method is that it measures the degree of variables association in a quantitative way. Meanwhile, there is also some problem on the subject of measuring the interdependence among financial markets through the correlation coefficient analysis. In other words, the non-stationary time series data can lead to biased results (Kiranand, 2004), therefore, the analysis of Pearson correlation coefficient should be accomplished with more caution in order to assess the relationship between the variables which are based on time series data. Indeed this correlation coefficient is nothing but deviation from the mean of data and does not give any information regarding the trend of assets’ price (Lhabitant, 2011). Time series data have the trend and the mean is not constant for such data, in which condition, the time series are non-stationary. Therefore, calculating Pearson correlation coefficient, based on the original level of time series data, may reflect a spurious correlation.

The original level time series data are usually integrated and if these data are used in the regression models, a high coefficient of determination ($R^2$) would be obtained, even though such time series data are not dependent on one another. In such cases, the existence
of high coefficient of determination along with low value of Durbin-Watson statistic ($R^2 > D-W$ statistic) is indicative of a spurious regression (Granger and Newbold, 1974).

Evaluation of the correlation between variables is required following steps:

- Calculate the correlation coefficient between the variables based on the original level of data.
- Compare the coefficient of determination and Durbin-Watson statistic based on the original level of data.
- Examine the stationary property of data.
- Calculate the correlation coefficients between variables based on the first difference level of data and
- Compare the coefficient of determination and Durbin-Watson statistic based on the first differenced level of data.

5.3.2. Cointegration Analysis

The cointegration analysis is also a widely used method to examine the financial markets interdependence, since it can directly employ the non-stationary time series data. Cointegration analysis is an econometric model for testing the long-run equilibrium relationships among variables based on the non-stationary time series data if a linear combination of these data is stationary (Engle & Granger, 1987). However, the cointegration analysis is meant to capture market interdependence in terms of long-run equilibrium relationship but this model is not able to gauge the degree of market equilibrium relationship in a quantitative way (He, Hongbo, 2012).
Scholars have emphasized the importance of financial markets integration from different perspectives. De Brouwer (1995) considers the domestic financial integration as an important factor in the assessment of international financial integration. He states that the macroeconomic impact of international financial integration depends on the extent of domestic financial integration. Reddy (1999) perceived integrated markets as a channel through which authorities receive important price signals and serve in price discovering. He also believes that integration of financial market paves the way for domestic financial sector to appear as an international or a regional financial centre. Ho (2009) highlights the improvement of capital allocation and risk diversification as the two important functions of financial market integration.

Mohan (2005), states that efficient and integrated financial markets foster the condition necessary for promoting national savings and investment in order to enhance economic growth. Trichet (2005) opines that financial market integration plays a vital role in financial stability by enhancing competition, creating of operational efficiency, and optimizing resource allocation. Jain and Bhanumurthy (2005) argue that financial integration induces changes in the basic economic structure and in the operating environment for policy, business and households. Integrated financial markets induce market informational efficiency and promote adoption of modern technology and payment systems to achieve cost effective financial intermediation services (RBI report, 2007).

5.3.2.1. Background of Cointegration Analysis

Cointegration analysis has been employed in many financial market studies, important among which are: Zhang (2012), Yahyazadehfar and Babaie (2012), Islami
5.3.2.2. Methodology of Cointegration Analysis

In the time series model, the variables must be stationary, meaning that the data have to possess constant mean and variance, so they should be independent of the time. To achieve the stationary, as one of the ways, variables are converted from the original to differenced level which is attained as $R_t = (P_t - P_{t-1})$, otherwise because of presence the trend in the time series data, running the time series models can result in what is called “spurious regression”. But, cointegration approach is the model to investigate the long-run equilibrium association among variables based on the initial level of data, without the risk of spurious regression. Cointegration approach has become one of the most widely used methods to investigate the long-run association between variables based on time series data.

Cointegration model was formulated first by Engle and Granger in 1987. This method is applied for two variables and involves a two-step estimator. In order to avoid their limitations, Johansen (1988) developed a method which can estimate and test the multiple co-integrating vectors which is the most popular approach to test long-run association among variables. The Johansen’s cointegration model is a system equation or vector auto regression model. In these types of models, dependent variable appears as an independent variable in the form of its lags. In other words, any dependent variable is a function of its previous value and other independent variables. **Johansen’s model** is formulated as follow:
\[ \Delta y_t = \mu + I_1 y_{t-1} + \sum_{i=1}^{p-1} I_i \Delta y_{t-i} + \varepsilon_t \]

Where \( y_t \) is an \( n \times 1 \) vector of variables that are integrated of order one and \( \varepsilon_t \) is an \( n \times 1 \) vector of innovations. If the coefficient matrix \( \Pi \) has reduced rank \( r < n \), then there exist \( n \times r \) matrices \( \alpha \) and \( \beta \) each with rank \( r \) such that \( \Pi = \alpha \beta \) and \( \beta y_t \) is stationary. \( r \) is the number of cointegrating relationships and each column of \( \beta \) is a cointegrating vector. Johansen proposes two different likelihood ratio tests of the reduced rank of the matrix: the Trace test and the Maximum Eigenvalue test.

Using Johansson model requires implementation of certain conditions, the absence of which won’t lead into correct results. Two prerequisites steps include: 1) the variables should be non-stationary and in the same order, 2) the optimal lag length should be selected.

**a) Non-Stationary and Unit Root Test**

The first step in the time series analysis is to examine the stationary properties of the variables. Non-stationary in a time series occurs when there is no constant mean \( \mu \), no constant variance \( \sigma^2 \) or both of these properties, meaning that the data are assumed to be stationary if the means, variances of the series are independent of the time. Analyzing time series data contain non-stationary properties usually generates **spurious regression** and it shows unreal relationship between variables (Ruxanda & Botezatu 2008).

In order to recognize the stationary quality of variables, it has to be identified whether the data have the unit root or not. The unit root exists in the non-stationary time
series data. Usually, time series data have the unit root basically. In other words, they are not stationary. Among the models which measure the stationary quality of time series data, the augmented model of Dickey-Fuller which has been formulated based on their previous model (1979), has found a wide range of usage in this area. **Augmented Dickey-Fuller** model (ADF) is explained as follows

$$\Delta Y_t = \alpha + \beta t + (\rho - 1)Y_{t-1} + \sum_{i=1}^{k-1} \theta_i \Delta Y_{t-i} + \epsilon_t$$

Where $\Delta Y_t$ is differenced level of $Y$, $Y_t$ is a macroeconomic variable such as currency, commodity, bond, or stock price, and $\epsilon_t$ is a white noise term. In the ADF test the null hypothesis is formulated based on the existence of unit root, i.e. the variables being non-stationary at levels. If the coefficient of the lagged independent variable; $(\rho - 1)$ is zero, then a unit root exists, i.e. $H_0: \rho = 1$, and then $Y_t$ has the unit root property if one fails to reject $H_0$.

**b) Optimal Lag Length Selection**

The lag length has essential impact on the results of the Johansen’s co-integration test. In time series analysis the lag of a variable is defined as previous value of that variable. For example $LX_t = X_{t-1}$ for all $t > 1$.

There are a few ways to select optimal lags; one of them is to use the VAR lag order selection criterion based on the lowest criterion amount, including LR: sequential modified LR test statistic, Final Prediction Error (FPE), Akaike Information Criterion.
(AIC), Schwarz information Criterion (SC), and Hannan-Quinn information criterion (HQ).

In this study, first, the Augmented Dickey-Fuller test has been applied to identify stationary properties of the data and to find the order of variables’ integration. Then selecting the optimal lags by using the VAR lag order selection criterion and test of cointegration is conducted by the Trace and Maximum Eigenvalue tests applied in the Johansen methodology.

In summary, for examining the integration relationship the following steps are required:

- Test the stationary property of data.
- Obtain the optimal lags length.
- Examine the integration relationship.

5.3.3. Granger Causality Analysis

In parallel with the cointegration analysis, the Granger causality test is also vastly employed to investigate the interdependence of financial markets. Granger causality analysis is a technique for determining the lead-lag association between two time series data, which through one time series movement can be predicted based on the other. Granger causality analyses can assess market interdependence from the perspective of short-term dynamic relationship. In other words this method is meant to capture spillover effect among variables, but similar to the cointegration analysis. It is also not able to provide a quantitative degree of relationship among financial markets (He, Hongbo, 2012).
Granger causality tests are often used in the VAR analysis to decide the endogeneity of the variables (Li, Zhang, & Willett, 2012).

5.3.3.1. Background of Granger Causality Analysis

Many studies have employed the Granger causality test to examine the interdependence of financial markets among which are: Iqbal, Khalid and Rafiq (2011), Chattopadhyay and Gupta (2010), Diamandis (2009), Hacker & Hatemi (2006), Granger, Huangb & Yang (2000), Malliaris and Urrutia (1992).

5.3.3.2. Methodology of Granger Causality Analysis

Granger, Huangb & Yang (2000) argued that the Granger causality test is done in two forms of Vector Auto Regressive (VAR) and Error Correction Model (ECM). Vector Auto Regression (VAR) is a statistical model used to capture the linear interdependences among multiple time series. In the VAR model as a multi-equation system, there is one equation for each variable as dependent variable. Each dependent variable is a function of its own lags (its own previous values) and the lags (previous values) of the other independent variables. A Vector Error Correction Model (VECM) is a restricted VAR appropriate for using with non-stationary series that are known to be cointegrated.

a) Vector Auto Regressive (VAR) model to test the Granger causality:

\[ \Delta Y_t = \alpha_0 + \sum_{i=1}^{k} \alpha 1i \Delta Y_t - i + \sum_{i=1}^{k} \alpha 2i \Delta X_t - i + \varepsilon 1t \]
\[ \Delta Y_t = \alpha_0 + \delta Y_t - 1 - \gamma X_t - 1 + \sum_{i=1}^{K} \alpha_1 i \Delta Y_t - i + \sum_{i=1}^{K} \alpha_2 i \Delta X_t - i + \varepsilon_1 t \]

\[ \Delta X_t = \beta_0 + \delta Y_t - 1 - \gamma X_t - 1 + \sum_{i=1}^{K} \beta_1 i \Delta Y_t - i + \sum_{i=1}^{K} \beta_2 i \Delta X_t - i + \varepsilon_2 t \]

In this model, \( Y_t \) and \( X_t \) represent prices of two variables. Failing to reject the \( H_0: \alpha_{21} = \alpha_{22} = \ldots = \alpha_{2k} = 0 \) implies that the second variable do not Granger cause the first variable. Likewise, failing to reject the \( H_0: \beta_{11} = \beta_{12} = \ldots = \beta_{1k} = 0 \) suggests that the first variable do not Granger cause the second variable. If cointegration exists between \( Y_t \) and \( X_t \), an error correction term is required in testing Granger causality as shown below:

**b) Vector Error Correction (VEC) Model to test the Granger causality**

In this model, \( \delta_1 \) and \( \delta_2 \) denote speeds of adjustment. According to Engle and Granger (1987), the existence of the cointegration implies causality among the set of variables as manifested by \( |\delta_1| + |\delta_2| > 0 \). Failing to reject the \( H_0: \alpha_{21} = \alpha_{22} = \ldots = \alpha_{2k} = 0 \) and \( \delta_1 = 0 \) implies that the second variable do not Granger cause the first variable while failing to reject \( H_0: \beta_{11} = \beta_{12} = \ldots = \beta_{1k} = 0 \) and \( \delta_2 = 0 \) indicates the first variable do not Granger cause the second variable.

Selection of one of the two models depends on the existence or non-existence of integration between the variables under study. In case there is no integration between the variables, the VAR model and in case of integration, the ECM model, would be used for
the Granger causality test. Thus, before using these two models, the integration between the variables needs to be studied and evaluated. Applying the Johansen cointegration test requires that the variables must be at the initial level or non-stationary with integrated of the same order and optimal lag length should also be selected. Therefore, in summary the whole procedure of examining the Granger causality relationship can be accomplished by adopting the following steps:

- Test the stationary property of data.
- Obtain the optimal lags length.
- Examine the integration relationship.
- Evaluate the causality relationship in VAR or VEC model.

5.3.4. Volatility Spillover Analysis

The two main tests for examining the volatility transmission are Variance Decomposition (VD) and Impulse Responsive Function (IRF). These tests would be accomplished through the VAR and VEC models.

Vector Auto Regression (VAR) is a statistical model used to capture the linear interdependences among multiple time series. In the VAR model as a multi-equation system, there is one equation for each variable as dependent variable. Each dependent variable is a function of its own lags (its own previous values) and the lags (previous values) of the other independent variables.

A Vector Error Correction Model (VECM) is a restricted VAR appropriate for using with non-stationary series that are known to be cointegrated. The VEC model has
cointegration relations built into its specification so that it moderates the long-run behavior of the endogenous variables to converge to their co-integrating relations while allowing for short-run adjustments (Louli & Agnieszka, 2011).

5.3.4.1. Background of Volatility Spillover Analysis


5.3.4.2. Methodology of Volatility Spillover Analysis

a) **Variance Decomposition (VD)** and Impulse Response Function (IRF) are the two main approaches for assessing volatility transmission which are usually provided in VAR and VEC models. Impulse Response Functions indicate the influence of the different shocks from one variable on the other variables, and Variance Decompositions is a measure for gauging the impact of different shocks to the variation of different variables (Li, Zhang & Willett, 2012). In other words, the IRF represents the reaction of any dynamic system in response to some external impulse over time. Similarly, the variance decomposition determines how many percent of the error variance of each variable can be explained by exogenous shocks to the other variables in a VAR model (He, Hongbo, 2012).
b) **Volatility spillover index** also is a technique to measure the transmission shocks among different variables in the specific period. This technique was provided by Diebold and Yilmaz (2009) for the first time. Volatility spillover index is based on the variance decomposition test and determining the average of the shocks contribution from / to variables. This technique has been employed in many recent studies for gauging the interdependence among financial markets.

In summary the whole procedure of examining the volatility transmission can be accomplished by adopting the following steps:

- Test the stationary property of data.
- Obtain the optimal lags length.
- Examine the integration relationship.
- Evaluate the volatility transmission by VD and IRF.

### 5.4. Data and Variables Description

In this study, thirteen-year equal to 678 weakly observation data have been used to investigate interdependence among the stock, bond, commodity and currency markets in India. The variables included CNX 500 index of National Stock Exchange (NSE), T-bond of government securities (Treasury bond, sub maturity 8+years), RBI exchange rate of Indian Rupee to US Dollar (INR/USD), and MCX spot index of multi-commodity exchange for the period 2000 to 2012. To obtain more detailed results and assess the global financial crisis effect, the samples have been divided into four periods covering the full sample period and three sub-sample periods. The full sample covers the period 2000 to 2012 and the sub-samples 2000 to 2007, 2008, and 2009 to 2012.
For selecting the time period of this research, two objectives have been pursued. First one is that the time period is coincidental with the financial crisis of 2008. The severity of this crisis was different in different countries. The financial markets of India were affected too by the crisis to some extent and have experienced fluctuation as a result. Therefore, it is important that the behavior of economic and financial variables before, during and after the crisis be studied and compared. The second objective for choosing this time period is that such a period is the second decade after extensive economic reforms were lunched in India. To understand the consequences of such reforms and their effects on the financial market is important for the policy makers, academicians and investors.

- The data have been obtained from the websites of National Stock Exchange, Reserve Bank of India, and Multi-Commodity Exchange.
- Because of unavailability data, in this study the wholesale price index (WPI) has been used as a proxy of commodity market for the years from 2000 to 2005.
- In this research, the selecting of variables such as currency, commodity, bond, and stock has been done based on the purposive sampling approach and the selection of indices meet the purposive as well as convenience sampling criteria.
- Availability of data based on the working days in selected financial markets is different in different markets. For instance, in commodity market (MCX) data are provided on six days from Monday to Saturday, while data on stock market (NEC) and currency market (RBI) are available for five days from Monday to Friday. However, for unifying the data in different markets, Friday closing observation has been selected and this include five working days for each of the variables as the following tables shown.
Table 5.1

Numbers of the study observation (weeks)

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
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<td>53</td>
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Table 5.2

Working days in Indian financial markets

<table>
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<td>Bond market</td>
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<td>Commodity market</td>
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NSE = National Stock Exchange / RBI = Reserve Bank of India / MCX = Multi Commodity Exchange

5.5. Indices Description

In this study four indices including: 1) CNX 500 index of National Stock Exchange (NSE), 2) government securities sub maturity 8+years (Treasury bond), 3) MCX spot index of multi-commodity exchange and 4) RBI exchange rate of Indian Rupee to US Dollar (INR/USD) have been selected as representative the Indian stock, bond, commodity and currency market respectively.
5.5.1. CNX 500 Index

“The CNX 500 is India’s first broad based benchmark of the Indian capital market. The CNX 500 index includes 500 companies, disaggregated into 71 industry indices and represents about 95.76% of the free float market capitalization of the stocks listed on NSE as on June 28, 2013. CNX 500 Index is calculated with base date of 01-01-1995 and base value of 1000. Selection of the index set is based on the key criteria such as market capitalization, Industry representation, trading interest” (http://www.nseindia.com).

The CNX stand for CRISIL NSE index and CRISIL also stand for Credit Rating and Information Services of India Ltd. CRISIL is India's leading Ratings, Research, Risk and Policy Advisory Company.

5.5.2. T-Bond Index

“The increased activity in the government securities market in India and simultaneous emergence of mutual (gilt) funds has given rise to the need for a well-defined Bond Index to measure returns in the bond market. The NSE-Government Securities Index prices components off the NSE Benchmark Zero Coupon Yield Curve (ZCYC). 'Zero Coupon Yield Curve' (ZCYC) is a product that will help in valuation of sovereign securities across all maturities irrespective of its liquidity. It aims to create uniform valuation standards in the market.

The index is available from January 1, 1997 to the present. Both the Total Returns Index and the Principal Returns Index are computed. The indices provided are: Composite, 1-3, 3-8, 8+ years, and Treasury bill index” (http://www.nseindia.com).
5.5.3. MCX Spot Index

“MCX COMDEX is designed & developed by the Research & Planning Department of Multi Commodity Exchange of India Ltd. (MCX) in association with the Indian Statistical Institute (ISI), Kolkata. This is the maiden Composite Commodity Index in India based on commodity futures prices of an exchange. Also Group Indices for MCX AGRI, MCX METAL & MCX ENERGY on commodity futures prices have been developed to represent different commodity segments as traded on the exchange.

The index is a significant barometer for the performance of commodities market and would be an ideal investment tool in commodities market over a period of time. The MCX COMDEX futures will give users the ability to efficiently hedge commodity and inflation exposure and lay off residual risk. Protection can be established regardless of overall market direction.

MCX Spot Index also computes the daily Spot Index value for its MCX COMDEX, MCX AGRI, MCX METAL, & MCX ENERGY by using the current spot prices of the respective commodities vis a vis their spot prices in the same base period of average of 2001”.

(http://www.mcxindia.com/SitePages/abtcomdex.htm)

<table>
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<td>Components of MCX spot index</td>
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<td><strong>MCX INDEX</strong></td>
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<td>Metal Index</td>
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<td>Energy Index</td>
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<td>Agriculture Index</td>
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Source: (http://www.mcxindia.com/SitePages/abtcomdex.htm)
5.5.4. Exchange Rate

Exchange rate data for this study has been attained based on the indirect quotation approach. An exchange rate has two components including a *base currency* and a *counter currency*. In direct quotation, the foreign and domestic currency is used as the *base* and *counter* currency respectively. For example, US$1 = INR 60, is a direct quotation in which the US dollar is the *base currency* and the Indian Rupee is the *counter currency*, but in an indirect quotation, the domestic and foreign currencies are used as the *base* and the *counter* currencies respectively. For instance, INR1= US$ 0.0167, is an indirect quotation in which the Indian Rupee is the *base currency* and the US dollar is the *counter currency*. Indirect quotation is more in agreement with the definition of exchange rate which it is stated as the price of a domestic currency in terms of a foreign currency.